W-ReTuDiS: a Reflective Tutorial Dialogue System

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ABSTRACT

W-ReTuDiS is a web-based open learner modeling system designed to support tutorial dialogue through reflective learning. It models human diagnosis of learner's cognitive profile and constructs the learner model of historical text comprehension. The learner model is open for inspection, discussion and negotiation. The system promotes learners' personalized reflection through tutorial dialogue, helps learners to be aware of their reasoning and leads them towards scientific thought. The system offers a two level open interactive environment: learner level and tutor level. In learner level, the learner participates in the construction of his learner model through dialogue activities, which promote reflective learning. In tutor level, the tutor based on the learner model makes decisions concerning the appropriate activity, reflective dialogue and dialogue strategy for the learner. The evaluation results are encouraging for the system's educational impact on the learners.

KEY WORDS: open learner modeling, reflective learning, historical text comprehension

INTRODUCTION

Over the last few years, interest has grown in employing open learner modeling as a learning resource to promote an individual's reflection on his evolving knowledge. This is one way of using the computer as a tool for learning through reflection. Interactive open learner modeling encourages the learner to reflect on his beliefs and on the learning process and helps him overcome his learning difficulties (Bull & Nghien, 2002, Kay, 2001). Reflective tutorial dialogue is an established technique for supporting computer-assisted learning, which can make a learner model open (Schultz et al., 2003). Open learner models encourage learners to reflect on the domain being studied, on their own strategies for learning, on their own understanding. Towards this direction, the dialogue management, the dialogue strategies and the dialogue tactics, which mainly formulate the dialogue framework, aim at the promotion of personalized reflective learning (Freedman, 2000, McSherry, 2002, Zapata-Riviera & Greer, 2002, Zinn et al., 2002, Greer & McCalla, 1994).

Recently, approaches involve learners in personalized dialogues: TAGUS provides dynamic learner modeling (Paiva & Self, 1995), STyLE-OLM encourages learners in inspection of the learner model (Dimitrova et al., 2001, Zapata-Riviera & Greer, 2002), SQL-TUTOR is a dialogue-based problem-solving tutor (Dimitrova et al., 2000), ATLAS-ANDES promotes knowledge construction (Freedman, 2000) and ScoT proposes a scalable, reusable, conversational tutorial dialogue system (Schultz et al., 2003). Moreover, developments promoting learner reflection through discussion, dialogue planning and dialogue management (Freedman, 1997, Zinn et al, 2002) have been explored.

On the other hand, text comprehension is a relatively new area in computer-assisted learning. The educational potential of combining open learner modeling and historical text comprehension has been identified in the research community (Tsaganou et al., 2003b, 2003c).

The objective of this work is to present W-ReTuDiS (Web-Reflective Tutorial Dialogue System) that implements open learner modelling for historical text comprehension. W-ReTuDiS is a dialogue-based learning system for web-based (http://members.lycos.co.uk/ekellis) personalized reflective learning, which models dialogue derived from the learner model of historical text comprehension (Grigoriadou et al., 2003, Tsaganou et al, 2003b). The system's tutorial dialogue promotes and facilitates reflection in the knowledge domain of comprehension of historical text. In the second section, we present the basics of MOCOHN -a historical text comprehension model. In the third section, we describe the computer-based modelling process of learners' historical text comprehension in W-ReTuDiS, the basic components of the open learner model: the domain knowledge, the learner model, the diagnostic module, the dialogue generator module and the interface module. In the fourth section, we concentrate on learner-system and tutor-system interactivity provided by the interface module and we describe the two levels: learner and tutor level. In the fifth section, evaluation and results are discussed and in the sixth section, we conclude and give our future perspectives.

HISTORICAL TEXT COMPREHENSION

MOCOHN is a theoretical model of historical text comprehension (Cavoura, 2000), which supports that the reader's cognitive system utilizes certain fundamental semantic categories for establishing and organizing the meaning of the text (Baudet & Denhière, 1992). According to the model, during comprehension of historical text the reader attributes meanings to causal connections between occurrences. 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 the expert traces in his discourse the arguments, which reveal the recognition or not of the three cognitive categories.

THE W-ReTuDiS

W-ReTuDiS, which has been developed using the theoretical model MOCOHN and further research, is a dialogue-based open learner modeling system for personalized reflective learning, which models dialogue based on the learner model of historical text comprehension. Basic components of the system are the *domain knowledge*, the *learner model*, the *diagnostic module*, the *dialogue generator module* and the *interface module*.

Domain Knowledge

The domain knowledge consists of the *activity worksheets*, the *cognitive profiles*, the *dialogue-parts' library* and the *dialogue plans.*

Activity worksheets: The system involves the learner in activities, which include the reading comprehension of a historical text and the answering of question-pairs by selecting from the given alternative answers (Tsaganou et al., 2003b). Historical text includes a number of *factors*, which represent indices of the three cognitive categories action, state and event. For every factor a question-pair, is submitted to the learner. During the activity the learner answers the question-pairs using the given alternative answers. The first question in the question-pair is related to the significance of this factor and the answer is called *position*. The second question is related to the learner's justification concerning the position and the answer is called *justification*. The learner expresses his position and supports it by selecting a justification.

Figure 1 depicts an example of historical text concerning 5 different factors, which have been the causes of the outbreak of French Revolution. In the historical text, factor1 represents the cognitive category state, factor2 the cognitive category action, factor3 the cognitive category event, factor4 and factor5 the cognitive category action. In figure 1 factor 1 (the living conditions

of the 3rd class) is discussed. The question-pair1 refers to the "living conditions before the outbreak of the French Revolution". Each of the alternative answers expresses different type of answer. For example, the selection of the answers a3 (valid) and b4 (towards-valid) means that the learner is based on quantitative criteria, in justifying factor1 and in comprehending the cognitive category state.

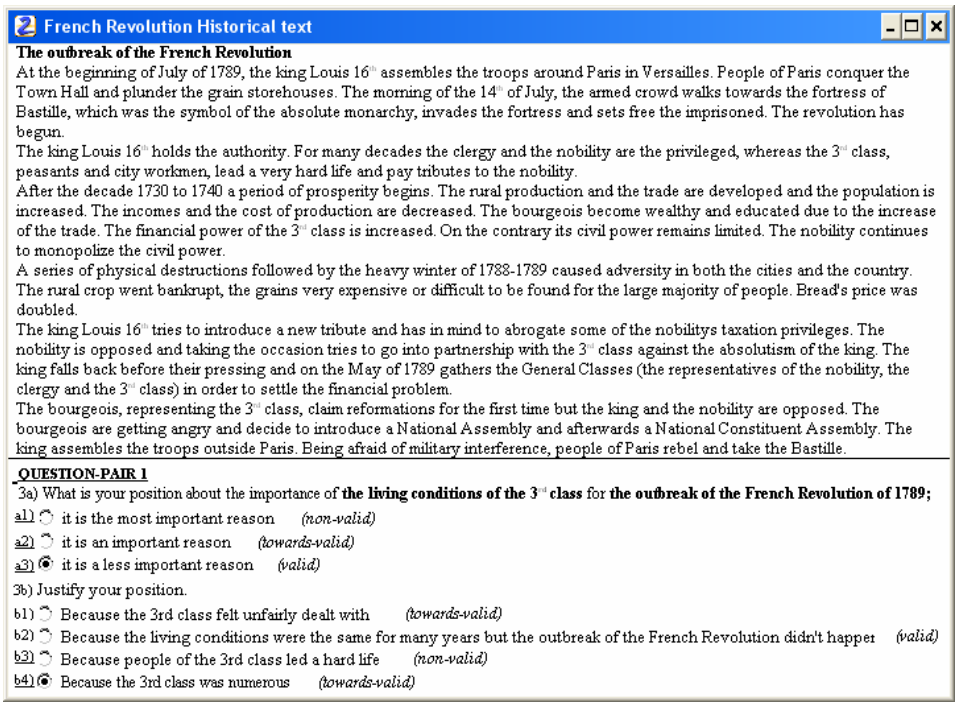

Fig. 1. A screenshot depicting a historical text about the outbreak of French Revolution, question-pair-1 concerning factor-1, which corresponds to the cognitive category state, and alternative answers with characterizations. The characterizations are not visible to the learners.

Cognitive profiles: The alternative answers concerning position and justification are classified as *valid* (including valid answers), *towards-valid* (including experience, quantity, continuity and views) or *non-valid* (including cyclic answers). 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* in case both position and justification are valid. 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. The cognitive categories are of different *quality*. The quality is characterized *superior* for the action, *medium* for the state and *inferior* for the event.

Table 1 expresses the rules of construction of the argument completeness. All possible combinations of position-justification pairs and the corresponding argument completeness are demonstrated. Possible values of argument completeness are: *complete, almost complete,*

intermediate, nearly incomplete and *incomplete*. The less complete the argument the more the learning difficulty the learner faces.

In the example of Figure 1, where the learner gives a valid position and a towards-valid justification, the argument is characterized as nearly incomplete and the learner is *towards-recognition* of the cognitive category state. The learner's contradiction between position and justification is not minor. Moreover, the fact that he bases his argument on quantitative criteria is taken into account and is exploited in the dialogue generator module for the construction of the personalized reflective dialogue.

The learners' cognitive profiles of historical text comprehension are formulated taking into account the degree of argument completeness. The cognitive profile expresses the degree of recognition of the cognitive categories. Possible values of cognitive profiles are: *very low, low, nearly low, below intermediate, above intermediate, nearly high, high* and *very high* as well as *very low+, low+, nearly low+, below intermediate+, above intermediate+, nearly high+* and *high*. Learners with very low profile seem to have serious difficulties in thinking historically. Learners characterized by the terms 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 scientifically. The existence of the symbol + in the profile indicates that the learners face less difficulty than without it.

The *profile descriptor* describes the learner's cognitive profile in more details and is formulated taking into account all of his arguments, which may have different degree of completeness. Example of a profile descriptor is the following: a *quantitative* argument of inferior quality category (factor1), a *cyclic* argument of superior quality category (factor2), an *experience* argument of inferior quality category (factor3), an expressing *views* argument of inferior quality category (factor4), a *cyclic* argument of superior quality category (factor5)

Table 1. Argument completeness values concerning position -justification combinations.

characterization of position	**characterization of justification**	**characterization of argument**	**recognition of the cognitive category**
valid	valid	complete	recognition
towards valid	valid	almost complete	towards-recognition
non-valid	valid	intermediate	towards-recognition
valid	non-valid	nearly incomplete	towards-recognition
valid	towards-valid	nearly incomplete	towards-recognition
towards-valid	towards-valid	nearly incomplete	towards-recognition
non-valid	towards-valid	incomplete	non-recognition
towards-valid	non-valid	incomplete	non-recognition
non-valid	non-valid	incomplete	non-recognition

Dialogue-parts' Library: The system has at its disposal the *dialogue-parts' library* (tables 2, 3), which contains *general* dialogue-parts and *specific* dialogue-parts of different types. Each general dialogue-part is seen as a reusable component for the construction of the dialogue between the learner and the system and is independent of the historical text. Each specific dialogue-part is seen as a reusable component, which is dependent on the specific historical text. Specific dialogue-parts that the learner uses in the dialogue are the alternative answers. Specific dialogue-parts are: factors, alternative answers which appear in the worksheets and dialogue tactics (Tsaganou, 2003a, Collins, 1987).

Table 2. Dialogue-parts' library- General parts

types of dialogue-parts	examples of dialogue-parts
comparisons	the most important reason, important reason, less important reason
position or justification descriptions	valid, towards-valid, non-valid
argument descriptions	complete, almost complete, intermediate, nearly incomplete, incomplete experience, quantity, continuity, views, cyclic
explanations	explain, don't explain
intentions	insist, don't insist
selections	happened, not happened, yes indeed, no I don't believe, yes I'd like, no I don't like
contradictions	contradictory to, not contradictory to

Table 3: Dialogue-parts' library- Specific parts

types of dialogue-parts	examples of dialogue-parts
factors	the living conditions of the 3rd class, the heavy winter of 1789,
learner's argumentations expressing:	
scientific thought	the living conditions were the same for many years
experience	the 3rd class felt unfairly dealt with,
quantity	the 3rd class was numerous, the financial development increased the number of bourgeois
continuity	the heavy winter made the poverty worse,
views	due to the heavy winter the rural crop was bad,
cyclic thought	3rd class lead a hard life
dialogue tactics:	
positive and negative exemplars	the heavy winter or an earthquake are accidental events
counterexamples	whenever the living conditions of people are bad do we have a revolution?
generation of hypothesis	form the hypothesis that the living conditions as a reason for the French Revolution didn't exist.

Dialogue Plans: In order to construct an initial overall tutoring dialogue plan (see below), the system uses information stored in the learner model concerning the learner's performance in a comprehension activity about the historical text. The initial tutoring plan can be dynamically revised during the tutorial dialogue according to the learners' responses to the dialogue. The following is an example of a dialogue plan.

1 **System:** Your answers concerning the…(*factor*) indicate that you consider it as … (*comparison*) for the French Revolution. Do you want the system to… or to….? (*selection)*
Learner: I'd like to …(*explanation)*

2 **System:** You asked the system to explain. Your answers concerning the …(*factor*) consist of your position and your justification. Your position is that the …(*factor*) were… (*comparison)* for the French Revolution. Your justification for that position is that the …(alternative answer).Your position about the …(*factor*) is …(*contradiction)* your justification. What do you intent to do now?... or ….(*intention)*
Learner: I …(*selection*) in my position that the …(*factor*). … (*comparison).*

3 **System:** You …(*decision*) in your position. Let consider that the …(*factor*) 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 …(*selection*).
System: But the outbreak of the French revolution has happened. So, what is your logic conclusion?
Learner:The …(*factor*)…(*comparison*)

4 **System:** Would **y**ou like to try to answer again?....(*selection*).

Learner Model

The learner models' base keeps (for educational aims) a record, called learner model, for every learner interacting with the system. The learner model includes: (1) personal information about the learner, (2) the characterizations of the learner's answers to the question-pairs, (3) the characterizations of the learner's arguments (taken from table 1), (4) the learner's cognitive profile, (5) the learner's profile descriptor, which describes the cognitive profile and expresses experience, quantity, continuity, views or cyclic answers), (6) information data about the participation of the learner to the reflective dialogue and (7) information data about the behavior of the learner during the reflective dialogue.

Diagnostic Module

The Diagnosis module of the system first infers the argument completeness for all the learner's arguments using the technique of Fuzzy-Case Based Reasoning. The arguments characteristics are used to infer the learner's cognitive profile and his profile descriptor. The diagnostic results are used by the dialogue generator module for the construction of the personalized dialogue.

Dialogue Generator Module

The dialogue generator module uses *dialogue strategies*, *dialogue tactics* and *dialogue plans* (Collins, 1987, Freedman, 2000, Tsaganou et al., 2003a) to generate the appropriate reflective learning dialogue for the learner's learning difficulties according to his learner model. The system has at its disposal the dialogue-parts' library (tables 2, 3). In order to generate the appropriate dialogue in response to the learner' answers in the activity worksheet, the system taking into account the profile descriptor finds the contradictions within the learner's arguments (between positions and corresponding justifications). W-ReTuDiS is designed to allow for personalized reflecting tutoring using dialogue strategies and dialogue tactics. Examples of dialogue strategies are the following:

- the system begins the dialogue starting from the factor which the learner considers as the most important of all the others (for the outbreak of the FR).
- the system begins the dialogue starting from the factor for which the learner seems to face the less learning difficulties.

Examples of dialogue tactics are shown in table 3. Based on the selected dialogue strategy the dialogue generator is activated by the diagnostic results, plans the appropriate sequence of dialogue-parts using the appropriate dialogue tactics and constructs an initial overall tutoring dialogue plan.

Interface Module

The interface module provides a two levels communication medium between the users and the system: the learner level and the tutor level. In learner level, the learner participates in reflective learning dialogue activities, which result in the construction and revision of his learner model. In tutor level, the tutor makes decisions concerning the appropriate activity and dialogue strategy for the learner according to his learner model. In interactive open learner modelling systems that allow the learner to inspect and discuss the model the system has built of him (Dimitrova et al., 2000). A critical issue is the maintaining the communication between the learner and the system. This includes the design and implementation of an interaction medium as well as the method of managing the dialogue with the learner.

LEARNER LEVEL-TUTOR LEVEL

***Learner-System Interaction**:* The learner communicates with the system through the activity worksheets and the reflective dialogues. The learner is encouraged to read the historical text and response to the question-pairs by selecting the valid answers according to his opinion. At the end of this process the system constructs the open learner model, which is accessible by the learner:

- formulates characterizations of the learner's answers and the argument (see Table 1),
- makes the diagnosis of the learner's cognitive profile,
- expresses the profile descriptor

The learner model contains representations of the learner's performance on the activity worksheet concerning the historical text and reflects his learning difficulties. The learner model is open for inspection, discussion and negotiation. The learner can inspect, discuss and negotiate his model with the system through the reflective dialogues. The actions of the system have to be driven towards the aim of eliminating the contradiction within the learner's arguments 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. In this stage of interaction the system:

- prepares the appropriate dialogue plan according to the learner's answers, which are not characterized as valid
- provides the learner, step by step, with reflective activities in the form of questions with alternative answers and participates in the dialogue with the learner.

The learner is involved in interactive dialogue concerning his contradictions within his arguments through a sequence of reflective activities where the system:

- *encourages the participation in dialogue*: 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.
- *indicates the contradiction:* The system uses qualitative criteria to indicate where the learner has contradiction between his position and his justification.
- *schedules the dialogue tactics*: The learner's decisions can guide the system to use the appropriate individualized dialogue tactics.
- *motivates discussion and justification:* The system discusses and justifies itself and argues with the learner for his contradictions.
- *encourages participation in diagnosis*: At the end, the system encourages the learner to try again to read the historical text and answer the questions. So, the learner is involved in the diagnosis process and the revision of the learner model.

The following personalized dialogue example illustrates in 4 stages the interaction concerning question-pair 1. The learner has given *non-valid* position and *valid* justification, which correspond to answers a1 and b2 of Figure 1 and result in an *intermediate* argument of the category *state*. W-ReTuDiS uses dialogue tactics to support tutorial interactions.

Stage 1

System: Your answers concerning the LIVING CONDITIONS indicate that you consider it as THE MOST IMPORTANT REASON for the French Revolution. Do you want the system to EXPLAIN or to CONTINUE?

Learner: EXPLAIN

Stage 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. Your justification for that position is that the LIVING CONDITIONS WERE THE SAME FOR MANY YEARS.

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.

Stage 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.

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

Stage 4

System: You can try to answer again.

For example, in stage 3, the tactics: selection of counterexamples and generation of hypothesis are used (table 3). The learner considers the "*living conditions of the 3rd class before 1789*" as the most important reason. The tutor's counterexample can be "*whenever the living conditions of people are bad do we have a revolution*"? The tutor generates the hypothesis that "*if the heavy winter of 1789 did not have happened, would the outbreak of the French Revolution have happened*"? in order to make the learner to reason about it.

Tutor-System Interaction: The environment of W-ReTuDiS is open to the tutor since it facilitates him to identify learning difficulties that learners face in order to adapt and schedule the appropriate instructional dialogue strategies**.** The human tutor can have access the tutor level interface, which allows him easily activate the appropriate activity worksheets to provide the learner or groups of learners. The tutor can also select the appropriate for the learner dialogue strategy and determine the dialogue plan. Moreover, the tutor can suspect the current learner model and take information concerning learner's difficulties in the recognition of the cognitive categories, the number, the quality and the degree of recognition of the cognitive categories. The system provides the tutor with capabilities for the management of the learner models' base.

EVALUATION

Evaluation was conducted as part of the implementation cycle of the system and with the participation of 4 human experts and 20 learners and was used for further revisions, modifications and improvements (Chin, 2001, Mitrovic , 2002). This evaluation focused on indicating problems with the effectiveness of the reflective dialogues in helping learners change their reasoning, dialogue coherence, suitability of dialogue tactics and strategies for planning effective personalized dialogues. W-ReTuDiS recorded the learners' answers and inferred their cognitive profiles and profile descriptors before and after the application of the reflective dialogue. Figure 2, presents the learners' cognitive profiles before and after the application of the reflective dialogue. It is worth noticing that most of the learners with high degree of argument completeness, indicated improvement in their learner models. For example, in the group of learners S6, S7, S8 and S9 with low cognitive profile, only S7 improved his cognitive profile for one level, whereas in the group of S10 and S11, with low+ cognitive profile, S10 improved his cognitive profile for one level and S11 for two levels.

The participating experts were given explanations about the aims of W-ReTuDiS and asked to explore a variety of potential situations envisaging the behavior of a learner who would discuss his domain knowledge with the system. In general, dialogue planning appeared suitable for organizing dialogue that meets the requirements of dialogue-based interactive and personalized reflective learning. Since the tutor level facilitates tutor to identify groups of learners with similar or

particular learning difficulties the system can be used to adapt and schedule the appropriate instructional strategies for particular learner groups. The dialogue tactics in W-ReTuDiS were considered adequate in respect to maintaining the local focus of the dialogue. Few problems with the current implementation were identified, e.g. occasionally, repetitions of system's statements and questions about already made claims occurred. A richer domain knowledge base could lead to higher chances for obtaining adequate dialogue tactics.

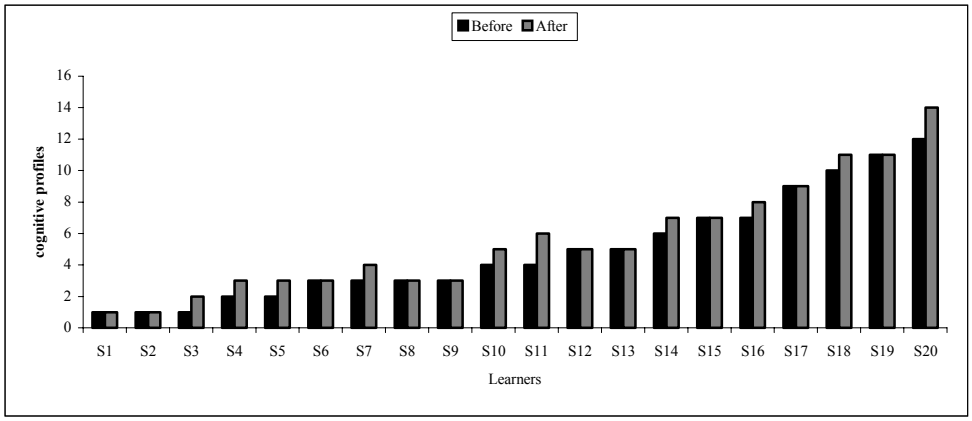

Figure 2. Graph showing the changes in the cognitive profiles before and after the application of the reflective dialogue. The horizontal axis shows the 20 learners (S1 to S20) classified from lower to higher cognitive profiles. The vertical axis shows the cognitive profiles {very low, very low+, low, 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}

CONCLUSIONS AND FUTURE PLANS

In this work we presented personalized reflective learning historical text comprehension in W-ReTuDiS. According to the case-based reasoning diagnostic results the dialogue generator component engages the learner in learning dialogue. The dialogue indicates the contradictions within the learner's answers and discusses with the learner in order to help him eliminate his contradictions. The dialogue promotes learner's reflection in an open and interactive environment and helps him to be aware of his reasoning, to construct more coherent arguments and leads him towards scientific thought. So the learner participates in the construction of his learner model through dialogue activities. The system is also open to the tutor who can manage the learner model and makes decisions concerning the appropriate activity and dialogue strategy for the learner according to his learner model. The application perspectives of this dialogue-based interactive and reflective learning environment aim at personalized learning in history, by activating the appropriate dialogue for a learner interactive dialogue with the system.

The evaluation results proved the effectiveness of the reflective dialogue on learners with minor contradictions. The results are encouraging for the system's educational impact on learners and for future work. There are educational benefits of the system for the learners in changing their reasoning. In our future plans falls research concerning the application and evaluation of the diagnostic and learning interaction in classroom conditions. We also plan to study and revise the dialogue strategies and tactics and improve the reflective dialogue in order to help learners overcome major contradictions and learning difficulties.

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