Dialogue-Based Reflective System for Historical Text Comprehension

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Abstract. In this contribution we present the Dialogue-based Reflective Diagnostic and Learning System (DRDLS) for Historical Text Comprehension (HTC). The diagnostic module of the system infers the learner's cognitive profile and profile descriptor. The diagnostic results activate the dialogue generator, which generates the appropriate reflective diagnostic and learning dialogue for the learner. Throughout the dialogue with the system the learners reflect back to claims about their reasoning and may change their reasoning. Evaluation before and after the application of the reflective dialogue indicated that reflection helps learners to overcome their learning difficulties in comprehending the historical text and may result in changing their learner models.

Keywords. dialogue-based reflection, interactive dialogue and historical text comprehension.

1 Introduction

Advanced computer learning environments, which promote reflection, require open learner models in order to help learners overcome their learning difficulties [1,2]. What can make a learner model (LM) open are the interactive dialogues between the learner and the system about learner's own beliefs and the beliefs of the system about the learner [3]. Interactive open learner modeling involves human learners in diagnostic and learning dialogues to improve learning through promoting and facilitating reflection. Open learner models encourage learners to reflect on the domain being studied, on their own strategies for learning, on their progress in learning, on their own understanding. The learner defends his views to the system by collaborating, discussing and arguing the system's assessment of his knowledge and beliefs [1]. The recently growing interest in opening the learner model to the learner encourages the development of systems that give the learner greater responsibility and control over learning [4]. Results of a successful diagnostic process can be beneficial in guiding individualised learning.

Recently, approaches that involve learners in diagnosis [5, 2], diagnosis agents that involve learners in negotiating dialogues, student models which encourage learners in inspection [6] and modification of the model, promoting learner reflection through discussion [3], tutorial dialogue and dialogue planning [7,8] have been

proposed. ATLAS-ANDES is a tutorial dialogue system, which uses a combination of knowledge construction dialogues and allows on the fly the generation of tutorial dialogues [8].

Our system is a dialogue-based diagnostic and learning system, which models dialogue based on the experimental model for learners' cognitive profiles of HTC [9,10]. The system's tutorial dialogue promotes and facilitates reflection in the domain of comprehension of historical text.

In section 2, we point to the Learner Model of HTC (LMHTC). In section 3, we demonstrate the architecture of the DRDLS system and concentrate on the dialogue generator module, which generates the appropriate dialogues. The dialogue strategies and an excerpt of the four stages interactive dialogue between the learner and the system are displayed. How the dialogue engages the learners to reflect on their own strategies for learning and how reflection improves the learner modeling are discussed. In section 4, application results and evaluation are depicted. In section 5, we conclude and give our future perspectives.

2 The Learner Model of Students' HTC

2.1 Models of HTC

Comprehension of text is a special kind of the complex and interactive process of cognition [11]. The reader utilises certain fundamental cognitive categories for establishing and organising the meaning of the text. During comprehension of historical text the reader attributes meanings to causal connections between occurrences [12]. In the level of comprehension as a cognitive task, the learner composes a representation of the historical text, which contains the cognitive categories: *event*, *state* and *action*. For the interpretation of the learner's cognitive processes we trace in their discourse their arguments, which are based on the recognition or not of the three cognitive categories.

2.2 The LMHTC

The underlying model of the DRDLS system is the LMHTC model [10]. The LMHTC presents to the learner a historical text in the appropriate form and question-pairs with alternative answers. The historical text includes factors, which represent the 3 cognitive categories action, state and event. For every factor a question-pair, which consists of two questions concerning the same factor, is submitted to the learner. The first question in the question-pair is relative to the learner's *position* about the significance of this factor and the second question is relative to the learner's *justification* of this position. The learner has to use the given alternative answers, in order to express his position for certain historical issues and support it by selecting a justification. The answers concerning position and justification are classified as *scientific*, *towards-scientific* and *non-scientific*. The alternative answers reflect scientific thought, towards acquiring scientific thought, and non-scientific thought. Figure 1 depicts a historical text concerning 5 different factors of the outbreak of French Revolution. In the historical text, one factor represents the cognitive category event, one the cognitive category state and three the cognitive category action. For question-pair 1, alternative answers a1 and b3 are non- scientific, a2, b1 and b4 are towards-scientific, whereas a3 and b2 are scientific.

2.3 Arguments

For every question-pair the combination of the learner's position and the corresponding justification constitute the learner's *argument*. An argument is defined as *complete* when both position and justification are scientific. Otherwise the argument is *non-complete*. The expert defines the different degrees of *argument completeness*. The argument completeness, which is associated with the recognition or not of an instance of a cognitive category, is used as a vehicle to reveal the degree of the recognition or not of the corresponding cognitive category.

Table 1 demonstrates all possible combinations of position-justification pairs and the corresponding argument completeness. Possible values of argument completeness are: c*omplete, almost complete, intermediate, nearly incomplete* and *incomplete.*

The degree of recognition of the three cognitive categories: event, state and action is used to formulate the cognitive models of HTC, which reflect the learners' levels of historical thought [14]. The learners' cognitive profiles of HTC (Table 2) are formulated taking into account the number of his arguments with high degree of argument completeness. The cognitive profile expresses the degree of recognition of the cognitive categories.

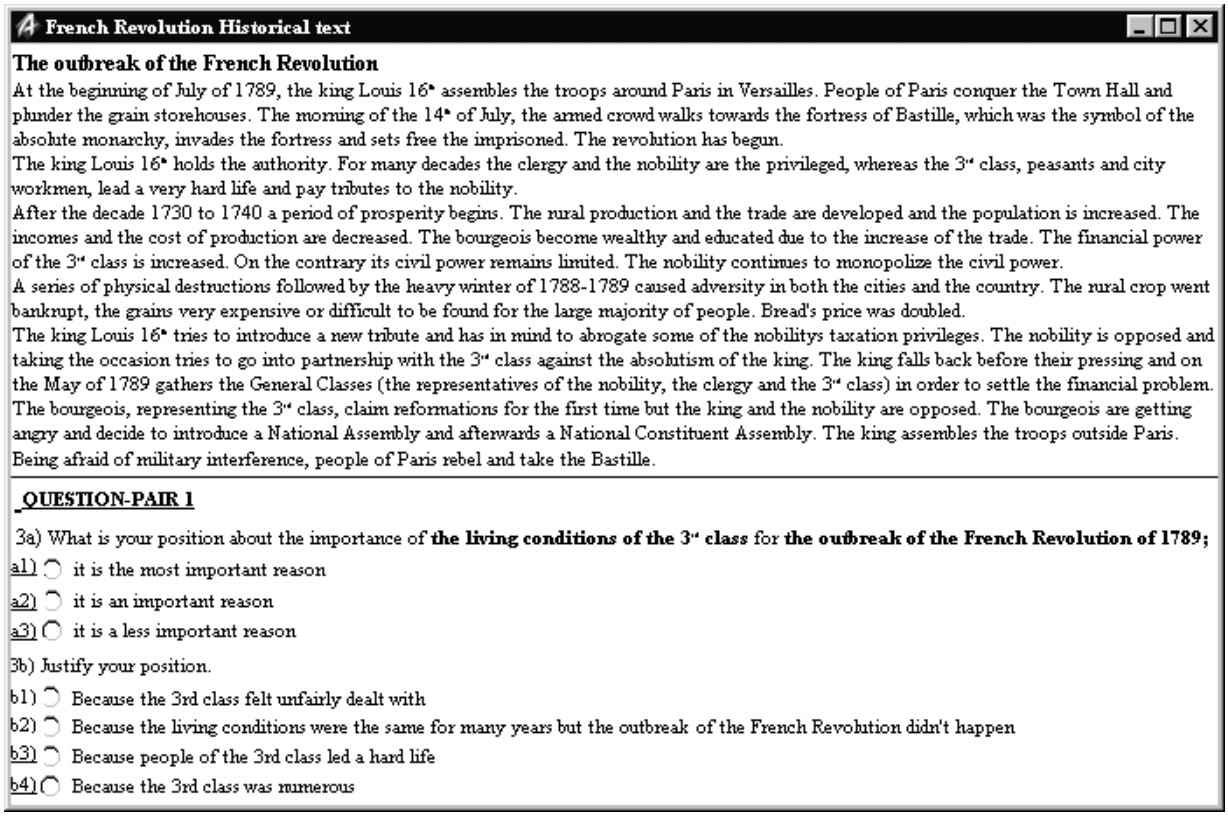

Figure 1: A screenshot depicting a historical text concerning the outbreak of French Revolution, question-pair number 1 and alternative answers.

Table 1: Argument completeness values

position	**justification**	**argument completeness**
scientific	scientific	complete
towards scientific	scientific	almost complete
non-scientific	scientific	intermediate
scientific	non-scientific	nearly incomplete
scientific	towards-scientific	
towards-scientific	towards-scientific	
non-scientific	towards-scientific	

towards-scientific	non-scientific	incomplete
non-scientific	non-scientific	

Learners with *very low* profile seem to have serious difficulties in thinking historically. Learners characterized by terms like *low*, *nearly low*, *below intermediate*, above *intermediate*, *nearly high* and *high*, seem to encounter difficulties in thinking historically. Learners with *very high* profile seem to have no learning difficulties in thinking historically. The existence of the symbol + in the profile indicates that the learners face less difficulties than without it. The profile descriptor describes the learner's cognitive profile and is formulated taking into account all of his arguments, which may have different degree of completeness.

Table 2: Cognitive categories and cognitive profiles.

Number of cognitive categories recognised fully or closely	**Cognitive profiles**
no close to recognition of any cognitive category	very low
close to recognition of one cognitive category	very low+
recognition of one cognitive category	low
close to recognition of more than one instance of a cognitive categories	low+
recognition of more than one instance of a cognitive category	nearly low
close to recognition of two cognitive categories	nearly low+
recognition of two cognitive categories	below intermediate
close to recognition of more than two instances of two cognitive categories	below intermediate+
recognition of more than two instances of two cognitive categories	above intermediate
close to recognition of three cognitive categories.	above intermediate+
recognition of three cognitive categories	nearly high
close to recognition of more than two instances of three cognitive categories.	nearly high+
recognition of more than two instances of three cognitive categories	high
close to recognition of all instances of the three cognitive categories	high+
recognition of all instances of the three cognitive categories	very high

3 The Dialogue-Based Reflective Diagnostic and Learning System

3.1 The DRDLS' architecture

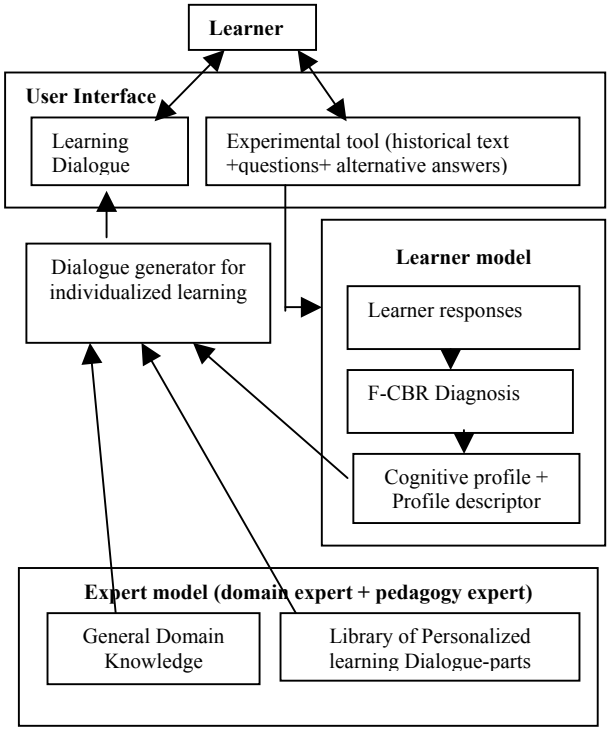

Figure 2: Overview of the DRDLS architecture.

The focus of the system is to help the learner in changing his reasoning if it differs from the expert's. Figure 2 depicts the architecture of the DRDLS system. Basic components of the system are the learner model, the expert model and the user interface.

The interface offers the environment where the learner is asked to read the historical text and answer questions using given alternative answers. The diagnosis module infers the learner's cognitive profile and profile descriptor. The expert model contains the pedagogy expert and the general domain knowledge of the system. The dialogue generator activates the appropriate for the learner dialogue-parts, which generate the individualized learning dialogue. Through the interface the system is able to communicate to the learner how the expert's reasoning is different from the learner's and if necessary go through the dialogue itself, demonstrating to the learner how the problem effectively can be solved.

3.2 The Dialogue Generator

The heart of the DRDLS system is the Dialogue Generator module. The system has at its disposal a library of dialogue-parts, each of which is designed to remedy a particular learning difficulty. In order to generate the appropriate dialogue in response to the learner feedback, the system first analyzes the student's essays to assess, which are the contradictions within the student's arguments. In our design, dialogue-part is seen as a component in the library of dialogue-parts, which can be reused. The task of the dialogue generator is to activate from the library the appropriate sequence of dialogue-parts for the learner. The Dialogue generator correlates the learner's feedback with an individualized learning dialogue. The dialogues are appropriate to the learner's learning difficulties, as they appear according to his LM.

Dialogue Tactics: The system uses the following dialogue tactics for the construction of the dialogue-parts, which support the tutorial dialogue [13]:

- Selection of positive and negative exemplars
- Selection of counterexamples
- Generation of hypothesis
- Tracing the consequents to contradictions

Dialogue Strategy: To generate the dialogue, which is appropriate for the learner, the system follows 3 steps. First, selects the factor, which the learner considers as the most important of all the others (for the outbreak of the FR). This consideration characterizes his attitude towards comprehension of the world of history and denotes his learning difficulties. In case this is not in accordance with the system the dialogue begins with discussion about this factor. Second, the system sorts the rest arguments in a list according to decreasing degree of argument completeness. In this way the system continues with the factor for which the learner seems to face the less learning difficulties. Third, the system generates the sequence of dialogue-parts for this factor. Then the system prepares the next dialogue-part based on the results of the previous dialogue-part.

Dialogue Stages: The dialogue is generated in 4 stages (Figure 3) as a sequence of dialogue-parts each based on the results of the previous stage. The learner changes

have to be predicted so that the appropriate interventions can be made in the learning system during the interaction.

STAGE 1: The system makes the learner aware of the general framework of the assessment results, that is whether the learner is correct or not and encourages him to take his first decision for participating in discussion. The dialogue-part S1D1 is generated by the system in case the learner wants the system to explain him the differences between his answers and the system. The dialogue-part S1D2 is generated in case the learner does not want the system to explain to him and the dialogue is terminated.

STAGE 2: The system uses qualitative criteria to indicate where the learner has contradiction between his position and his justification. The dialogue-parts S2D1 to S2D5 are generated by the system according to the different combinations of the learner's responses, which correspond to different degrees of argument completeness and are related to a factor. When the dialogue-part S2D5 is generated the system returns to stage 1 and continues with the next argument.

STAGE 3: The learner's decision trigger the system to use the appropriate individualized tactics. The dialogue-part S3D1 is generated in case the learner insists in his answer and the S3D2 in case he does not insist, which means that he recognizes his contradiction and changes his reasoning.

STAGE 4: The system discusses and justifies itself and argues with the learner for his contradictions. The appropriate dialogue-parts S4D1, S4D2, S4D3 are generated in case the learner insists in position, in justification or in both respectively. The actions of the system have to be driven towards the aim of eliminating the contradiction and therefore changing the learner's reasoning. The elimination will only be possible when the learner himself removes the contradiction and so he is able to construct a more coherent argument. At the end, the system encourages the learner to try again to read the historical text and answer the questions so it can have a second chance to reassess the learner. So, the learner is involved in the diagnosis process and is expected to change his model.

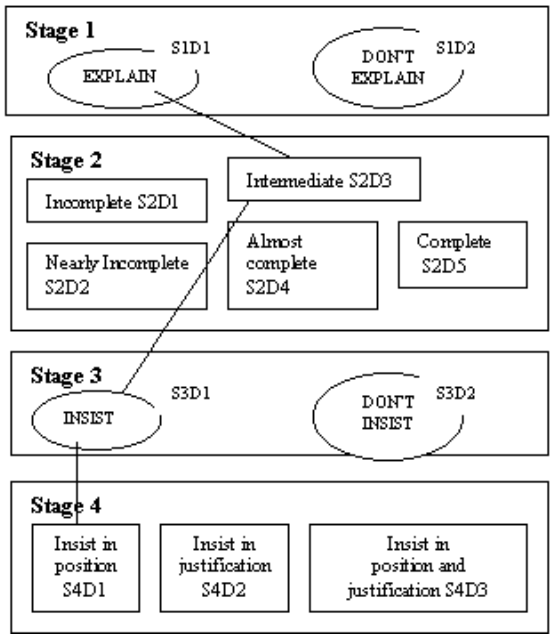

Figure 3: Dialogue stages.

The excerpt bellow presents interaction concerning question-pair 1. The learner has given non-scientific position and scientific justification, which correspond to answers a1 and b2 of Figure 1 and result in an intermediate argument of the category state.

1 System: Your answers concerning the LIVING CONDITIONS indicate that you consider it as THE MOST IMPORTANT REASON for the French Revolution. Your argument is characterized INTERMEDIATE. Do you want the system to EXPLAIN or to CONTINUE?
Learner: EXPLAIN
2 System: You asked the system to explain. Your answers concerning the LIVING CONDITIONS consist of your position and your justification. Your position is that the LIVING CONDITIONS were THE MOST IMPORTANT REASON for the French Revolution. This is a NON-SCIENTIFIC position. Your justification for that position is that the LIVING CONDITIONS WERE THE SAME FOR MANY YEARS. This is a SCIENTIFIC justification.
Your position about the LIVING CONDITIONS is CONTRADICTORY TO your justification. That is why your argument is characterized INTERMEDIATE. What do you intent to do now? INSIST or NOT INSIST.
Learner: I INSIST in my position that the LIVING CONDITIONS ARE THE MOST IMPORTANT REASON.
3 System: You INSIST in your position. Let consider that the LIVING CONDITIONS as a reason for the French Revolution didn't exist. Do you believe that the outbreak of the French revolution would have happened?
Learner: I believe that the outbreak of the French revolution would have NOT HAPPENED.
4 System: But the outbreak of the French revolution has happened. So, what is your logic conclusion?
Learner: The LIVING CONDITIONS ARE NOT THE MOST IMPORTANT REASON
5 System: You can try to answer again.

4 Reflective Dialogue Application

We derived the following questions in order to give structured overview of the used evaluation criteria of the dialogue-based reflective system. (1) Are there any differences in the recognition of the instances of the cognitive categories? (2) Are there any differences between more and less able students when they are given the opportunity to reflect through an open learner model? [14]. (3) Do students comprehend the historical text more effectively with an open learner model?
We applied the reflective dialogue with the participation of 20 learners. The historical text, concerning the French Revolution, included 5 factors and 5 question-pairs with alternative answers. The students were asked to read the historical text and select from the alternative answers. The system recorded their answers and inferred their cognitive profiles and profile descriptors before and after the application of the reflective dialogue.

4.1 Changes in the recognition of the cognitive categories

Figures 4, 5 and 6 demonstrate the changes in the recognition of the cognitive category state, event and action respectively. The horizontal axis shows the 20 students (1st to

20th). The vertical axis shows argument completeness and {1,2,3,4,5} correspond to {incomplete, nearly incomplete, intermediate, almost complete and complete}.

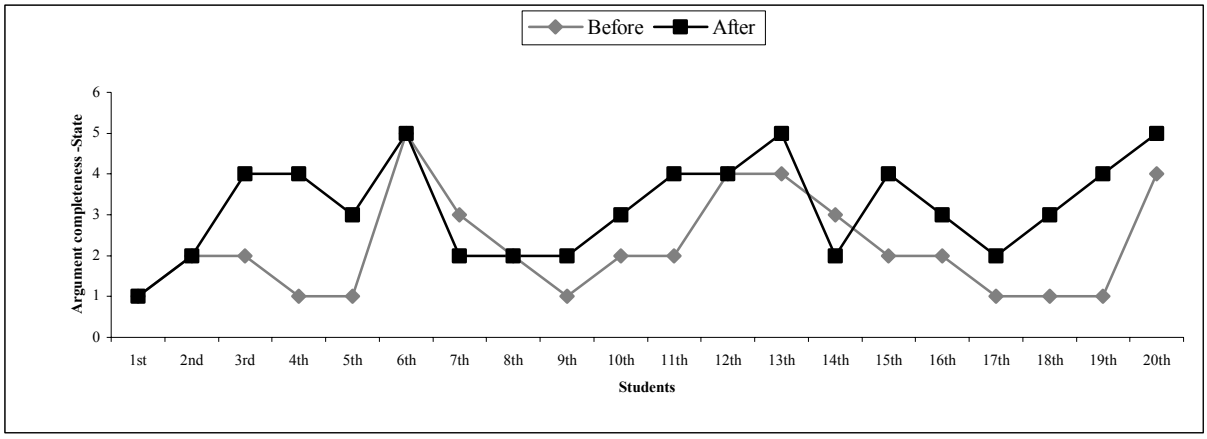

Figure 4: Changes in the recognition of the cognitive category state.

Before the interaction 19 out of 20 learners didn't recognize the category state. After applying the interactive dialogue 16 out of 20 learners changed their reasoning. Before the interaction 17 out of 20 learners didn't recognize the category event. After applying the interactive dialogue 16 out of 20 learners changed their reasoning. There are differences in the recognition of the three instances of the cognitive category action. Before the interaction 17 out of 20 learners, on average, didn't recognize the category action. After applying the interactive dialogue 15 out of 20 learners changed their reasoning.

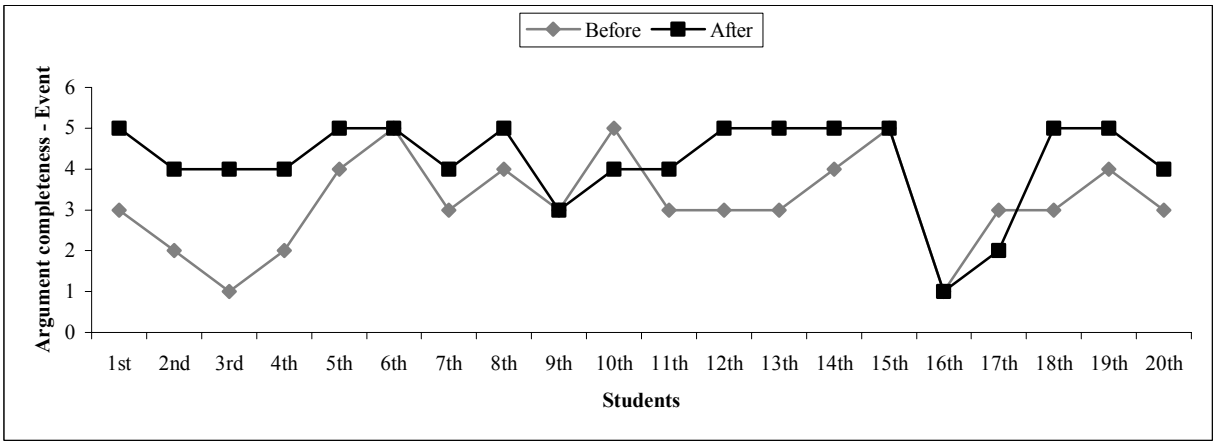

Figure 5: Changes in the recognition of the cognitive category event.

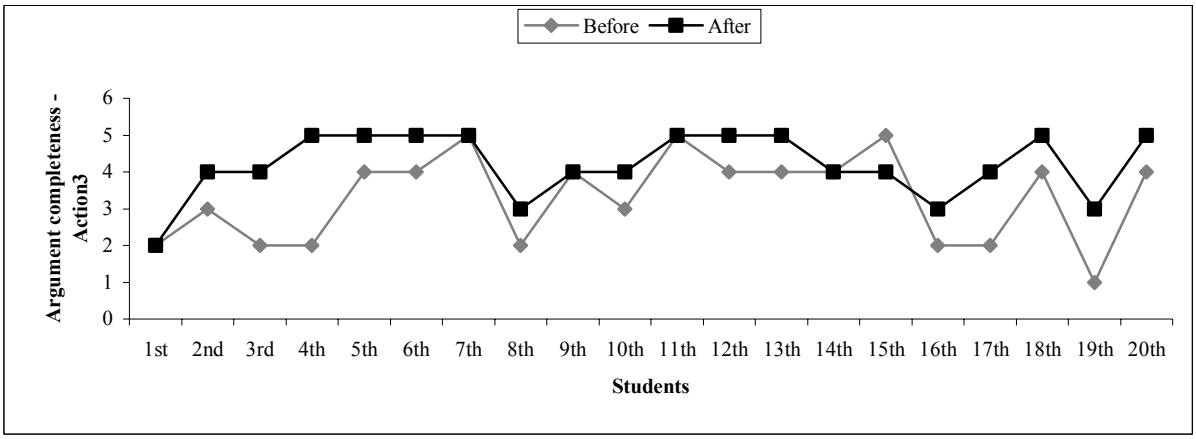

Figure 6: Changes in the recognition of the cognitive category action

Students seem to face fewer problems in the recognition of the cognitive category action. According to the research results students seem to reflect back to claims about their reasoning and change their reasoning more dramatically (make more progress), when involved in interactive dialogues concerning the cognitive categories action and event rather than the cognitive category state.

4.2 Changes in the learner model

Figure 7, presents the students' cognitive profiles before and after the application of the reflective dialogue. It is worth noticing that most of the students with + cognitive profile, which are close to recognition of a cognitive category and have high degree of argument completeness, indicated improvement in their learner models. For example, in the group of students S6, S7, S8 and S9 with Low cognitive profile, only S7 improved his learner model for one level, whereas in the group of S10 and S11, with Low+ cognitive profile, S10 improved his learner model for one level and S11 for two levels.

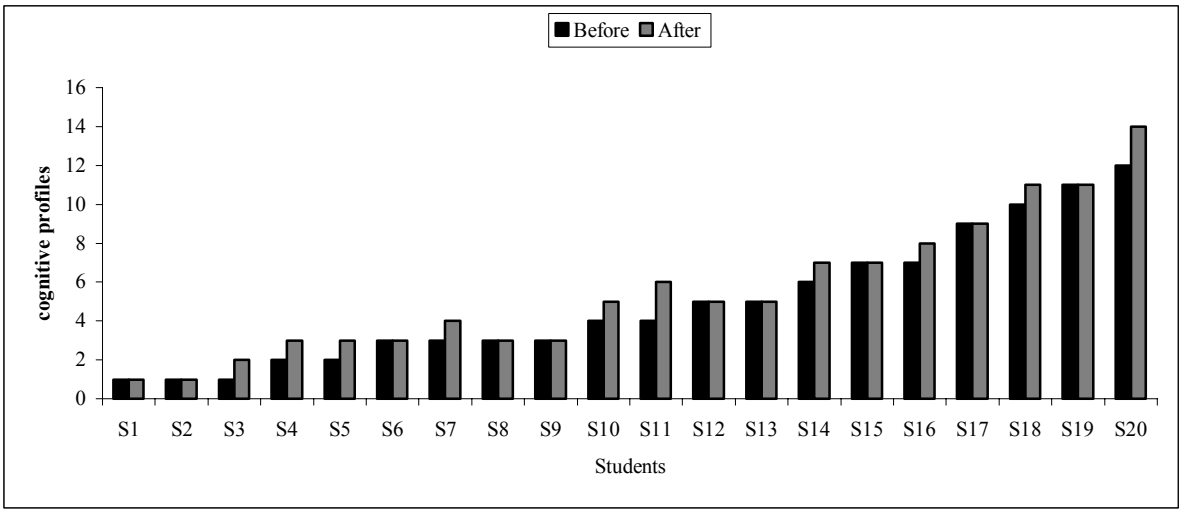

Figure 7: Changes in the cognitive profiles before and after the application of the reflective dialogue. The horizontal axis shows the 20 students (S1 to S20) classified from lower to higher cognitive profiles. The vertical axis shows the cognitive profiles {Very Low, Very Low+, Low, Low+, Nearly Low, Nearly Low+, Below Intermediate, Below Intermediate+, Above Intermediate, Above Intermediate+, Nearly High, Nearly High+, High, High+ and Very High}, which correspond to {1,2,3,4,5,6,7,8,9,10,11,12,13,14}

Differences are detected not between more and less able students but between students with high and low degree of argument completeness when they are given the opportunity to reflect through an open learner model. So, reflective dialogues must concentrate on these points to help learners themselves eliminate or remove their contradictions with the system by changing their reasoning and therefore overcome their learning difficulties. How the learners changed their reasoning needs further investigation.

4.3 Reflection results

Our system aims both at learning and diagnosing through reflective activities supported by interactive dialogues. The learner becomes aware of the system's assessment about himself and is encouraged to make decisions concerning the participation in the dialogue. The system indicates the contradictions between a position and the corresponding justification and by using the appropriate tutorial tactics can discuss and argue with the learner in order to help him eliminate his contradictions. The learner changes his reasoning and constructs more coherent arguments. The application results showed that:

- The changes in the recognition of the cognitive categories reveal that interactive learning dialogues promote and facilitate reflection. This means that dialogue makes learners overcome problems concerning learning difficulties and improve their comprehension of historical text more effectively.

- The improvement of comprehension also affects the learner models as the learner can participate in interactive diagnosis. So, due to reflective dialogues the learner model changes.
- According to the application results, learners (less or more able) but with minor contradictions seem to make more progress than that with major ones.

5 Conclusions and Future Plans

In this work we presented and evaluated the dialogue-based process of the DRDLS system. Based on the diagnostic results the dialogue generator component engages the learners in interactive diagnostic and learning dialogues. The dialogue promotes learners' reflection and helps them to be aware of their reasoning, and some times change it. The application perspectives of this dialogue-based interactive and reflective learning environment aim at individualized learning in history, by activating the appropriate for a learner interactive dialogue with the system. There are educational benefits of the diagnostic system for the students in changing their reasoning. As students comprehend the historical text more effectively with an open learner model, this is useful in helping the experts to recognize learner difficulties in history, enabling them to respond to specific learner populations or individuals in appropriate ways.

We plan to implement the system as an intelligent educational environment. In our future plans falls research concerning the application and evaluation of the diagnostic and learning interaction in classroom conditions.

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