

Didactic Situation and Knowledge Used by the Student in a Problem Solving: Analysis and Application in a Computer-Assisted Learning-to-Read Environment

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Abstract

A didactic activity is a complex multifaceted object. Among these facets is a problem related to a learning domain that the student has to solve. When such a problem occurs in a human-computer environment, the difficulties come not only from the learning domain and the problem-solving strategies but also from the manipulation within this environment. Therefore, the student calls on various kinds of knowledge in order to solve these problems. This research aims to analyze these kinds of knowledge in a particular context of computer-assisted learning-to-read environment. The main purpose of this knowledge analysis is to allow the teacher or the system to design the didactic activities which will enhance the student's knowledge acquisition, facilitate his interface use, and activate his metacognition. This analysis allows as well to choose the existing didactic activities which appropriate to the student's knowledge and it also allows to interpret his behaviour.

Keywords: didactic situation, problem solving, knowledge, reading, interface, metacognition

Note: The most part of this paper goes over again the paper of Panita Bussapapach [2] written in French and presented at the conference *Hypermedias et Apprentissage*, April 2001, France.

1. General introduction

The design of a computer-assisted learning environment requires not only the organization of the learning domain knowledge but also the knowledge on the student using this environment. It also calls on a thorough understanding of the didactic activity proposed to the student. Any didactic activity is indeed a complex entity. It is, on the one hand, an object of numerous teaching decisions, and on the other hand, for the student, a critical space of access to the knowledge to be acquired.

Regarding the complexity of a didactic activity, we will mainly distinguish six facets: (1) a didactic activity as a teaching action, (2) as a complex problem that the student has to solve, (3) as an interaction space between the student and the system, (4) as a motivation factor, (5) as an observation space of the student, and (6) as a knowledge structure for the computer system. The information coming from the analysis of this complexity will allow us to envisage a design of a computer-assisted learning

environment which will match to the student's knowledge and behaviour.

To start with, we mention briefly our research framework: the AMICAL project. Next, we present an overview of a didactic activity as a multifaceted object and for each of these facets, we describe some of the analytical approaches. Then, we tackle the analysis of a didactic activity as a complex problem that the student has to solve. This analysis will focus in particular on the knowledge used by the student in his problem solving. Last, we discuss the metacognition which deserves to be taken into account in the student's problem-solving process.

2. AMICAL: Architecture Multi-agents Interactive Compagnon pour l'Apprentissage de la Lecture¹

AMICAL is the theoretical research and development project on a computer-assisted learning-to-read environment. It is composed of three types of modules: (1) a tutoring module, (2) a resource module, and (3) an exploration module. The tutoring module directs in an individualized and dynamic way the learning of the student. The resource module proposes to the student a set of information related to the knowledge acquisition. The exploration module puts together numerous elements that the student can combine with in order to create his own elements more complex [10]. These three types of modules can be considered, according to the teaching's viewpoint, as complementary.

This analysis is in the framework of the AMICAL tutoring module which functions in the *individualized* and *dynamic* way. It is *individualized* in relation to the knowledge and the learning behaviour of a particular student. It is *dynamic* because each crucial element of the module such as the student representation, the goal of a didactic session, the activity and its interface is constructed in a dynamic way (See Figure 1).

¹ An interactive learning-to-read environment with a multi-agent architecture

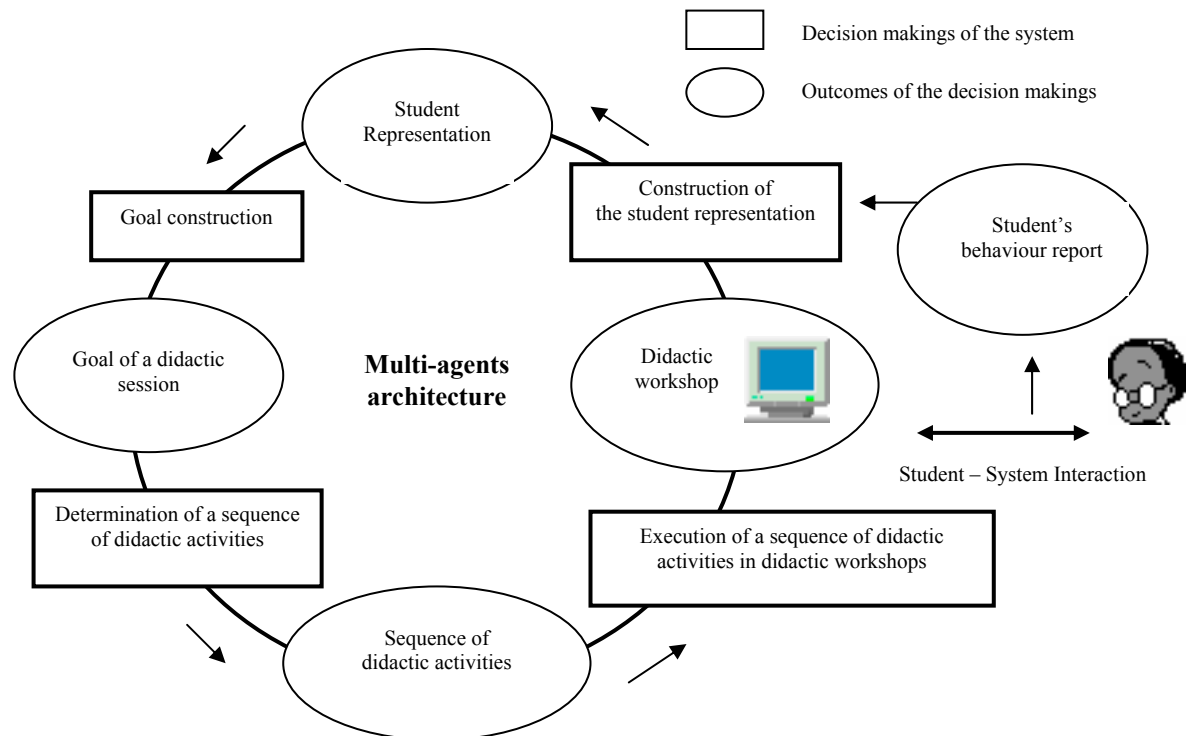


Figure 1 : The functional cycle of AMICAL system

The functional cycle of AMICAL mentioned above represents indeed the decision makings of the system and their concrete outcomes. The first decision making is to establish, from the student representation and other kinds of knowledge involved, a goal for a didactic session. The outcome is the goal that matches to the teaching problem. Then the system decides a sequence of didactic activities that could enable this goal to be attained. This sequence of didactic activities will be next produced by the system in didactic workshops or in another word interfaces related to the didactic activities [7]. The didactic workshop is a place where the student is in contact with the knowledge to be acquired. While the didactic activities are in progress, the system observes the student's learning behaviour through his interactions and collects the relevant information so as to update the student representation.

The AMICAL research works concern, in this way, the following four main problems: (1) the construction of a goal, (2) the determination of a sequence of didactic activities, (3) the characterization of a didactic activity and (4) the construction of the student representation.

3. Didactic Situation as a Multifaceted Object

In the AMICAL project, a didactic activity is called a « didactic situation ». A didactic situation refers to any proposed activity for the learning of a domain [4]. It appears to the student as the *central* and *complex* entity of the learning process. A didactic situation is *central* because whatever the learning

domain, the mode in which the learning is conducted or the type of knowledge to be acquired, it is always, for the student, the place where the knowledge to be acquired is accessed. A didactic situation is *complex* because it is, on the one hand, the result of numerous teaching decisions, and on the other hand, it is the medium of both information and action, or in another word, a space where the student and the knowledge to be acquired come together. It is also an observation space of the student's behaviour. A didactic situation is consequently considered according to the teaching and learning viewpoint, as a multifaceted entity.

We distinguish two categories of didactic situation: (1) a didactic situation type and (2) an individualized didactic situation. The first category corresponds to a type of didactic situations with instantiation parameters. The second is a didactic situation resulted from the instantiation of these parameters.

It is to note that the instantiation of a didactic situation type is only a part of the individualization. The AMICAL individualization process concerns, as we have previously presented in the functional cycle, (1) the goal construction of a didactic session from the student representation as well as the learning domain knowledge and the teaching knowledge, (2) the determination of a sequence of didactic situation types enable the goal to be attained and (3) the instantiation of parameters of didactic situation types [3].

The individualization of the teaching and learning is, on the one hand, the result of the *constructivist theory* which underlines that learning is

an active process in which students construct new knowledge based upon their current or past knowledge [1]. Each student has different kinds of knowledge, the teaching should be then adapted to a given student. The individualization in the AMICAL project is, on the other hand, the result of the complexity of the learning domain, that of the reading. The reading is a complex process which calls on various kind of resources from the reader, for instance, the linguistic resources, the cognitive resources, the metacognitive resources, etc. These different kinds of resources are used by the reader, novice or expert, at various degrees. There is also the variability of the use of these resources. The permanent adaptation to the student's reading process becomes then indispensable [5].

For the individualization process, the information on the basic elements of the teaching and learning should be explicitated. These basic elements are the teaching goal, the didactic situation and the student representation. In order to explicit these three elements, the theoretical analysis is then crucial.

The analysis of a didactic situation is based on three main goals. The first one is to choose and individualize the didactic situation types. The second one aims to interpret the student's learning behaviour and to check up his knowledge state. The last one is to design some new didactic situation types.

We distinguish six facets of a didactic situation as the following:

3.1 A didactic situation as a unit of action

In relation to the didactic planning, a didactic situation is a unit of teaching action that the system has at its disposal in order to establish the goal of a didactic session. The analysis criterions of this facet refer to:

- the identification of the elements that characterize a didactic situation as a unit of action: the nature of the actions and the knowledge, the relationship between them, and the different configuration of the action-knowledge pairs <action, knowledge>,
- the characterization of the processes dealt with by a didactic situation taken as action: the theory of action in AI.

3.2 A didactic situation as a complex problem to be solved

In relation to the student, a didactic situation is a complex problem to be solved. We can mention here some analytical approaches:

- the types of constituents of a didactic situation such as the instruction given to the student, the data for the problem to be solved, the feedback that may be made at different stages in the student's attempts to solve the problem, the help available to the student, or again the marks of the student's step that he may have access to,

- the types of knowledge that the student applies in a didactic situation: the learning domain knowledge, the knowledge of the problem-solving strategies, the knowledge of the interface, and the metacognitive knowledge necessary to the problem-solving process.

3.3 A didactic situation as a space for student-system interaction

In relation to the student and to the system, a didactic situation is a space for interaction between the student and the system. In the perspective of pedagogical scenario, we analyze:

- the different components of this space such as the instruction messages or the interaction objects as well as their functions in this space,
- the scenario of a didactic situation type,
- the design and development methodologies of human-computer interface.

3.4 A didactic situation as a motivation factor

In relation to the student, a didactic situation is a motivation factor. The analysis criterions of this facet concern:

- the pedagogical factors of motivation: the teaching goal and the problem to be solved,
- the ergonomic factors of motivation: the components of the interface,
- the operational factors of motivation: the scenario of a didactic situation.

3.5 A didactic situation as an observation space

In relation to the student and to the system, a didactic situation is a space for the system to observe the student's learning behaviour. The relevant information from this observation will lead to the update of the student representation. We raise here:

- the problem of information filtering,
- the interpretation of the information selected.

3.6 A didactic situation as a knowledge structure

In relation to the system or the agents, a didactic situation is a knowledge structure taken into account in the decision-making process of the system. In fact, the elements of the theorization of the first five facets will be the constituents of this sixth facet. Its analysis criterions refer to:

- the definition of the knowledge necessary to each agent,
- the characterization of the individualization procedure and all the dynamic problems.

The design of a didactic situation type calls on various kind of knowledge such as the learning domain knowledge, the knowledge on the teaching methodology, the knowledge on the student, the

knowledge to be acquired by the student, etc. The instantiation of a didactic situation type, as for it, focuses on the knowledge on a particular student and on his behaviour. These different kinds of knowledge come from the theoretical research on the learning domain and on its learning. The integration of these different kinds of knowledge in the development of didactic situations relies on the analysis of these different constituents of such situation.

4. Complex Problem to be Solved

A didactic situation as a complex problem to be solved could refer to different analysis aspects. We will mention here only the one concerning the different types of knowledge that the student applies in a problem-solving process: the learning domain knowledge (or in our case, the reading knowledge), the knowledge of the problem-solving strategies, the knowledge of the interface, and the metacognitive knowledge necessary to the problem-solving process.

4.1 Reading knowledge

The student uses the reading knowledge to find a solution to the subject domain problem. As reading is a complex process, the knowledge concerned is of several different types, for instance, linguistic, metalinguistic, cognitive, metacognitive, etc. We mainly stress on the linguistic knowledge which relates to the four fundamental units of a written language: (1) letter, (2) word, (3) sentence, and (4) text [5].

- The knowledge on letter is, for example, to recognize identical letters, to differentiate between capital and small letters, etc.
- The knowledge on word concerns, for example, to know that a word is a set of letters, to recognize words, etc.
- The knowledge on sentence is, for example, to know that a sentence is limited by a capital letter and a full stop, to know different punctuation marks, etc.
- The knowledge on text concerns, for example, to know that a text is a set of information, to understand the linearity of a text, etc.

Reading is also a process of constructing meaning from print. The student must be able to decode letters and letter combinations, to translate them into sounds and to construct the meaning [8]. The three aspects of these four units are consequently concerned.

- The first facet of written object, i.e. each unit has a written form in the written system.
- The second facet of correspondence between speech and writing, i.e. each unit has a correspondence in the spoken system, and vice versa.

- The third facet of meaning unit, i.e. each unit is related to a meaning, except for letters.

We also analyze the knowledge concerning reading strategies, for instance, a logographic strategy, an alphabetical strategy, or a contextual strategy, etc.

In relation to the reading knowledge, the design of a didactic situation must focus on the theorization of the conceptual organisation of the reading knowledge, on the theorization of the learning of reading by a particular student and on the theorization of the teaching methodology.

4.2 Knowledge on the problem-solving strategies

The second type of knowledge needed is independent of the learning domain. It is the problem-solving strategies likely to be used by the student. A didactic situation can be constructed, according to its nature and its student interaction scenario, so as to give special importance to the use of a particular strategy such as the inductive and deductive strategy, the strategy of trial and error, or the strategy of analogy and transfer [11]. A didactic situation can be also constructed in order that we can observe the student's behaviour through the use of numerous strategies in different didactic situations, thus permitting the observation of the student's individual tendencies. Moreover, the taking into account of hypotheses concerning the strategy used will influence the hypotheses introduced into the student representation.

4.3 Knowledge on the interface

Since the problem solving takes place in the computer environment, the student must have the knowledge on this environment or in another word on a space of interaction between the student and the system. The interaction is executed by means of the interface components which are essential for many cognitive tasks because it guides, contrains, and even determines the student's behaviour [13].

The knowledge on the interface is then required. The student has to know all the interface components, such as text, button, dialogue (instruction, feedback, help), etc. and then to know their functions. An example for a button, the student must be able to identify an answer validation button, know that it is used to validate an answer, and understand that its function is to switch from the problem space to the answer evaluation process. The student also needs the knowledge of the interface use, i.e. to know how to use these interface components. For example, an answer validation button, he has to click on the button in order to activate its function. Our example is obvious but it is sometimes not easy for the student to handle certain kinds of interface components. The manipulation in this interaction space could become, as a result, a problem itself.

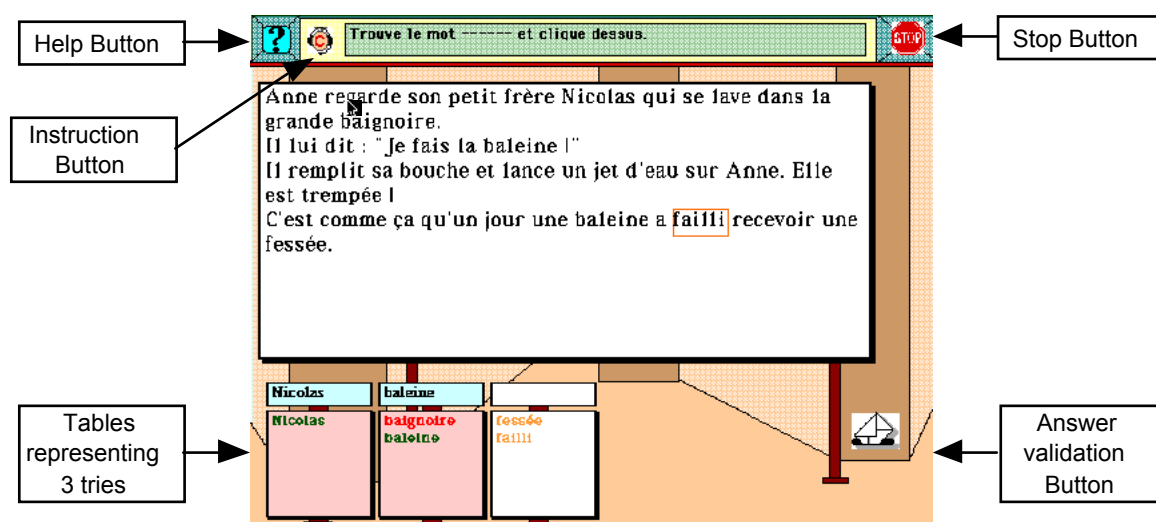


Figure 2 : AMICAL Interface of a didactic situation

The way this kind of knowledge is taken into account is important both for the design of didactic situations and for the interpretation of the solutions proposed by the student. It is also to note that this kind of knowledge is directly linked to a didactic situation as a space for interactions.

It is to emphasize that this three kinds of knowledge mentioned above are cognitive nature. There is also one kind of knowledge that should be mentioned here, that of the metacognition.

5. Metacognition

The term « metacognition » here refers to the knowledge about one's own cognitive knowledge [6]. It is the metacognition which controls any cognitive activities such as the reasoning, the planning, the decision making and the problem solving.

5.1 Metacognition and reading

The reading is a complex cognitive task in which the metacognition is necessarily present. Before reading, it concerns the knowledge that the student has about himself, or in another word, he considers himself able or not to carry out the task. The metacognition during the reading is the awareness of the task difficulty and the strategies needed. After reading, the student checks if this cognitive task has been accomplished.

5.2 Metacognition and problem solving

A problem-solving activity can be divided into three phases: (1) a pre-active phase, (2) an interactive phase and (3) a post-active phase. These three phases correspond to the three metacognitive processes played a part in the problem solving. The first process is the planning of the sequences of operations. The second process is the control and the adjustment of these sequences of operations. The last one is the evaluation and the correction, if necessary, of this sequences of operations [12].

5.3 Metacognition and interface

The interface components of a didactic situation could be used as a means to arouse the metacognition. *The instruction*, for example, must supply to the student the information on the task and on the goal to be attained. Indirectly, it brings about the motivation to learn. *The constituent data for the problem to be solved*, as for it, must be explicitly presented so that the student could understand the problem. It is also one of factors that determine the sequences of operations. The metacognition can also be favored by *the didactic dialogue*. The feedback is a means to encourage the autoevaluation strategy of the student thus to insure his success. *The help* can stimulate, if necessary, some passive strategies of the student [9].

The metacognition is a very important factor for the success in the problem solving. The computer-assisted learning environment should, on the one hand, supply to the student a possibility to use and improve his metacognition during the problem solving and on the other hand, allow, according to the variety of didactic activities, the evolution of the metacognition and the possibility to put in concrete form some metacognitive approaches.

6. Conclusions

To design a computer-assisted learning environment, the designer needs, therefore, to understand not only the organization of the learning domain knowledge, the teaching methodology and the student who learns in this environment, he also needs to understand the characteristics of didactic activities proposed to the student. The analysis of a didactic activity as a complex problem to be solved by the student must consequently allow us to better understand the different types of knowledge that the student needs during the progress of a didactic activity.

The four main types of knowledge mentioned in this paper are, in turn, necessarily underlying to the design of the student interaction scenario of a didactic activity. This student interaction scenario implements a set of information on the multimedia interface components (from the formulation of problem to be solved to the validation of the proposed solutions). According to the interactions between the student and the system, the student interaction scenario also makes use of the dynamism of the interface evolution in a pedagogical dialogue. These four types of knowledge, the form of the student interaction scenario, the dynamism of the progress of a didactic activity are equally considered as the fundamental elements to take into account in the research on the design methods and the developments of human-computer interface.

In the current prospects of the AMICAL project, our research focuses, as a result, on an explanation and a theorization of these four types of knowledge. This explanation and this theorization aim in the immediate future to design a library of didactic situations adaptive to the concerned learning, to refine the criterions for choosing a didactic situation for a working session, to deepen the instantiation criterions of parameters of a didactic situation type and to improve the qualitative interpretation of the student's behaviour. These different elements must contribute to a high individualization of the learning. Their theorization opens equally to the possibilities to transfer to other learning domains.

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