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Affordances for Learning in a Non-Linear Narrative Medium

**Diana Laurillard¹, Matthew Stratfold¹, Rose Luckin²,
Lydia Plowman³, Josie Taylor¹.**

Abstract:

A multimedia CD makes an impressive resource for the scholar-researcher, but students unfamiliar with the subject-matter may not always work so effectively with such a resource. Without any narrative structure, how does the novice cope? The paper describes how we are investigating the design features that 'afford' activities that generate learning: What are the design features that encourage students to practise the role of the scholar? What encourages them to explore, but also to reflect on their analysis of the data they find? What kind of learning takes place when students are allowed to explore at will? The paper goes on to compare the learning experiences of students using commercial CDs with those using material with contrasting designs, in an attempt to identify the design features that afford constructive learning activities. It concludes with an interpretation of the findings, comparing them with work in related educational media, and situating the findings in the context of a conversational framework for learning.

Keywords:

Narrative, hypertext, non-linear, learning.

Interactive materials:

The *MENO (Multimedia, Education and Narrative Organisation) Project* has further information about the research presented: <http://meno.open.ac.uk/meno/default.html>

A demonstration of the Galapagos CD-ROM evaluated will be added shortly.

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1. Introduction

The work we describe here is a collaborative research project deriving initially from a series of projects and theses focused on how students learn through multimedia. The MENO project (Multimedia, Education and Narrative Organisation¹) was designed to develop our understanding of the form and function of narrative in educational interactive multimedia programmes. The research question concerns the fact that educational media, such as lectures, books, TV programmes, are all narrative in form, and for good reason. Narrative provides a macro-structure, which creates global coherence, contributes to local coherence and aids recall through its network of causal links and sign posting. The structure provides a linear dynamic using a variety of structural cues, such as headings, textual signposts, and paragraphing, to allow learners to maintain their plans and goals. It has both cognitive and affective impact, performing an essential organising function for the learner by shaping the creation of meaning from texts of all kinds. Narrative is fundamentally linked to cognition and so is particularly relevant to the design of multimedia for learning.

Clearly structured and navigable texts are important. Cognitive costs accumulate for learners using interactive media because the narrative impulse is thwarted. Learners can discern narrative more easily when using textbooks or video. These media have a linear format, and have developed a variety of design features which both generate and conform to our narrative expectations; there is not yet this heritage to draw on for multimedia. Multimedia has a non-linear format, which cedes control over both sequence and internal relationships to the users. They decide on the order of the material, and they determine the nature of the link between one section and the next. In this context, the narrative line cannot be held entirely by the program. Instead, it results from an interactive collaboration between the user and the program. The learning activities linked to narrative in a linear medium are likely to be different, therefore, from those in a non-linear medium such as multimedia.

¹ *The acronym explicitly refers to Plato's 'Meno' dialogue in which Socrates demonstrates that Meno's slave apparently 'knows' Euclidean geometry. Socrates gradually elicits from the boy his agreement with each step of the logic of the proof, but without ever nurturing the learner's own ability to develop it for himself. By contrast, in this project we explore the characteristics of interactive media that would have enabled Meno's slave to conduct his own dialogue with his teaching resource.*

2. Affordances

'Affordances' is a word now in common currency in describing characteristics of the learning process. The word is borrowed from the psychology of perception, where it expresses very well the fact that there is an internal relation between the perceiver and the perceived.

"What we perceive when we look at objects are their affordances, not their qualities" (Gibson, 1979)

A designer may describe the features of an educational medium objectively and accurately - learner choice, self-paced, structured index - but the learner may perceive it very differently. Our question is rather: 'what are its affordances for the target learner?' The way it is perceived by the learner may be very different from the designer's expectation.

Affordances describe how the interaction between perceiver and perceived works - and that is exactly what we need to understand in educational research. Although the source is psychology of perception, Gibson offers a valuable concept for describing educational interactions. Examples for everyday perception would be:

A door with a flat plate affords pushing
A door with a handle also affords pulling

Contrastingly, examples for education would be:

A large lecture affords listening
A small group also affords preparing to speak.

In each case the features as perceived by an observer create the possibility for a certain kind of behaviour. We may like to think that a lecture affords learning, but the additional affordance of 'preparing to speak' creates the possibility that learners focus their attention and content processing in a way that is more productive for learning. Different learning media are likely to have different affordances for learning. What are the affordances of multimedia for learning?

3. Background to the MENO project

One of the aims of the MENO project is to develop a theoretical framework to describe the learning process in a way that clarifies the role that narrative plays in interactive multimedia.

The theoretical framework is used in part to drive the empirical work, the design of experi-

mental sessions, and the analysis of data. At the most general level of description, the learning process is characterised as a 'conversation' between teacher and student (see Figure 1), operating on two levels, discursive and interactive, the two levels being linked by the twin processes of adaptation and reflection (Laurillard 1993). This conversational framework was derived originally from research on student learning that demonstrated the productive and unproductive approaches to learning found in the context of different learning methods. It expresses the iterative interactions that must take place for conceptual learning to occur.

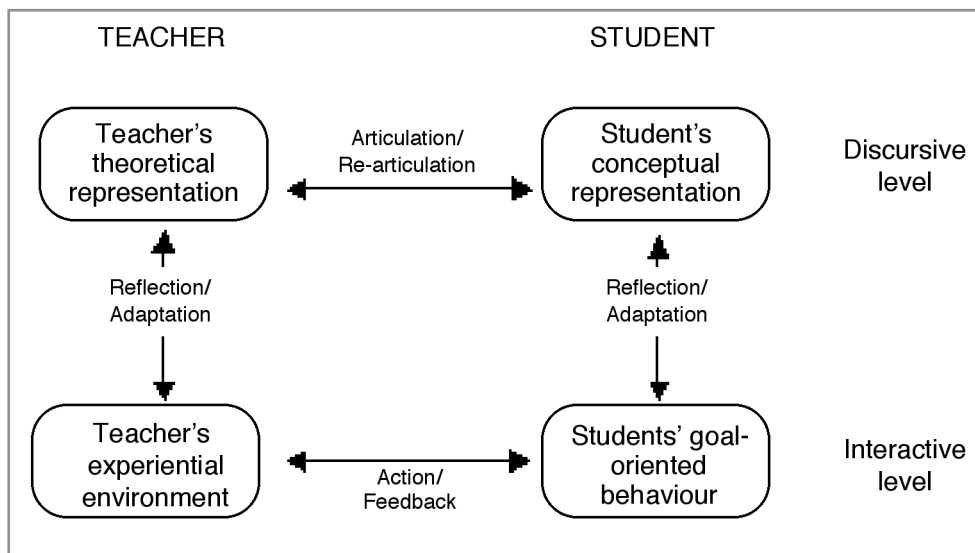


Figure 1: *The conversational framework for the learning process*

Students' work on an interactive resource will take place at the interactive level, where students adapt their actions in the light of their current conceptual understanding, and discuss and reflect on their practical work in order to develop their conceptual understanding at the discursive level. Similarly, the interactive resource, expressing the 'teacher's experiential environment' is an adaptive response by the teacher who chooses it in the light of discursive level conversations with students, and a sense of what they need to do in order to learn the topic. Again, the teacher's reflection on what the students do during the interaction will drive their further discussions at the discursive level.

The sequence described here can be applied at any level of description of the learning process, whether it is a short dialogue with the teacher explaining something, suggesting a practical example, and commenting on the student's performance of it, or a much more attenuated

period covering several encounters, class sessions, assignments and debriefing. In the context of the MENO project, the relevant sequence runs over a period of days, beginning with the teacher's initial introduction to the material being studied in the multimedia, the session at the computer, the students' follow-up discussion or assignment, and the teacher's subsequent debriefing.

Implicit in the conversational framework, as should be evident from this description, is both a time-based sequence, and a succession of iterative cycles. The sequence and the amount of iteration are indeterminate, but the framework expresses a minimum degree of complexity, if learning is to take place. Following an optimal sequence through, it could run as follows:

teacher presents conceptual knowledge
student expresses partial understanding via comment, question or answer
teacher adapts experiential task to help student experience the concept task sets goal for student
student adapts action in the light of conceptual knowledge student acts to undertake task student receives feedback on action
student reflects on interaction using conceptual knowledge student further adapts action student generates new action to undertake task student receives feedback on new action
student reflects on interaction to develop conceptual knowledge teacher reflects on student interaction to begin new dialogue
student articulates understanding of conceptual knowledge
teacher gives feedback on student's account

This minimalist sequence of iterations of dialogue, action-feedback, adaptation and reflection allows the students to be exposed to new ideas, to link these to enhancing their practice, to improve their practice and link this improved practice to further developed understanding, and to assure the quality of their understanding. The format of the layout above is meant to show the internal structure of the sequence as a series of matched pairs operating at different levels of description of the learning process, each one completing a circuit of exchange - a series of conversations between teacher and student, between student and task, and within the student and the teacher. The narrative line of the learning session can then be interpreted as cycles within a sequence, iterating progressively towards something like consensus between teacher and student.

For our work on this project we have defined narrative as: *'a process of both discerning and imposing structured meanings which can be shared and articulated'*. In the conversational framework control of the narrative is balanced between learner and teacher, and is continually negotiated between them. In learning media such as lectures and books control tends to lie with the teacher. In a research project it is with the learner. The successful media will be those designed to enable the control to be balanced and the negotiation of the narrative to be shared, e.g. the lecture with question and answer sessions, or a research project with supervision.

This conceptualisation of the learning process underlies our approach to the analysis of student-computer interactions. From the student's point of view, the more teacher-controlled form of learning is 'narrative guidance', whereas the more student-controlled form is 'narrative construction' (Plowman et al, 1999). Ideally, teachers aim for bridging forms between these two extremes, where teacher and student share responsibility for progressing the sequence. Can we locate interactive multimedia among these intermediate forms, or is it necessarily found in instructional forms at the two extremes?

The project set out initially to test the use of CDs in schools in the light of our hypothesis that the narrative form of the learning session was critical to learning. Were these CDs supporting narrative guidance or narrative construction? To what extent were they scaffolding the full complexity of the learning process, as understood from the conversational framework?

4. Empirical studies

There were two series of studies: the first using commercial CDs already in use in a school, and the second using an experimental CD, designed using the results from the first study.

Negotiations with schools using multimedia in the classroom enabled the fieldwork to be conducted on genuine learning tasks. It was essential that the students we studied should be engaged in a process that from their point of view was real learning, not a laboratory exercise. Teachers co-operated by arranging for our studies to be conducted at the appropriate point in the delivery of the curriculum, by briefing their students and setting realistic tasks for use with the CDs, and by following through into debriefing or assessment of the students' work.

4.1 Finding the affordances (1)

Stage 1 of the empirical studies used CDs already in use in the partner schools. The analysis of the data at this stage took the form of searching for critical sections of discourse and interaction between the learners, and between the learners and the material. We were looking for evidence of productive learning activity, but usually found evidence of clearly unproductive activity. In

either case, the task was then to examine the data in the context of that activity as a micro-level case, exemplifying an aspect of the learning conversation between the materials, the interface, and the learners.

Throughout the observational data, at this stage, we kept finding evidence of lack of engagement by the students, and a consistent focus on the operational aspects of the task in hand, rather than its content or meaning. The following is an illustration of this kind of data. The example comes from a project set by the teacher, for a group of three 14 year-old students using a history disc on the second world war to investigate the topic of nuclear bombing. There is a varied set of resource materials on the disc, all well indexed, including documents, speeches from war leaders, newsreel documentaries of the time, video, and audio, all fully controllable by the user.

The dialogue excerpt below begins at a point about 10 minutes into the session when they are using the index and media controls to find their way to the resource material they need (numbers indicate different students speaking).

1: There is no film there, is there?
1,2: No
2: That one has no film there, either
3: It's the last one
2: Is there any text to go with it? (Reading from text "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?

This is an example of dialogue that we interpreted as entirely operational. The focus of their attention is all on the task form, and the navigational aspects of the interface. A similar kind of dialogue is found in another group, at about the same point in the session:

1: What else shall we do?
2: Go back to the index...See if we can..
3: Go down, keep going.. 2: Hiroshima..
3: Just type it in at the top. Fill in the box.You only have to put the first couple of letters in for it anyway. -2: Alright.
3: You see, 'Dropping the bomb', and 'Using the bomb'.
3: This is what we did before. OK
3: Go back because that's the one we did before.
1: There's a film. Try this.
2: So we can see the text of that...(reads) 'Quote President Truman'.
3: Go on to the next one, the film.

Focusing in the task form is appropriate for some parts of the exercise, but it seemed there was little else in the data. The same approach is evident even when they find some relevant material. This extract continues with them watching a newsreel clip of about 1 minute, showing the aftermath of the Hiroshima bombing. The voiceover is emphasising the devastation and the human tragedy of the event. As might be expected, it is very shocking, emotionally-charged footage.

Despite the nature and relevance of the material, however, the students remain focused entirely on the process, on the operational aspects of the task in hand.

2: So...
1: Did you stop that?
2: No it just finished
3: It didn't finish properly, actually.
1: So what do we do now?

This was material that was highly relevant to their overall goal, to investigate nuclear bombing, it was highly engaging material, and yet it appears to have afforded no productive response of any kind. There is no sense of a storyline to their investigation, no goal in sight, no progression towards it, no sense of achievement.

A similar example comes from the same disc being used to research a different topic, and with a group of three 14 year-old students. This time the students are making comments as the video is played.

Video begins, showing the Allies entering a concentration camp and being horrified by what they see.

1: It's good quality, the sound

2: Hmm. Pause.

2: Sick.

1: Can we maximise the screen...?

2: Hmm, dunno...

1: ... to get a bigger screen?

2: Yeah, double click on that, yeah.

1: I dunno, maybe we should...

2: ..dunno - don't think you will.... yeah.

1: Well, we'll have a look anyhow.

Video clip ends

Again, they find a video clip exactly appropriate for their topic, but again the focus of the talk is entirely operational. There were many such episodes in our observation of learners using these kinds of discs (Plowman, 1996).

The video transcripts captured the nature of the experience from the students' interaction with each other and with the program. Evidence of the nature of the learning experience from the students' point of view comes most directly from their dialogue as they work. In our analysis of student dialogue we were looking for evidence of each aspect of the conversational framework in operation: the students' interpretation of the overall goal set by the teacher, the intermediate sub-goals they form to collect the material they need, the actions appropriate to finding this, interpretation of the material they find, relation of this to the sub-goal, articulation of the synthesis in terms of the overall goal.

Analysis of the interactions showed that students' manipulation of the interface tended to dominate their talk with the effect of making the students focus on the operational components of the task. Taylor, *et al.* have distinguished between the 'task semantics', which refers to the implicit knowledge students use to understand the task, and the 'task syntax', the aspects of the interface which students operate in order to address the task semantics (Taylor, Sumner and Law, 1997). In some activities the two are seamless, where the affordances of the task syntax match the requirements of the task semantics - as in, for most of us, using a pen to write a message. In such situations the syntax remains background to the semantics, as it does in the context of spoken language. However, for the students we were observing the task syntax level was the foreground. This meant that any possible narrative line being constructed either by the

teacher or by the students themselves was continually disturbed by the difficulty of making the transition from one cycle in the conversational framework to another. If they managed to decompose the overall task into a constituent sub-goal, the task syntax involved in meeting that sub-goal was so difficult to operate that attention became focused on that, and they lost the thread of their own narrative.

From these findings, we designed the second study. Its aim was to remove those design features which afforded off-task talk (e.g. difficulty of the task syntax), and to incorporate features that would guide the narrative (e.g. clear goals, sub-goals), and promote the students' own narrative construction (e.g. discussion, feedback).

4.2 Design of materials

To explore the extent to which we could assist students in the process of maintaining a narrative structure for their work, we designed an interactive multimedia program in the light of the theoretical framework. For each component of the narrative outline above, the teaching method has to offer support of some kind. In the classroom it would be the teacher's questions and instructions. In a stand-alone teaching medium students need scaffolding of the following kind:

teacher presents conceptual knowledge	<i>access to presentational material</i>
student expresses partial understanding via comment, question or answer	<i>means to articulate viewpoint</i>
teacher adapts experiential task to help student experience the concept + task sets goal for student	<i>choice of activities relevant to tasks</i>
student adapts action in the light of conceptual knowledge	<i>support for generation of task-related plan</i>
student acts to undertake task	<i>interactive tasks available</i>
student receives feedback on action	<i>feedback on actions available</i>
student reflects on interaction using conceptual knowledge	<i>motivation to reflect on interaction</i>
student further adapts action plan + student generates new action to undertake task	<i>opportunity to repeat actions to improve performance on task</i>

student receives feedback on new action	<i>adaptive feedback available</i>
student reflects on interaction to develop conceptual knowledge	<i>motivation to develop concepts in the light of experience</i>
teacher reflects on student interaction to begin new dialogue	<i>alternative presentations available</i>
student articulates understanding of conceptual knowledge	<i>means to articulate conceptions</i>
teacher gives feedback on student's account	<i>feedback on conception</i>

The new design set out to meet these requirements on the medium by providing features that we hoped would act as affordances for the activities identified as essential components of the learning process:

- a clear statement of an overall goal - to support generation of a task-related plan
- continual reminders of the goal - to support keeping to the plan
- index of sub-goals - to provide a choice of activities relevant to task
- multimedia resources - as alternative presentations of the material
- interactive activities - to provide adaptive feedback on actions; to motivate repeat actions to improve performance
- an editable Notepad - to enable students to articulate their conceptions
- a model answer - as feedback on their conceptions; to motivate reflection on their conceptions.

The aim of the new study was to discover the extent to which these new design features acted as affordances for the intended learning activities. Would students respond to the narrative guidance offered by the overall goal, the reminders of the goal, and the multimedia resources? Would they be supported in their own narrative construction through their use of the Notepad, the index of sub-goals, and model answer features?

4.3 Finding the affordances (2)

The new CD was used in our partner schools by negotiation with the teacher, to ensure that the material was relevant to the students' study. Data collection methods were more extensive for the second study, including also questionnaires, teacher assessments, field notes, and students' entries into the Notepad (see Luckin et al, 1999 for further detail). Altogether 36 students were

observed in groups of three.

At the end of each session we asked the students to audio record what they found out, and their teachers were asked to judge how well they had done, from their final answer in the Notepad. This provides a way of triangulating the data from the session itself, both the observational data from the students' talk and behaviour, and the recorded data from their entries in the Notepad.

The videotape analysis made use of specialist software (NUD*IST²), and data representation techniques documented fully elsewhere (Luckin et al 1999). The analysis is case-based, not statistical. To discern the internal relationship between the design features and the students' interpretation and use of these, we have to document the micro-level interactions that occur throughout the session and characterise these for the quality of learning activity that appears to take place. Affordances cannot easily be disassembled into predictable cause-and-effect descriptors that can be counted and correlated. They are possibilities fulfilled, potentials achieved. For example, although the Notepad is a predictable feature, being present in all cases, the way it is used varies with context, and yet each way may constitute a productive learning activity. The affordance made possible by the Notepad is completed by the students' interpretation and use of it.

In the new CD, students are asked to 'investigate the causes of variation in wildlife on the Galapagos islands'. Once again, there are extensive, indexed media resources taken from television documentary material on the islands, their formation and their wildlife, but there are some additional features as well. The overall task is stated explicitly in the introduction, there is a Notepad available for students to record their findings, and there is a model answer available once they have completed some work.

² NUD*IST: *Qualitative Solutions & Research* www.qsr.com.au

To illustrate the kind of student dialogue elicited by this material, consider an extract at a comparable point in the session. This dialogue occurs about 10 minutes into the session, as the students gather material to answer the overall aim.

1. Do you want to make notes on this - did you hear what they said?
2. The islands are tips of volcanoes.
1. Is it Notepad?.. 3. Yeah..
2. Under the sea....
3. Under the sea - but that's got nothing to do with the variation.
2. But that's nothing to do with the variation of the wildlife - is it? 1. Well...

This kind of talk contrasts with the earlier examples because it is much more task-oriented, the students discussing what they have found, and whether it is relevant.

Again, this exchange is followed by about one minute of video, as engaging as the earlier material, showing how volcanic action formed the islands and how the first forms of life arrived there.

Here, however, the talk remains task-focused. The students are considering the relevance of the material to the current goal, struggling to articulate their ideas, not only from this section of video, but referring back also to some previous findings they had gathered about the effects of ocean currents and trade winds.

2. When they first came they were - or do we not really need that?
3. I don't know.
1. No - oh, you can say that it got there from ocean currents and trade winds and, these are the factors in how...
3. OK - The islands, the wildlife got there..
1. Is there a better word for 'got there'?
2. Well, arrived, formed - population grew.

By contrast with the commercial resource-based discs, the repeated focus on and support for the task here enables students' dialogue to remain task-focused.

A further example of the dialogue afforded by the new CD is taken from the episode where students are discussing the model answer, and matching it to what they have already drafted in the Notepad.

1. Well I just put that
2. Did you put that?
1. Yeah
2. Well done. 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...

Using the model answer has prompted the group to focus on the contrast with their own answer. The information on *strong winds and ocean currents* in the model answer is present in their own answer, but the comparison enables them to identify the important omission of information about how the birds arrived. Using the model answer appears to afford reflection on their performance on the task. Further discussion of the group interaction is reported in Luckin et al (1999).

5. Affordances for maintaining a narrative line in multimedia

A narrative line in any context will have an internal structure that develops over time. In a well-organised educational session, the narrative will begin with the high-level enduring concept of the overall message, which the teacher will clarify then decompose into sub-components of the high-level message. The sub-goals would then be used to generate the actions or procedures appropriate to the task. In the history example above, the appropriate action might be looking for information about aspects of nuclear bombing. For the evolution example, it might be investigating the environmental conditions for evolution. The session would then move on to interpreting the feedback offered in response to those actions, and revising those actions as necessary - perhaps looking for additional information, or more detailed explanations. The teacher would encourage students to relate this experience to what they are supposed to be finding out. They would finish with a debriefing session to reflect on their work and relate it to the overall message or description of the goal. Something like that complexity of structure must be present in any meaningful learning session. The narrative line will follow a structure similar to the following: where are we going? what do we need to get there? how do we do that? what do we get when we do it? how far does that help us? where have we got to? That is what learners need to do, and they need support for each of those stages. Figure 2 shows the kind of cyclical internal structure a narrative line needs for meaningful learning to take place. The learner begins at the level of the overall aim or message, cycles through the relevant action-feedback loops at

the level of the sub-components, and returns to articulate their overall understanding at the level of the message.

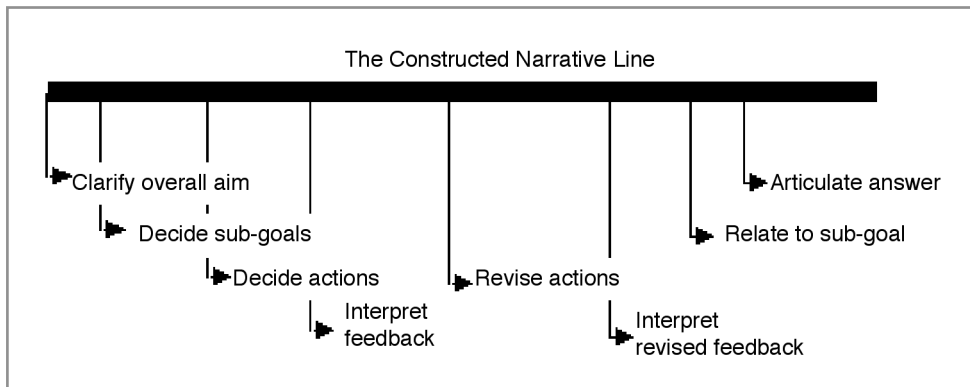


Figure 2: Representation of the internal cyclical structure of the narrative line

Our observation of learners using interactive multimedia shows that design features can be built in to act as affordances for these learning activities. The contrasting data presented above suggests that with design features such as statement of task goal, Notepad, model answer, it is possible to elicit more meaningful discussion, focussed on the task-semantics. Our hypothesis is that these features create the possibility for learners to develop and sustain their own narrative line:

- The goal is stated to clarify the overall aim.
- The relevant sub-goals are offered as choices.
- The menu allows learners to set up their investigations.
- The multimedia resources provide feedback.
- Interactive activities enable them to revise their actions.
- What prompts them to interpret the feedback they get, instead of simply moving on, is the knowledge that there is a model answer to be matched.
- What prompts them to relate what they have found to the sub-goal they are working on is the continual reminder of what they are trying to achieve.

- The editable Notepad enables and encourages them to articulate their answer, and to keep trying to refine it to better match the model answer.

That is the crucial substructure of support that learners appear to need. Figure 3 shows how these design features for an interactive multimedia program would support each stage of the development of the learners' narrative.

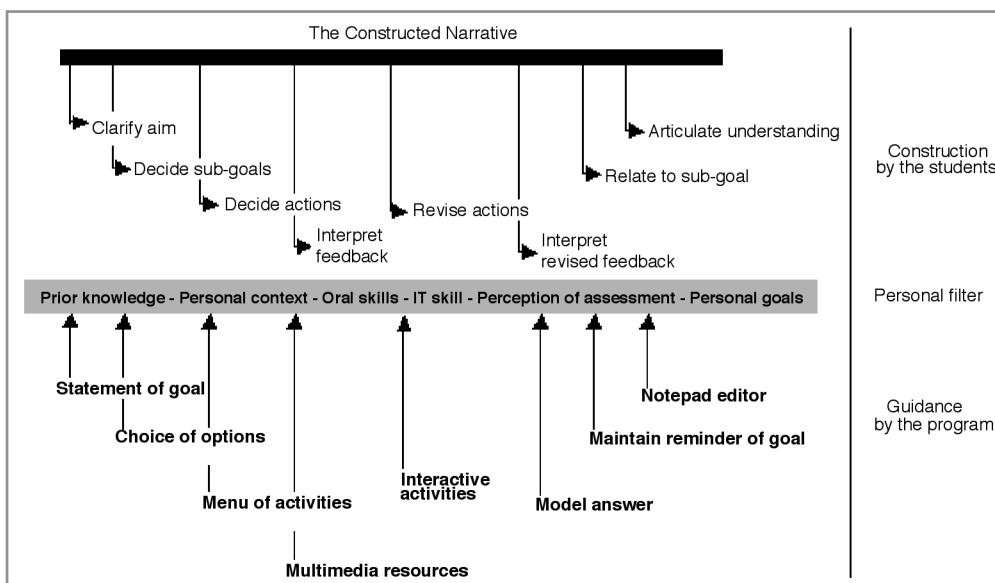


Figure 3: Design features to support some of the learning activities needed to construct and maintain the learner's narrative line

The chronological development of the learners' construction of the narrative takes place within a larger context - the teacher's lesson, the sequence of lessons in this part of the curriculum, the school, their longitudinal educational experience, etc. The aggregate of these layers of context is represented as a kind of filter, through which the features of the particular program are perceived and interpreted. The design of the material is present to their current awareness, but so is their perception of how long this session is likely to last, how much value the teacher is likely to put on their work, how interested they are in the topic, what else they already know about it. The learners' construction of their narrative is governed by the way the guidance in the program is mediated by their personal filter. The guidance is necessary, but does not constitute the sufficient condition to guarantee learning. What we try to do here is understand what constitutes the role that must be played by the material itself. The complementary task of the teacher is the subject of a different paper (Luckin et al, 1998).

Most commercial interactive CDs, offer little more than the option choices and the multimedia resources. As we have seen, that does not provide sufficient support to allow the learner to maintain all the learning activities necessary to achieve a meaningful goal. Without the appropriate affordances, students remain unsupported through the crucial stages of maintaining their narrative line, and are left with nothing other than the action-feedback pair that goes nowhere, that constitutes nothing more than browsing, as shown in Figure 4.

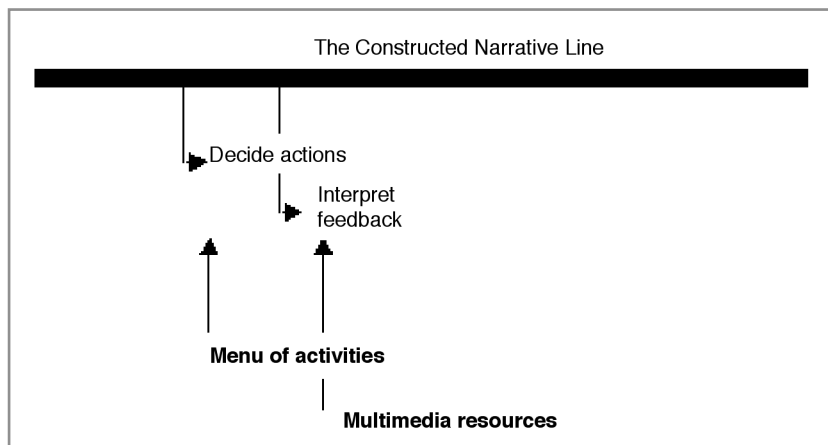


Figure 4: Design features that provide only access to multimedia data support only a limited range of learning activities: the uncontextualised action-feedback pair

To summarise: (i) there are learning activities we want to support in sending students to learn from multimedia materials; (ii) here are affordances we have found for those learning activities; (iii) if those affordances are not present in the learners' experiences of the materials, then the learning activities they afford are less likely to occur.

6. Conclusion

The overall message of the narrative line of this paper, is that within an educational experience provided by a non-linear narrative medium, such as interactive multimedia, we must take care to maintain a narrative, in collaboration with the learner. Teachers and designers must be clear what kinds of learning activities it takes to understand a topic, and then create the affordances for those activities. We have seen that students inevitably follow the lead of the interactive environment they are working in. It is the responsibility of teacher and designer to create the environment that makes it possible for them to maintain a focus on the development of the argument: clarify the overall goal, keep reminding them of the goal, help them define their own

sub-goals, motivate their own articulation of what they know, motivate them to refine it, and enable them to assess for themselves the extent to which they are achieving the goal. With such design features, the non-linear medium is able to afford something more than mere browsing: it will afford structured, meaningful learning.

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7. References

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