# APPENDIX D DATA ANALYSIS OF PRELIMINARY EVALUATION

This appendix presents the analysis of the data gathered during the preliminary evaluation carried out with MAPTUTOR

**Table D–1** presents a summary of the subjects' mapping activities during the experimental studies. Note that *Duration of Session* includes the time of introduction to the task. *Resulting Links* is the total number of links in the final map, whereas *Total Number of Links* is the total number of links drawn during the session, including renamed and inverted links. *Wrong Links* refer to the number of links considered wrong during the session; typically, very few of them were part of the final map. *Slips* are errors the experimenter could identify as resulting from distraction of the subject, and this figure is included in the Wrong Links column.

| Subject | Duration of Session | Number of Concepts | Resulting Links (Final Map) | Total Number of Links (Whole Session) | Wrong Links | Slips |
|---|---|---|---|---|---|---|
| $S_1$ | 48 min | 16 | 15 | 19 | 5 | 3 |
| $S_2$ | 34 min | 18 | 20 | 25 | 5 | — |
| $S_3$ | 34 min | 17 | 13 | 23 | 11 | 2 |
| $S_4$ | 60 min | 23 | 22 | 41 | 16 | 10 |
| $S_5$ | 23 min | 23 | 23 | 28 | 2 | — |
| $S_6$ | 30 min | 14 | 11 | 26 | 11 | 3 |
| $S_7$ | 39 min | 9 | 5 | 19 | 14 | 2 |

**TABLE D–1: EVALUATION SUMMARY OF SUBJECTS' MAP**

**Table D–2** presents a summary of MAPTUTOR's performance during the experimental studies[1]. Note that *Slips* correspond to the inverted link diagnosis — the only form of slip it is able to identify. Note also that *Failed* means that MAPTUTOR failed at arriving at the nature of the error, not at spotting it, since this process

[1] Subjects $S_1$ and $S_2$ had the trace of their sessions reconstructed with the new parameter settings used in the second stage of experiments so as to get uniform account of the performance of the program. Thus, the results corresponding to these subjects should be read as what MAPTUTOR would have diagnosed if it had used the latter settings with subjects $S_1$ and $S_2$.

is deterministic[2]. The *Asked* column refers to the number of times the program decided to ask the learner before arriving (or failing) at a diagnostic. *Concept*, *Link* and *Relationship* are those diagnostic results discussed in **Chapter 4**.

No subject successfully completed the mapping task (nor were they asked to) according to MapTutor's successful task criterion (see **Section 3.2.2**). **Table D–3** shows the concepts the subjects knew at the end of each session according to the learnability (BD) criterion (see **Section 3.5**).

| Subject | Slips | Concept | Link | Relationship | Asked | Failed | Total |
|---|---|---|---|---|---|---|---|
| $S_1$ | 2 | 1 | 2 | — | — | — | 5 |
| $S_2$ | — | — | 5 | — | — | — | 5 |
| $S_3$ | 2 | 1 | 2 | — | 1 | 6 | 11 |
| $S_4$ | 7 | 3 | 4 | — | 2 | 2 | 16 |
| $S_5$ | — | — | 1 | — | 1 | — | 2 |
| $S_6$ | 3 | — | 7 | 1 | 1 | — | 11 |
| $S_7$ | 2 | 4 | 8 | — | — | — | 14 |

**TABLE D–2: SUMMARY OF MAPTUTOR'S DIAGNOSTIC PERFORMANCE DURING THE EXPERIMENTAL STUDIES**

| Subject | Minor Concepts | Major Concepts | Total |
|---|---|---|---|
| $S_1$ | 8 | 1 | 9 |
| $S_2$ | 12 | — | 12 |
| $S_3$ | 5 | 2 | 7 |
| $S_4$ | 12 | 1 | 13 |
| $S_5$ | 11 | 4 | 15 |
| $S_6$ | 5 | 2 | 7 |
| $S_7$ | 1 | — | 1 |

**TABLE D–3: SUBJECTS' UNDERSTANDING OF CONCEPTS AT THE END OF EXPERIMENTAL SESSIONS ACCORDING TO MAPTUTOR'S CRITERION**

[2] That is, assuming the limitations of the program's closed-world assumption, it will always know what is a wrong link — i.e., one which is either actually wrong or has not been input into the system.

**Table D–1** to **Table D–3** do not say very much about actual developments during the experimental sections, so that the subjects' sessions are best described in isolation.

## *Subject $S_1$*

Subject $\mathbf{S}_1$ had trouble finding important concepts and even with the notion of concept itself. For example, at the beginning of the session, she asked 'What's a concept?,' 'Why isn't interaction a concept?' These misunderstandings made the experimenter wonder whether he was using a non-intuitive notion of concept. Fortunately, she soon got used with the term and went on.

Subject $\mathbf{S}_1$ was an overseas student and did not know either the meaning of concept of SNAIL or STILL, and although she perceived STILL was a type of water, she was reluctant to select and link it, insisting instead in asking the experimenter what *still* was[3]. Subject $\mathbf{S}_1$ was after all able to map concepts SNAIL and STILL, despite the fact that she was not sure about their meanings, but even if this were not the case, MAPTUTOR would not have been able to help her because the trouble here was that the basic assumptions underlying the system design was violated: the subject did not have the entry level required by the system (hardly will an English-speaking child not know the meaning of snail).

Subject $\mathbf{S}_1$'s approach to the mapping task was to read the whole text, then select a fair number of concepts, and then start linking them. She took about 10 minutes to select 16 concepts. Among those concepts were all those concepts considered as major ones (see **Table 3–2 on page 58**), but by reviewing the video-tape of the session, one can see that she seemed to have had some difficulties in other minor concepts. Subject $\mathbf{S}_1$'s first mistake was to connect concepts HABITAT and MICROHABITAT by means of link IS A. According to her, this was just a slip since she thought that the current link name was PART. MAPTUTOR classified this error as misunderstanding of concepts[4]. Her second mistake was to link FRESH to ABIOTIC FACTOR by means of IS A, representing the proposition *fresh is an abiotic factor*. According to the subject, her mistake was that she did not know what the correct relationship was. But in fact there is no direct relationship between those concepts, and MAPTUTOR found that this error was caused by misunderstanding of concept ABIOTIC FACTOR (**Case 1** of procedure *DiagnoseWrongLink* — see **Section 4.5**). The third mistake made by subject $\mathbf{S}_1$ was an inverted link.

[3] As a matter of fact, the experimenter did not know a good definition either: only that still was a kind of mineral water found in the supermarkets!

[4] In the reconstruction of the trace referred to above, the diagnosis was misunderstanding of links.

The fourth wrong link (BIOTIC FACTOR PART OF HABITAT) was caused, according to her, by misunderstanding of links, whereas according to MAPTUTOR it would have been caused by misunderstanding of concept BIOTIC FACTOR (in the reconstruction of trace, misunderstanding of link HAS — the appropriate one).

Performance of MAPTUTOR in the subject $\mathbf{S}_1$'s session was not bad, except the case of the wrong link IS A between FRESH and ABIOTIC FACTOR, because these concepts are indirectly related to each other by means of concept TYPE OF WATER. This information could have been inferred from the text domain if the program were able to reason about links and inheritance. Inheritance here does not seem to be a trivial issue and will be further discussed in **Section 7.2**.

## *Subject $S_2$*

Subject $\mathbf{S}_2$ decided to construct her map in tandem with her first reading through the text. That is, in her first pass through the text, as soon as she found an important concept, she selected it; and as soon as she realised what the relationship between two concepts was, she attempted to represent the respective link between those concepts in her map. Notice that this approach is radically different from that followed by subject $\mathbf{S}_1$, who read the whole text, then came back to it in order to select concepts, and only after selecting a fair number of concepts, did she decide to link them in her map.

Subject $\mathbf{S}_2$ first mistake was to connect HABITAT to ADDRESS by means of link EQUIVALENT. Since all three basic diagnostic procedures succeeded, MAPTUTOR asked her about her understanding of the relationship between the two concepts, and she confirmed to understand this relationship. Thus, MAPTUTOR arrived at concept misunderstanding as the cause of the error[5]. According to her this error was caused by misunderstanding of the link involved. The next three mistakes committed by the subject were caused either by misunderstanding of the text or meaning of canonical links. She was not able to specify precisely what the reasons for these errors were, but she complained that the links were a bit confusing for her, and at the end of the session, she suggested that there should more alternative links (e.g., influences, affects).

## *Subject $S_3$*

Subject $\mathbf{S}_3$ appeared to like to organise his map in his own way, so that he moved all concepts as soon as they were drawn. This resulted in ambiguity when he tried

[5] In the reconstructed session with the new parameter settings, the diagnostic would be misunderstanding of links without asking, because the confidence threshold of Procedure *MisunderstandsRelationship* was increased and therefore this procedure did not succeeded.

to connect his first pair of concepts because he arranged two concepts too close to each other.

When prompted by the experimenter to explain the cause of a wrong link, he was not precise in his answers, but he seemed to have accepted well all suggestions offered by MapTutor. However, when the program suggested renaming a link, he preferred to deleted the link and then draw a new one, thus ignoring the existence of the rename tool. The most interesting aspect of this session was the fact that the subject wanted to be able to connect CLIMATE and TEMPERATURE, because according to his experience (i.e., prior knowledge), these concepts would 'obviously' be related to each other. The examiner replied that he should instead worry about representing relationships appearing in the text, but yet he insisted in doing so twice again.

Two assertions failed[6] and the session had to be interrupted because the experimenter quitted the program as a safety measure. Fortunately, MapTutor automatic saving feature worked very well and soon afterwards the subject could return to his work at the right state of solution of the problem.

MapTutor failed at finding the cause of the wrong link the subject drew between concepts ORGANISMS EATING EACH OTHER and ORGANISMS. As a matter of fact, the wording of the text is ambiguous in this case because it reads organisms which eat each other, and thus, an IS A link between this concept and ORGANISMS seems correct. However, according to the domain expert who validated the knowledge in MapTutor, this textual information is misleading, since it is not the organisms themselves in the original sentence which determine the biotic factors of a habitat, but instead it is the fact that they eat each other[7]. The expert's advice in this case was to modify the text so as to improve its clarity, but in the end, the

[6] **Late Implementation Note:** Assertions in C++ (or C) are very useful devices used by programmers as bug-catchers during the test stage of the program. When an assertion fails to be satisfied, it raises an exception which presents on the screen the file and line in which it happened. These bug-catchers are mostly used in two ways: (1) to warn the user (or more precisely the tester) of an imminent danger of crash (e.g., a stray pointer), or (2) to test the consistency of the program (e.g., when the concept teaching procedure is called it makes an assertion to make sure that from this point on it will have at least one concept to teach). Assertions are not part of the final code of the program; instead, they are pre-processor directives which the compiler ignores when the program is compiled with the debugging option off. As MapTutor is a fairly large program and by then the author and his supervisors were the only alpha- beta-testers, it had (and still has) the debugging option on. Thus, the subjects who took part in the experiments inadvertently helped a lot as beta-testers. Incidentally, the bug pinpointed by one of assertions which failed during the experimental studies turned out to be in the assertion itself!

[7] The same happens with concepts ORGANISMS PROVIDING SHELTER and ORGANISMS COMPETING FOR FOOD, and their original counterparts.

text was left intact for two reasons: first, to investigate the effect of these ambiguities; second, to reinforce the point that the program must contain information about this source of difficulty, and see how it would behave in these situations. Unfortunately, this information in $\mathbf{S}_3$'s case was completely useless: MapTutor failed simply because there was no relationship[8] between the two concepts.

Subject $\mathbf{S}_3$'s suggestion at the end was that, 'an example of links [usage] would be good.'

## *Subject $S_4$*

Subject $\mathbf{S}_4$ verbalised her chain of reasoning voluntarily whenever she did something (perhaps because this is part of her own natural style of learning). This voluntary verbal protocol proved to be very useful and may show some points argued in **Chapter 4**. For example, she read aloud, 'microhabitat is part of habitat'; then, she looked for both concepts (i.e., MICROHABITAT and HABITAT) in the map pane, and went on talking to herself 'then the link is part of'. This seems to indicate that a natural way of mapping is to establish the relationship between the concepts in the text and then map the relationship onto one of the link names provided. Subject $\mathbf{S}_4$ also had some initial trouble in identifying important concepts in the text (i.e., the ones most relevant for the comprehension). Her approach to this particular sub-task was what seems to be most obvious (but not the most advisable) one: she simply clicked on all words in the text and checked to see whether they were drawn in the map pane or not. She made several mistakes by drawing the links in the wrong direction, but in the end she agreed that they really make more sense when drawn in a consistent direction.

Subject $\mathbf{S}_4$ was the most persistent mapper, and her session lasted more than an hour. However, at the end she knew (according to MapTutor's criteria) only one major concept (plus 12 minor ones). She produced an interesting sequence of moves which, when reconstructed, illustrates the internal working of MapTutor very well. This sequence of moves will be discussed next. The part of the Mapping Tasks Section of the end-of-session report (see **Section 5.8**) generated by MapTutor which is relevant to the discussion which follows is presented below (pieces of text enclosed by square brackets are comments added by the author).

[8] More precisely, this means that there is no link among the set provided that could map the relationship between ORGANISMS EATING EACH OTHER and ORGANISMS. In other words, there is no link that could map the fact that some kinds of organisms are the agent of the fact represented by the second concept.

There follows the list of actions the student performed in the map pane:

[1] Drew a link named ISA from Organisms to Habitat. MapTutor found that this link was wrong and the cause was misunderstanding of meaning of canonical links.

[2] Renamed a link named part from Organisms to Habitat. MapTutor found that this link was correct.

[3] Draw a link named ISA from Habitat to Place. MapTutor found that this link was correct.

[4] Drew a link named ISA from Habitat to Address. MapTutor found that this link was correct.

[5] Drew a link named ISA from Habitat to Woodland. MapTutor found that this link was wrong and the cause was that the link was inverted.

[6] Inverted a link named ISA from Woodland to Habitat. MapTutor found that this link was correct.

[*Sequence of moves non-relevant to the discussion*]

[10] Drew a link named ISA from Habitat to Microhabitat. MapTutor found that this link was wrong and the cause was misunderstanding of concepts.

[11] Renamed a link named part from Habitat to Microhabitat. MapTutor found that this link was wrong and the cause was that the link was inverted.

[12] Inverted a link named part from Microhabitat to Habitat. MapTutor found that this link was correct.

[*Sequence of moves non-relevant to the discussion*]

[32] Drew a link named HAS from Physico Chemical Factor to Habitat. MapTutor found that this link was wrong and the cause was that the link was inverted.

[33] Inverted a link named HAS from Habitat to Physico Chemical Factor. MapTutor found that this link was correct.

[34] Drew a link named LEADS from Habitat to Humidity. MapTutor failed at evaluating this link.

[*At this point,* MapTutor *asked whether she understood concept habitat*]

[35] Drew a link named LEADS from Habitat to Temperature. MapTutor failed at evaluating this link.

[36] Drew a link named LEADS from Habitat to Amount of Sunlight. MapTutor found that this link was wrong and the cause was misunderstanding of concepts.

[*End-of-session report proceeds up to move 51*]

As can be seen in the end-of-session excerpt presented above, subject $\mathbf{S_4}$ concentrated initially on mapping concept HABITAT (sequences of moves [1] to [6] and [10] to [12]).

At the end of **Step [12]**, MAPTUTOR believed that she knew this concept. **Table D–4** shows the evolution of the belief-degree (BD) of concept HABITAT right after each move she carried out.

Between **Steps [13]** and **[32]**, subject $\mathbf{S_4}$ did something else, such as linking concepts other than HABITAT or moving (dragging) concepts around the map pane. In **Step [32]**, she turned her attention back to concept HABITAT. As the program's knowledge threshold KT was *0.6*, BD reached the value *0.636* at **Step [12]**, and she did not link any concept to/from HABITAT, the BD of this concept still had this very same value at **Step [32]**. In **Step [32]**, she committed a slip — an inverted link, which she repaired in the next move, which resulted in BD(HABITAT) being increased a bit more. From **Step [34]** on, she started a sequence of mistakes involving this concept. The links she made in **Steps [34]** to **[36]** refer to relationships which the text does not refer to[9]. Right after the first mistake (**Step [34]**), MAPTUTOR asked her whether she was sure she understood concept HABITAT. Why did the program act so? At this point it still believed (according to the BD criterion) that she knew this concept, but as there was no relationship between HABITAT and HUMIDITY in the text (and consequently no link would be expected to exist), MAPTUTOR was left with only one option to investigate the nature of the error: concept misunderstanding. Diagnostic procedure *MisunderstandsConcepts* (see **Section 4.3**) was called upon to carry out its duty, but it failed because the subject proved to know HABITAT — the only concept likely to become a suspect[10]. Then, as a last resource, the program asked her whether she surely understood this concept. As she said so, the program failed and the only feedback it could deliver was to tell her that it suspected that her link was wrong, but it could not provide more elaborated feedback. Nonetheless, as her last link represented a non-existent relationship, BD(HABITAT) decreased. Even so, it was still considered a known concept (see **Table D–4**). In **Step [35]**, she committed a similar mistake and MAPTUTOR failed again at arriving at a diagnosis, but now it did not ask her again because it remembered that she had already answered the question it would otherwise ask. Again, BD(HABITAT) decreased, and this time

[9] This might have been caused by conflict between her background knowledge of the text. Since she had already read the text at least twice and found no relationship involving HABITAT and other concepts in the text, she might then have decided to include relationships from her own naive knowledge to see what would happen.

[10] Remember that HUMIDITY could never be a suspect-concept because the program assumes the learner understands it beforehand.

it fell below KT so that it was no longer believed to be known. In **Step [36]**, the subject persisted in the same sort of error and MAPTUTOR proceeded in a similar way. However, as HABITAT stopped being a known concept and became a possible suspect, procedure *MisunderstandsConcepts* succeeded at determining concept misunderstanding as the nature of the error, and the program ended up offering her a feedback message containing an explanation about this concept.

Subject $\mathbf{S_4}$ demonstrated real interest in finishing the task (even after the program's crash), but after making three wrong links in a row, she got a bit disappointed and her enthusiasm began to diminish. Soon afterwards, she gave up. Subject $\mathbf{S_4}$'s finished map is the one presented in **Figure 1–1 on page 12**.

| Right After Step... | Value of BD(HABITAT) |
|---|---|
| 1 | 0.000 |
| 2 | 0.182 |
| 3 | 0.273 |
| 4 | 0.318 |
| 5 | 0.318 |
| 6 | 0.500 |
| 10 | 0.500 |
| 11 | 0.500 |
| 12 | 0.636 |
| 32 | 0.636 |
| 33 | 0.818 |
| 34 | 0.727 |
| 35 | 0.636 |
| 36 | 0.545 |

**TABLE D–4: VARIATION OF BELIEF-DEGREE (BD) OF HABITAT DURING EXPERIMENTAL SESSION WITH A SUBJECT**

## *Subject $S_5$*

Subject $\mathbf{S_5}$ seemed to be the most expert computer user among all subjects. He was also the only one who was familiar with two graphical strategies (concept maps and mind maps) as well as six non-graphical ones. Not surprisingly, subject $\mathbf{S_5}$ produced the best map of all. He took only 23 minutes to link some of most important concepts, so that he proved to have understood (according to MAPTUTOR's criterion) 4 out of 6 major concepts.

Subject $\mathbf{S_5}$ used a mapping approach similar to $\mathbf{S_2}$ (i.e., mapping while reading). But he preferred to make his own arrangement of concepts and moved them as soon as they were selected (which led to one ambiguous link). He made only one wrong link, which he later repaired. This mistake is worth commenting about. The mistaken link was made between concepts ORGANISMS EATING EACH OTHER and BIOTIC FACTOR, where he used IS A. In this case, all diagnostic procedures succeeded, as explained below:

- Procedure *MisunderstandsConcepts* succeeded because BIOTIC FACTOR was a potential suspect which he had not proven to understand at that point.
- Procedure *MisunderstandsRelationship* succeeded because the relationship between those concepts was considered ambiguous as well as some inference was needed to uncover and then map it onto the appropriate link.
- Procedure *MisunderstandsLinkMeaning* succeeded because the subject had not ever used link LEADS TO — the expected one, and thus it became a suspect of misunderstanding.

Then, the program asked him whether he understood the meaning of link LEADS TO so as to attempt to clarify the ambiguous preliminary findings of the diagnostic process (see **Section 4.5**). As far as the interaction is concerned, the interesting point is that subject $\mathbf{S_5}$ was somewhat puzzled by the question posed by MAPTUTOR, 'Why is it asking me about leads to? I've drawn an is a link.' Nonetheless, he looked carefully at the definition of LEADS TO in the links definition pane before deciding about the answer.

**Figure D–1** presents the finished graphical map resulting from subject $\mathbf{S_5}$'s experimental session. It is interesting to compare his map with the one constructed by subject $\mathbf{S_4}$, presented in **Figure 1–1 on page 12**. Notice that, despite the fact that both maps are quantitatively similar (i.e., both maps have the same number of concepts and $\mathbf{S_4}$'s map has only one link less than $\mathbf{S_5}$'s), qualitatively (i.e., in cognitive terms), these maps are substantially different not only for a human observer, but also for MAPTUTOR. That is, it seems evident from a rapid analysis of both maps that $\mathbf{S_5}$ knows a great deal more than $\mathbf{S_4}$ about the domain. According to the program, $\mathbf{S_5}$ understood four major concepts, whereas $\mathbf{S_4}$ understood just one.

At the end, subject $\mathbf{S_5}$ told the experimenter that he both understood and liked the fact that MAPTUTOR highlighted the piece of text corresponding to a correct link, but would prefer a colour different from the one used to highlight the text when he clicked.

## *Subject $S_6$*

Subject $\mathbf{S_6}$ was the only one who confessed to being anxious, and her overall performance was not very good. Nevertheless, she was cleared delighted and put at ease when she noticed the tutor telling her she had made a correct link. Sadly, this experiment was disturbed by outsiders so that the environmental conditions were not very good. She was also the only subject who wanted to have the ability to have a duplicate (i.e., cloned) concept (perhaps in order to be able to better organise her map).

Subject $\mathbf{S_6}$ read the whole text before starting the map construction, and although she was very familiar with the subject (according to her own words), at the end, she complained that the text was a bit long for an experiment.

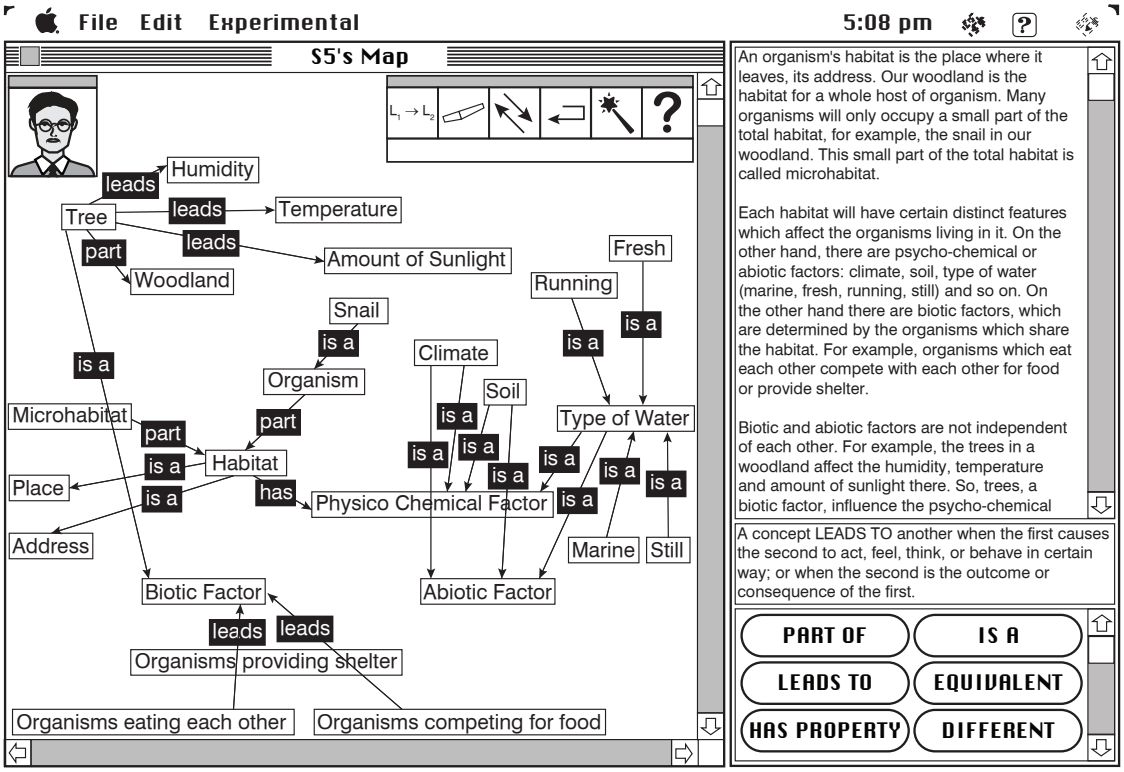


**FIGURE D–1: SUBJECT $S_5$'S FINISHED MAPS**

Subject $\mathbf{S_6}$ wanted to link ABIOTIC FACTOR to PHYSICO-CHEMICAL FACTOR by using link IS A (twice, one in each direction). In both situations, MAPTUTOR correctly indicated link misunderstanding as the nature of her error. Because link IS A could not be a suspect, since she had shown to know how to use it, MAPTUTOR pointed out only EQUIVALENT as the suspect-link. What would a human tutor say in such a situation? Probably, the same as MAPTUTOR: that EQUIVALENT was more appropriate to the situation than IS A. At the beginning of the session, subject $\mathbf{S_6}$

seemed to like the tutor's messages and read them carefully, but by nearing the end, the subject complained about the fact that the system did not let her alone. That is, she was frustrated because the program provided her with explanations which were not the straight answer. Therefore, in her opinion, it would be better not to provide any feedback altogether. In the short interview after the session, she complained again that the program was too obtrusive and suggested that it should only present feedback upon request. In her own words, 'The program is too intrusive [i.e., obtrusive], maybe it will be good to have the choice of going on reading about the mistake or just try to find the good link by oneself.'

## *Subject $S_7$*

Subject $\mathbf{S_7}$'s first link was ORGANISM IS A HABITAT, which sounded a bit odd and senseless for the evaluator (let alone for the program). After a while, he commented, 'The text is a bit specific. I'd prefer an easier text. I can't understand the story!' Obviously, the observer started wondering, Why is it that he's finding the text so difficult? He seemed to have perceptual difficult in reading the text because the characters were too small for him.

Subject $\mathbf{S_7}$'s second link was incorrect, but not as bad as the first one: HABITAT EQUIV PLACE. In both situations, MAPTUTOR identified misunderstanding of links as the likely cause of error. The subject appeared to read the message carefully, but still complained that he could not comprehend the text. The subject's next nine links were almost all wrong (the only exception was a correct link between SNAIL and ORGANISM). At this point, not only was the subject confused, but also the experimenter was puzzled trying to figure out what his reasoning could be (What on earth could he possibly be thinking about?). Sometime later, the experimenter decided to verify what was going on, given that no previous subject had found any difficulties in understanding the text. Then, the subject was asked what the problem seemed to be, and he replied, 'I can't understand! The text says inhabitant is a place...' The source of misunderstanding could then be sorted out. In fact, habitat and inhabitant (or the less common form habitant) not only are very similar in sound and spelling, but they are also to some extent related to each other[11]. But, despite this similarity, the sample-text will be nonsense if one replaces habitat for inhabitant.

Right after the first wrong link, MAPTUTOR did not act as it should by diagnosing concept misunderstanding and then providing the appropriate feedback (i.e., an alternative definition of HABITAT — see **Appendix B**). However, it did tell

[11] For instance, each one is directly related to place: one can say that habitat is a place as the sample-text does, and that inhabitant is 'one that inhabits a place' (Microsoft Bookshelf 1994).

the subject that using link IS A would result in a proposition like ORGANISM is a type of HABITAT, which clearly contradicted the text. Moreover, curiously, the subject did appear to have (or at least attempted to) read the feedback message carefully. But probably, he did not pay the required unbiased attention to the message. Perhaps, this phenomenon can be best explained by *schema theories* (see, e.g., Bartlett, 1932; Rumelhart & Ortony, 1977; Rumelhart & Norman, 1978). Briefly, according to these theories, when one is faced with new information (as the sample-text was for subject $\mathbf{S}_7$), schemata are activated in memory in order to interpret the information[12]. Comprehension and recall will be good to the extent that the information matches the relevant schemata. A piece of information which fits well into a schema slot will be recalled better. Misconceptions occur when the incoming information is filtered through a schema which is oversimplified, distorted or incorrect. In the specific case of $\mathbf{S}_7$, he somehow retrieved his schemata of inhabitant and stuck to it. The feedback message provided by MAPTUTOR informing him that the use of the IS A link would be inconsistent with the text was worthless because, despite the fact that he did read the message which mentioned concept HABITAT, he still had the schemata of inhabitant ready to be used in the interpretation of concept habitat. Only when the experimenter realised what the mistake was and clarified it, did the subject retrieved the correct schema (that of habitat) and the text began to make sense to him.

During the time this misconception stuck subject $\mathbf{S}_7$, MAPTUTOR feedback messages were clearly worthless. But, how should the program proceed then? After all, even the experimenter tried hard to make sense out of why the subject had linked concepts HABITAT and ORGANISM by means of link IS A intending to represent the senseless proposition organism is a habitat. Even if MAPTUTOR had all possible interpretations a concept can admit, as Feifer (1989) suggested (see **Chapter 2**), it is very unlikely (at least in a small number of trials) that the program would be able to 'figure out both the learner's context and his interpretation' (Feifer, 1989, p. 55). Even so, it is doubtful whether even this would be effective in this particular case, because only when the experimenter told the subject emphatically that the text was about habitat and not about inhabitant, was he able to retrieve the adequate schemata. This was the only situation, in the whole series of experiments, in which clearly concept misunderstanding actually jeopardised a subject's map construction.

Not surprisingly, in the open-question of the questionnaire, which asked for suggestions, $\mathbf{S}_7$ complained about the text. In his words, 'I could not understand

[12] More precisely, schemata are constituted of variable slots which are filled in by the new incoming information as learning takes place (Rumelhart & Ortony, 1977).

the text. It was written very condensed [he referred to the size of characters in the text]. I think it would be much better [if ] the text (domain) was related to the subjects background.'[13]

[13] The severe mistake made by subject $\mathbf{S}_7$ and his complaint about the difficulty of the text could also be explained by the fact that the text presented no title or heading. Bransford & Johnson (1972) presented striking evidence about the critical role played by cues (titles and pictures) in text comprehension. Briefly, they presented subjects with very familiar passages (e.g., about washing clothes) and noted that they were either rather easy or almost impossible to understand or remember, depending on whether the passages were preceded by a title or a picture. They concluded that the pictures and titles provided the context necessary for the subjects to invoke their prior knowledge.