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# *The potential contribution of encyclopaedic foreign language CD-ROM packages to the acquisition of language and knowledge*

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**Abstract**

The article describes an experiment which investigated the role played by an encyclopaedic CD-ROM in knowledge and language learning gains. It considers both quantitative and qualitative evidence (eg pre- and post-testing, and on-line audio-recorded data) to demonstrate that learning did take place and to suggest how it might have occurred.

## 1 Introduction and rationale

One of the great potential advantages of encyclopaedic multimedia is its power to facilitate individual or collaborative independent learning by students who often find such material both interesting and challenging. Yet work of this sort in secondary foreign language classrooms is as yet largely uncommon. Research is undoubtedly necessary if we want to demonstrate that the potential for learning as well as motivation is real. In a plenary session of EUROCALL (1996) given by Wolff (1997), one of three research points highlighted was "the learning potential of multimedia; do increased channels of perception result in learning?" Two years later Little (1998) argued for "empirical research in order to explore in a disciplined way how language learners actually use information systems." Chapelle (1997, 1998) also addressed the research issue by suggesting a review of the research questions and the methods used to investigate them. Although her articles deal with the nature of useful research paradigms on the one hand, she also poses very concrete questions around language input, output and interaction during CALL activity. Furthermore, she advocates classroom based research methods as a way of moving forward. Salaberry (1999) extended the scope of the proposed review by emphasising the importance of socio-cultural research as well as that arising from interactionist second language acquisition research.

What kind of research reporting is needed to enhance our understanding? If we look below the more 'global' level of Chapelle and Salaberry, and also of Crook (1994) and Warschauer (1997) the researchers writing in the area of multimedia applications and language learning tend to publish essentially three types of work. We see articles which describe the nature of software (recent examples, Kitts & Whittlestone, 1998; Blake,

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1999; Pusack, 1999), articles which present theoretical models for software design (e.g. Chun & Plass, 1996; Plass, 1998; Brett & Nash, 1999; Hoven, 1999), and those which evaluate the effects on learning of using multimedia, (e.g. Brett, 1997; Murray & Barnes, 1998; Fleta *et al.,* 1999). All are valuable but clearly the latter group are attempting to answer specifically the questions posed by Wolff, Little and others. Their findings seem very much to suggest learning enhancement over a period of time if multimedia facilities are in use. This study also attempts to do this in a very concrete and structured way, which offers views of the evidence presented from both quantitative and qualitative perspectives in order that the findings may be more secure. The objective was to create only a small scale experiment, but one which could demonstrate learning with as little doubt as possible over the reasons for it. In order to design this secure structure it is also necessary to review research around such factors as the role of the medium (ie the nature of the software), the rationale for an individual or collaborative context, and to determine the task-type adopted. Each of these is now considered briefly.

Mercer & Scrimshaw (1993: 191) pose the question "Is the computer best conceptualised as a tool, as an active participant in the learning process or something in between?" A computer can play a variety of roles in language learning but if we narrow the computer's role to a context where it is essentially a source of comprehensible input, then, within limits, it can be individualised for each participating learner. Information in a multimedia piece of software is clearly multi-faceted and multi-layered in a way that a teacher or a book cannot quite imitate. The availability of links between pages of information, either from individual words or to an on-page index, speeds up the location of definitions or connected material. The use of audio-animated and sometimes video-based files improves a learner's potential for comprehension through the activation of different modes of learning. As Light (1993: 54) writes, "It may be then that the computer can deliver something which other teaching and learning contexts tend to lack – perhaps by providing just sufficient structure, direction and support to the learning process to enable the collaborative learning process to be sustained". Marcus (1993) goes even further with his comment: "Hypermedia tools, in fact can be understood as allowing us to build models of our thought processes as well as the content of our thought". Certainly it seems likely that by offering alternatives to a single externally imposed direction and in facilitating perhaps a less linear set of thought processes, a multimedia package may allow a greater variety of meaning construction than may printed materials or teacher-given oral explanation.

Is there a case for or against individual or paired work around the computer? One could argue for collaborative learning in general terms using the well documented theories of Vygotsky (1978), Bruner (1966) and Wood (1988). In the specific context of meaning construction, Mercer (1995) and Almasi (1995) have demonstrated the power of talk in learning. Davis & Somekh (1997: 25) apply this to working with computers: "Group work around a computer may be more genuinely collaborative than other group work, thereby enabling more focused group talk. This in turn may enable learners to go further in developing their powers of hypothesising and problem-solving without needing to resort to the teacher for help. In these ways IT tools appear to be able to support learners in what Vygotsky calls the 'zone of proximal development'". Wegerif & Scrimshaw (1997) found the same effect.

But as with any collaborative work, we have to bear in mind both task-associated and affective factors. "Simply putting learners together in front of a computer will not

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ensure peer facilitation of their learning. Conditions have to be such that they engage both with the task and with one another in the course of their learning. The features of the computer itself will not ensure this" (Light, 1993: 48). To respond to this caveat we need to consider two issues: the role of task and affective factors. The task chosen for the collaborative work should involve sufficient challenge for the participants to need dialogue, with the computer and with each other. A problem solving task tends to generate greater collaboration than a non problem solving task, and in terms of the reading process a cloze exercise does constitute such a task (Underwood & Underwood, 1998). Affective factors are more difficult to predict. Gender related issues may be problematic. The relationship between individuals within the pairs may produce an effect, given that the nature of talk (Mercer, 1995; Almasi, 1995) can be crucial to success in a task.

## 2 The study: research questions

The study described in this article used a science-based CD-ROM package in French to investigate with a small sample of able advanced level students two key questions. The first very simply concerned learning: can students learn items of factual knowledge and foreign language vocabulary through structured but independent collaborative work on a CD-ROM? The second addressed the role of prior knowledge: if such learning does take place, does prior knowledge affect the scale of this learning? Ridgway investigated this area in his 1997 article: "There is no doubt much anecdotal evidence that many specialists with unexceptional [foreign language] have reported little difficulty in reading articles in their specialisms, which would be incomprehensible to the educated native layman" (Ridgway, 1997: 153). Mohammed & Swales (1984) and Alderson & Urquhart (1985) concurred with this finding. The six students who participated in this study included two who were also studying a relevant Science A-Level.

The second of the key questions then needed to be operationalised as follows: Will the biologist pair score more highly on any particular part of the testing? Will they complete more of the cloze task in the limited amount of time available? Will the online recording reveal more detailed knowledge leading them to understand the material in French, because they already had that knowledge?

## 3 The study: methodology

The study used a French encyclopaedic CD-ROM, *Encyclopédie du Corps Humain* as a resource. The subjects were a group of six students in Year 13 of a Sixth Form College, all studying French A-Level and expected to achieve A or B grades. They were all regarded by their teacher as approximately equally able as regards their reading skills in French. Two of the group (Subjects E and F) were also studying Biology A-Level.

Base-line data was first established through a pre-test in English of knowledge about the effects on the body of taking exercise and a 25-item single-word vocabulary and phrase test from English to French (Appendix A). A week after this test the six students in pairs worked for 30 minutes on a gap-fill and open question task in French (Appendix B), while having open access to the CD-ROM. The computer was set to display the initial page in the section they needed, but nothing was said about how they should do the task. In fact the group of pages which directly linked to the starting page could supply

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most of the information needed to complete the task. On that same page was a very clear hint as to which other section might be needed, but other parts of the CD-ROM also contained relevant information. The two biologists worked together as a pair. The interaction between the students was recorded on audio-tape. The six students were told there would be some follow up work, but it was not specified what form this would take. The following week the six were re-tested, using the pre-test again as a post-test.

## 4 The study: interpreting the data

Therefore, to gain a full view on the two research questions the factors examined from the written and aural data were: the pre- and post-test results; successful completion of the task; the overt use of background/prior knowledge during the task; and engagement with the task and with the materials.

Of the affective issues mentioned earlier, the gender question was not problematic as only one participant was male and he worked with his normal classroom partner during the study. There was however an affective issue concerning the pairing of the two biologists who were unaccustomed to working together. This is discussed below.

## 5 The study: statistical data

The statistical data (Appendix C) from the pre- and post-testing was analysed (the English to French vocabulary items by the researcher and the 'scientific' answers in English by a graduate biologist). The vocabulary items were only considered to be correct if they were absolutely correct. If they were recognisable, they were considered to be 'half-correct' (see Appendix C1). The pre- and post-test Science content responses for each participant were compared, and the rater considered whether their answers had become more or less precise and more or less detailed, or had remained the same (Appendix C3). The results of the Science content testing showed that:

- all except one student (participant F, one of the biologists) became either more precise or more detailed or both, in their understanding of the effects on the body of taking exercise.
- one of the biologists (participant E) was ranked top in her knowledge of the subject matter on both pre- and post-test, while the other (F) was ranked third on both tests. A non-biologist (participant A) was thus able to demonstrate more subject specific knowledge than the second biologist. This demonstrates that 'specialist' prior knowledge in this study was not just a factor relating to the academic courses being followed, but was part of the wider general world knowledge of all of the participants
- The three who made the highest percentage gains in the vocabulary section of the testing included the two with the greatest prior knowledge according to the content testing, which would indicate that there may be a link between prior knowledge and language learning. But to counter this, participant D, who made the second highest percentage vocabulary gain, was ranked sixth in the subject testing on both tests.
- there was one change in the ranking of subject knowledge between the pre- and post-test, with participant C making a greater gain than candidate B, and thus

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overtaking her. Since C was the highest scorer in both tests on the vocabulary section (see Table 1), her gain in subject knowledge may indicate that a high level of language competence can facilitate content learning.

From Table 1 it can be seen that:

- all of the participants gained in their knowledge of the vocabulary set. The initial percentage of entirely correct items ranged from 12% to 36%, and the equivalent post-test results ranged from 32% to 54% entirely correct. The theme the participants were following in their French lessons at this time was not related to the topic of the study, and therefore we can be reasonably sure that the vocabulary gain was directly as a result of the work on the CD-ROM. This demonstrates clearly that the 'method' is productive at least with a group of able and advanced linguists.
- the two biologists made, respectively, the largest and joint smallest percentage gains in the vocabulary tests. With participant E, this suggests that prior knowledge, when applied to a language task, may have greatly facilitated the internalisation of the vocabulary, so that her post-test performance dramatically improved.
- only the second biologist (F) showed any 'backtracking' in that some of her answers to the French item test were poorer on the post-test than on the pre-test and her subject specific answers were sometimes less precise on the post-test than on the pre-test. The likelihood is that this was due to affective factors as she questioned the pairing made for the work on the CD-ROM, and (as is shown below) the interactions between the pair while completing the task were far less intensive than with the other two pairings. The rationale behind the pairings was explained to her after the post-test, but deliberately not before as it was one of the factors the study was attempting to investigate.

## 6 The study: online data

The task consisted of a modified cloze passage and three open-ended statements, each consisting of the start of a sentence which needed to be completed using a reason or an example. The biologist pair completed the entire task (Appendix C2), except for two of the 20 cloze gaps. The other two pairs performed much less successfully on the open-ended statements, with AB having just one answer which was incorrect, and CD having no answers at all. Since the time limit of 30 minutes was strictly adhered to, this was more likely to be a feature of the speed of working than of insufficient linguistic knowledge. However this is an indicator of where prior knowledge is probably

Table 1. *Extract from Appendix C1 – French vocabulary pre- and post-test scores*

| | A | B | C | D | E | F |
|---|---|---|---|---|---|---|
| % initially right | 24 | 32 | 36 | 12 | 16 | 32 |
| % finally right | 48 | 44 | 54 | 32 | 48 | 44 |
| % gain | 100 | 37.5 | 50 | 166 | 200 | 37.5 |

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a significant factor. EF had strong prior knowledge, AB managed more than CD, with participant A placed second in the subject-knowledge testing. In fact A was a greater driving force in the interaction than B, which further strengthens that proposition.

The online audio-data showed that the biologist pair interacted far less than the other two pairs although they did complete more of the task. They appeared to use the resource less, reading the task sheet, completing the gap-fill with recourse to the CD-ROM only when necessary. They did however use it more substantially to answer the completion statements, which were more demanding. They demonstrated far less interest and engagement in the task than the other two pairs. The non-biologist pairs worked together very well throughout the 30 minutes each had on the computer. The transcripts were analysed for strategic behaviour, using Oxford's (1990) model of direct (memory, cognitive and compensation) strategies and indirect (metacognitive, affective and social) strategies. They reveal the use of direct strategies such as:

**Cognitive**

- repeating (i.e. re-reading of, re-listening to certain sections, because they were felt to be important); for example subjects A & B used the audio-clips very methodically, having isolated which gaps they were interested in and listening several times to each, gradually filling in the gaps.
- translation (as a means to understanding what was needed).
- inferencing: "batements sounds like beats" and "rapprochement means more close and then the waves get bigger"(A).
- predicting, using world or subject specific knowledge: there were surprisingly few instances of this, although subject A (a non-biologist) referred ironically to his "useless background knowledge" when making an aside about the body producing more carbon dioxide when exercising. In addition to this subjects AB and CD (ie both pairs) did discuss the two words *électrocardiographe* and *électrocardiogramme*, trying to remember via world knowledge which was the machine and which was the on-screen information. Otherwise both pairs, whose background knowledge would stem from pre-GCSE subject knowledge or simple world knowledge, made very few references to facts they already knew in making sense of the French either on the CD-ROM or in the gap-fill task.

**Memory**

- activating vocabulary from long-term memory: for example in the pre-test neither subjects C nor D remembered the French word *écran*, but during the gap-fill task they identified it from an audio-clip extract: "*...en les escrivant sur l'écran d'un appareil...*" The transcript at this point reads: (C) "*..sur l'écran, l'écran,* did you hear it..?" (D) "that was screen..." (C) "yeah on the screen of a machine." Both subjects subsequently gave the French word correctly in the post-test. Similarly, subjects A and B did not know either part of the phrase 'wave effect' in the pre-test, but both remembered it correctly or nearly correctly in the post-test.
- using grammatical knowledge: "I think that's an object there because that's the verb, isn't it?" (B).

They also used indirect strategies such as:

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**Metacognitive**

- proposing strategies for the completion of a particular part of the task: "Shall we just go through it and translate it and then have a look at this after?"(subject B).
- deciding to focus on certain aspects, to move on and return later: "Shall we just go on?" (B).
- using the CD-ROM structure to move to linked pages which might be helpful, for example, subjects C and D used the *pour en savoir plus* box to move to the main pages on lungs and from there discovered the correct gap-fill for carbon dioxide; subjects E and F did likewise and moved to a page about the circulation which was partly relevant to the item in the first open-ended question – as biologists they appeared to realise that would be relevant.
- monitoring how far the complete task was being covered.
- evaluating which aspects of source material were most useful: for example subjects A and B used the audio-clips very methodically, having isolated which gaps they were interested in and listening several times to each, gradually filling in the gaps.
- evaluating which aspects of the task were most important: for example subjects C and D used the gap-fill as the major focus and either skimmed for anything which appeared to be related or scanned for items they expected to hear. They also used the audio-clips at random, listening for key words and then seeing where they might help with the gap-fill. On the other hand subjects A and B used the CD-ROM text first, attempted to translate it together and then turned to the gap-fill to see what could be fitted in.

**Social and affective**

- cooperation (in carrying out task). There were frequent examples (see transcript below) of subjects agreeing to move to another section or repeat a listening.
- clarification (of uncertain material). Clearly one benefit of collaboration is the potential for knowledge to be shared and aggregated. Subjects AB and CD frequently discussed their separate interpretations. This is one striking difference which sets apart the EF transcript where only a small amount of sharing took place.
- discussion (of word-meanings or correct concepts). Sometimes it was through discussion that a conclusion was reached rather than one subject being able to tell another the correct meaning of a word. This was perhaps most noticeable in the AB transcript, as in the example quoted above regarding the words *électrocardiographe/électrocardiogramme*.

Subjects E and F whose tape is incomplete had very little spoken interaction when compared with the other two pairs. As biologists one might have expected more relating to prior subject specific knowledge, but with this pair this was not the case. It appeared that the two biologists, while in the same teaching groups for French and Biology were not as accustomed to working together as the other two pairs. This 'affective' issue may have skewed some of the findings as the second biologist appears to have been less committed to the project than the other five students. The disadvantages of 'enforced' collaboration are thus as evident as the benefits of willing co-operation shown by the other two pairs. A section of transcript from the tape of subjects C and D demonstrates the various aspects discussed in a connected piece of dialogue

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(the abbreviations indicate direct or indirect and cognitive, compensation, metacognitive and social/affective strategies in use). Additionally, it also demonstrates some of the enjoyment involved in working in this way:

| | | |
|---|---|---|
| D: | Go back to the *poumons* + (inaudible) | IM, organising |
| D: | What? Right, are we still on this one? | IM, clarifying task |
| C: | (reads) [*Quand on respire le sang* | |
| D: | receives oxygen, receives oxygen, ] we know that don't we ? | DComp, using prior knowledge? |
| C: | (reads) *par l'intermédi*– aire | |
| D: | through the intermediary | DC, translating |
| D: | we decided this one's oxygen. I'm sure it's oxygen. Go back to…oh, you are on *poumons*, sorry | DC, clarifying knowledge IM, organising ISA, apologising |

Tape starts: "*quand on marche tranquillement*"

| | | |
|---|---|---|
| C: | Sorry, I just felt like doing that | IM, exploring possible paths + SA humour |

(laughter)

| | | |
|---|---|---|
| C: | (reads) A *l'inspiration l'oxygène passe* .. | DC, reading aloud to make sense of text |
| D: | Why can't we listen to it? | IM, suggesting approach |
| C: | (reads) *dans le sang*. It's that, look (reads) *Quand on respire le sang reçoit* | DC, establishing comprehension |
| D: | [*l'oxygène* | |
| C: | *l'oxygène] par l'intermédiaire des poumons* | DC, extending the information needed |
| D: | all right then, on *reçoit* | I SA, accepting suggestion |
| C: | so it means, when you respire, the blood receives oxygen on the intermediary, by, you know, by, it means | DC, clarifying meaning |
| D: | (writes) *par l'intermédiaire des poumons*, how do you spell it, p-o-u-m | DC, noting |
| C: | -o-n-s | IM, pursuing task; ISA, co-operating |
| C: | (reads) *Quand on prend, on prend de l'exercise*, on … | DC, reading aloud |
| D: | something, that's the verb | DC, using grammatical awareness |
| C: | (reads) on something *quatre fois plus que normale* | DC, reading aloud |

(laughter)

| | | |
|---|---|---|
| C: | when you take exercise, one breathes | DC, clarifying meaning |
| D: | [ four times more | DC, clarifying meaning |
| C: | no, not breathes ] | DC, still trying to clarify for herself |
| D: | Yes, yes, yes – number of respirations per minute can multiply | DC, clarifying for both |
| C: | Does that make sense though? | DC, questioning a conclusion, and looking for justification from prior knowledge? |
| D: | When one takes exercise, one breathes up to four times more than normal. Yeah. | DC, summarising |
| C: | That sounds silly, sorry. Can you say it in English ? | DC, request for clarification; SA, tone + apology showing no offence intended) |
| D: | C, when you breathe, take exercise … | ISA, asserting own position, with humour |

(laughter)

| | | |
|---|---|---|
| C: | What's the next question ? | (IM, wanting to move on) |

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## 7 Conclusions

The pre- and post-test statistics prove that acquisition of both specific subject content and FL vocabulary took place in all subjects. It seems this was as a result of the combination of the three important elements of the study:

- exposure to the materials – all pairs made use of the range of facilities offered by the CD-ROM, (ie the concise illustrated texts, the simple linking facility between related pages, the audio recordings) in their construction of meaning of both the source texts and the task text.
- interaction with the task – the task itself caused both a great deal of the discussion and a problem solving oriented approach to the source materials.
- interaction with a partner – clearly the discussion was a very important factor in successful task completion for two of the three pairs and still a contributing factor for the third.

The role played by prior knowledge is less certain. The first biologist did make the greatest gain in French vocabulary, which might suggest that the familiarity with content allowed more focus on language. However the engagement with the task was more noticeable on the part of the non-biologists and this leads us to hypothesise that the motivational force involved in learning real informational content through the language is greater than that which might be generated by the security of familiarity with the material. This would indicate that prior knowledge is not always a motivator: interest in a topic is of course vital, but the power of learning something new is greater than re-learning something familiar in a different way. This premise would probably be accepted as 'common sense' by those who teach content subjects through a foreign language. For these learners and teachers such materials as encyclopaedic CD-ROMs are invaluable.

There is now a strong case for such research to be replicated with a larger, younger age group. The technical difficulties involved in networking CD-ROMs for large groups of users pose a small problem in terms of access speed and hence motivation to pursue the task, but these are not insurmountable difficulties. If we compare the content level with that of many modern foreign language learning programmes, especially for 14–15 year-olds, we can see that the degree to which effective reading strategies are demanded is far higher in this style of work. It seems likely though that this higher linguistic demand will be made more cognitively and affectively accessible by, respectively, the involvement of a collaborative approach to the task and the motivation of learners to use multimedia materials,

## Appendix A: Pre- and Post-test

**What happens while you are exercising?**

1. Describe briefly in English the effects of strenuous exercise on:

   - the lungs
   - the heart
   - the muscles

2. What role does oxygen play in the effects of strenuous exercise?

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3. How does the pulse function?
4. What approximately is an average heartbeat in a person walking slowly?
5. Give three factors which would determine the heart rate of a person running ?
6. What is the machine called which traces a heartbeat?
7. What approximately is the average number of breaths per minute of a person walking slowly?
8. Why do we breathe more rapidly when we run?

**Anglais – Français?**

*Ecrivez le français pour ….*

- the heart
- the lungs
- the muscles
- oxygen
- blood
- the pulse
- breath
- blood vessels
- nutritional elements
- strength
- stamina
- effective
- to grow / increase
- to dilate
- a screen
- during exercise
- by showing …
- the whole body needs …
- the more one is active …
- the quantity of blood leaving the heart …
- can be multiplied by …
- a wave effect
- making one's muscles work regularly …
- this machine allows us to check …
- lowering of stress

## Appendix B: Close task and Completion statements

Au cours de l'exercice physique …… propulse plus de …… pour apporter au corps plus …… et …… . Quand on marche tranquillement, le rythme cardiaque est de …… …… par minute – ça s'inscrit sur …… d'une machine, …… . Quand on court, le rythme du coeur s'accroît et ça dépend de trois facteurs: …… de la course; l'entraînement ou …… et …… . Quand on respire le sang reçoit …… par l'intermédiaire …….. . Quand on prend de l'exercice on …… jusqu'à quatre fois plus que normale. Si on mesure les respirations, chaque point sur le tracé réprésente …… et …….. . On absorbe plus …… et élimine …….. le tracé montre un …… et une plus grande magnitude ……

Pendant l'exercice les muscles reçoivent plus de sang parce que ….

Grace à l'exercice physique, on peut se faire du bien, par exemple …

Quand on sent le rythme du pouls, ce qui se passe, est …

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## Appendix C: Statistical data

### 1. English-French vocabulary testing

Table A1. *English-French vocabulary testing*

| Subject | A | B | C | D | E | F |
|---|---|---|---|---|---|---|
| **Gaining** | | | | | | |
| no answer to wrong | 2 | 3 | 2 | 7 | 0 | 0 |
| wrong to right | 3 | 2 | 2 | 2 | 1 | 2 |
| no answer to right | 3 | 1 | 4 | 2 | 6 | 1 |
| wrong to half-right | 0 | 0 | 0 | 1 | 0 | 0 |
| no answer to half-right | 0 | 0 | 0 | 2 | 2 | 0 |
| half-right to right | 0 | 0 | 2 | 1 | 1 | 0 |
| **Same result** | | | | | | |
| no answer | 4 | 6 | 3 | 4 | 6 | 5 |
| wrong | 7 | 5 | 2 | 3 | 3 | 3 |
| half-right | 0 | 0 | 1 | 0 | 2 | 2 |
| right | 6 | 8 | 9 | 3 | 4 | 8 |
| **Backtracking** | | | | | | |
| wrong to no answer | | | | | | 1 |
| right to wrong | | | | | | 1 |
| right to half-right | | | | | | 1 |
| half-right to no answer | | | | | | 1 |
| % initially right | 24 | 32 | 36 | 12 | 16 | 32 |
| % finally right | 48 | 44 | 54 | 32 | 48 | 44 |
| % gain | 100 | 37.5 | 50 | 166 | 200 | 37.5 |

### 2. Gap-fill and open-ended questions in French with CD-ROM

Table A2. *Gap fill*

| Subjects | Gaps filled correctly | Gaps filled part correctly | Gaps filled incorrectly | Gaps left blank |
|---|---|---|---|---|
| A+B | 14 | 4 | 0 | 2 |
| C+D | 16 | 4 | 0 | 0 |
| E+F | 13 | 4 | 1 | 2 |

Table A3. *Open-ended questions*

| Subjects | Q1 | Q2 | Q3 |
|---|---|---|---|
| A+B | incorrect | not answered | not answered |
| C+D | not answered | not answered | not answered |
| E+F | incorrect | correct | correct |

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### 3. Subject knowledge pre- and post-tests

Table A4. *Rank order of accuracy*

| Order | Pre-Test | Post-Test |
|---|---|---|
| 1 | E | E |
| 2 | A | A |
| 3 | F | F |
| 4 | B | C |
| 5 | C | B |
| 6 | D | D |

Table A5. *Pre-test to Post-test shift*

| Subject | Responses |
|---|---|
| A | more precise |
| B | more precise |
| C | more precise / more detailed |
| D | more detailed |
| E | more precise / more detailed |
| F | less precise |

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