COMPASS: AN ADAPTIVE WEB-BASED CONCEPT MAP ASSESSMENT TOOL

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Abstract. In this paper, we present the architecture of an adaptive web-based concept map assessment tool, named COMPASS, which aims to support the assessment as well as the learning process. The presentation of the main modules of the tool focuses on the representation of the domain knowledge and the learner model, the diagnosis of the learner's knowledge and the generation of the adaptive feedback. Based on an assessment goal that the learner selects, COMPASS provides various assessment activities, which employ concept mapping tasks. The diagnosis process identifies and analyses the learner's beliefs represented on his/her map in order to perform (i) a qualitative estimation of his/her knowledge based on a categorization of the different types of errors, and (ii) a quantitative estimation of his/her knowledge level based on specific assessment criteria. Aiming to stimulate learners to reflect on their beliefs, COMPASS incorporates different informative and tutoring feedback components, in terms of delivering individualized feedback.

1   Introduction

Concept mapping stimulates learners to articulate and externalise their actual states of knowledge. Novak and Gowin (1984) noted that concept mapping is a creative activity, in which the learner must exert effort to clarify concept meanings in specific domain knowledge, by identifying important concepts, establishing the concepts relationships, and denoting their structure. Also, concept mapping is regarded as a self-regulative and challenging activity as it fosters reflection on learners' understanding of concepts and their relationships, enabling learners to monitor their learning process and to focus attention on their learning needs (Novak & Gowin, 1984; Cañas et al., 2003). In educational settings, where assessment is aligned with instruction in order to support and enhance the learning process, concept mapping and subsequently concept maps are considered a valuable tool of the assessment toolbox. Various applications of concept maps in education and a number of concept mapping software tools are presented in (Cañas et al., 2003).

Towards the direction of interweaving assessment and instruction, and exploiting the value of concept maps as assessment and learning tools, we are developing an adaptive web-based concept map tool, named COMPASS (COncept MaP ASSessment tool). Based on an assessment goal that the learner selects from a set of proposed goals, COMPASS engages learners to the "assessment+learning" process through a set of assessment activities. The activities address specific assessment outcomes and employ various concept mapping tasks. COMPASS supports the identification and the qualitative analysis of errors presented on the learner's map. The results are further exploited for the qualitative diagnosis of the learner's knowledge (e.g. unknown concepts, false beliefs) and the quantitative estimation of the learner's knowledge level on the activity, according to assessment criteria defined by the teacher. Aiming to individualize feedback, COMPASS provides to the learner different informative and tutoring feedback components, tailored to his/her knowledge level, preferences and interaction behaviour. The provided feedback aims to stimulate the learners to reconsider their beliefs, reflect on them and reconstruct/refine their knowledge structure. The provision of adaptive feedback is considered as one of the discriminative characteristics of COMPASS in comparison to other tools. The paper is organized as follows. In Section 2, an overview of the COMPASS tool is presented. In section 3, the architecture of the tool is provided focusing on the representation of the domain knowledge and the learner model, the diagnosis of the learner's knowledge and the generation of the adaptive feedback. In Section 4, the paper ends with conclusions and our plans for further research.

2   An Overview of COMPASS Tool

The aim of COMPASS tool is twofold: to assess the learners' understanding as well as to support the learning process. In particular, COMPASS serves (i) *the assessment process* by providing a variety of assessment activities (through specific concept mapping tasks, see section 3.1.1) and applying a scheme for the qualitative and quantitative estimation of the learner's knowledge (see section 3.2), and (ii) *the learning process* by providing different informative and tutoring feedback components, tailored to each individual learner, through the "Knowledge Reconstruction + Refinement" (KR+R) process.
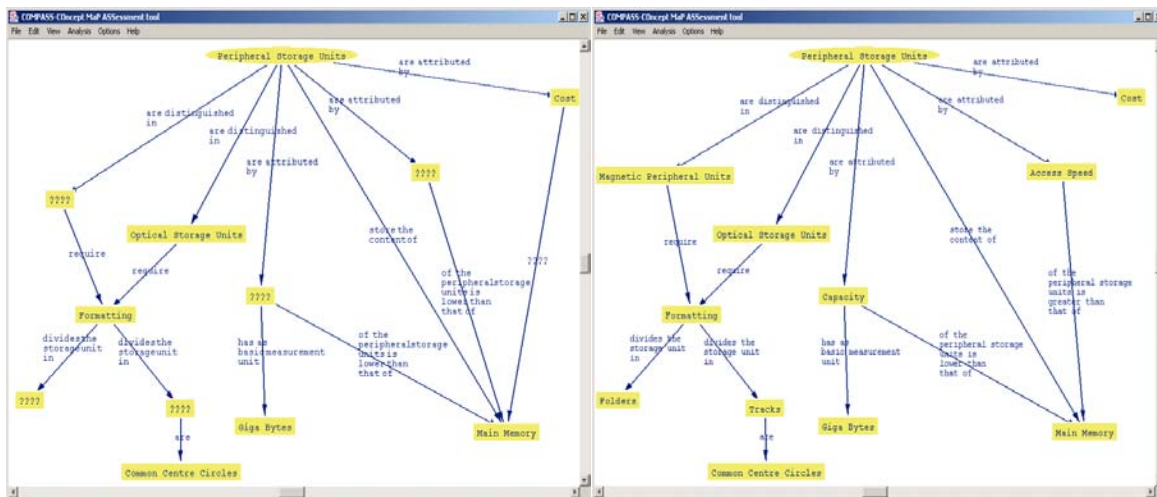
Figure 1. A screenshot of COMPASS at the beginning of a "concept-relationship list completion/evaluation" task

Figure 2. The concept map constructed by a learner for the concept mapping task, depicted in Figure 1.

Figure 1 depicts a screenshot of the COMPASS tool, as it appears to the learner at the beginning of a "concept-relationship list completion/evaluation" task (a description of the types of concept mapping tasks is given in Section 3.1.1). Concepts and relationships to be completed are indicated by four question marks. Figure 2 illustrates the concept map constructed by a learner for the specific mapping task. The toolbar of the learner's interface contains several tools, such as: (i) "Options" that allows a learner to select an assessment goal and an activity, (ii) "File" that allows a learner to "Create", "Load", and "Save" a concept map and "Exit" COMPASS, (iii) "Edit" that allows a learner to "Undo" and "Redo" his/her last action, (iv) "View" that presents the available lists of concepts/relationships according to the mapping task, and (v) "Analysis" that allows a learner to check/verify his/her map and receive the appropriate feedback; the automatic analysis of the map is supported in cases where the mapping tasks employ lists of concepts/ relationships, otherwise the teacher is responsible for the assessment and the provision of feedback..

Based on an assessment goal that the learner selects, COMPASS provides various assessment activities. After the learner has completed the activity or in case s/he asks for support/help, the learner may check/verify his/her map through the "Analysis" tool. In this case, COMPASS activates the "KR+R" process, which includes (i) the diagnosis process for the identification of errors, their qualitative analysis, the qualitative diagnosis of the learner's knowledge and the quantitative estimation of the learner's knowledge level, and (ii) the feedback generation process for the provision of appropriate informative and tutoring feedback components for each one of the errors. More specifically, the following sequence of interactions (stepwise presentation of the feedback components combined with a multiple try strategy) is taken place: (i) *First Step:* COMPASS indicates the error by providing learners with an initiating question (IQ), which gives them the possibility to rethink their beliefs and to identify and check their own errors. The applicability of the step depends on the error category (Table 1) (e.g. for a "missing relationship" error, this step is not applied). Following, the tool enters in a "wait" state, expecting the learner's action. (ii) *Second Step*: If the learner insists on his/her belief, then according to specific rules (see section 3.3) error-task related questions (E-TRQ) or tutoring feedback units and error-task related questions (TFU+E-TRQ) are provided. COMPASS enables the learner to think about the feedback and proceed with any changes; the tool enters again in a "wait" state, expecting the learner's action. (iii) *Third Step:* If an impasse is reached (learner insists on his/her belief) or the learner asks for the knowledge of correct response, then COMPASS informs the learner about the correct response (KCR feedback component). It is important to mention that the whole process is fully controllable by learners who always have the option to select the desired feedback component, ignoring the ones provided by the tool.

3   The Architecture of COMPASS

The architecture of COMPASS, illustrated in Figure 3, is comprised of five modules: (i) the *Interaction Monitoring Module* (IMM), which is responsible for (a) collecting data concerning the learner's observable behaviour, (b) activating the other modules according to the learner's actions (i.e. activation of the DM after the accomplishment of an activity and the AFGM after the completion of the activity or in case the learner asks for support/help), and (c) updating the LM with the newly acquired information (e.g. feedback components provided, duration of the activity's elaboration, etc.), (ii) the *Diagnostic Module* (DM) that supports the

assessment of the learner's concept map, based on the similarity of the map with the expert's one, (iii) the *Adaptive Feedback Generation Module* (AFGM), which is responsible to generate the appropriate feedback, according to the learner's knowledge level, preferences and interaction behaviour, (iv) the *Presentation Module* (PM), which is responsible for the presentation of (a) the constituent parts of the concept mapping task that will be available to the learner during the accomplishment of the activity (received from the DK), and (b) the feedback after generated by the AFGM, and (v) the *Data Storage* (DS), containing *the Domain Knowledge* (DK) and the *Learner Model* (LM). Below, we discuss in more detail the Data Storage, the Diagnostic and the Adaptive Feedback Generation Modules.
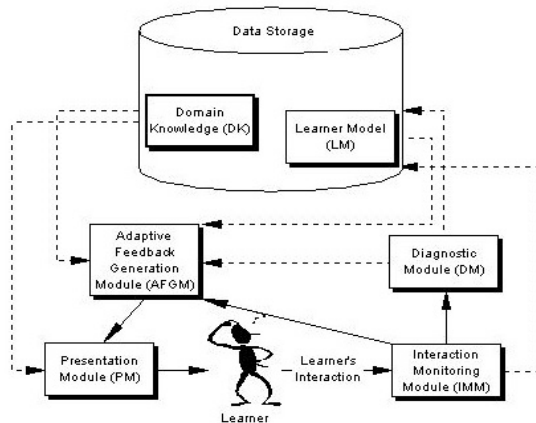

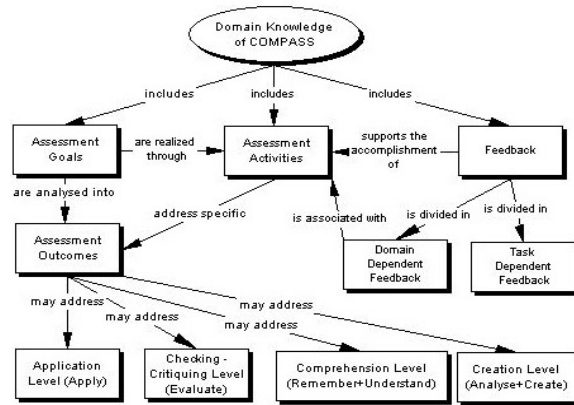**Figure 3**. The main modules of the architecture of COMPASS.   **Figure 4**. The constituent parts of the Domain Knowledge.

3.1   Representing the Domain Knowledge and the Learner Model: the Data Storage

3.1.1   The constituent parts of the Domain Knowledge

The domain knowledge of COMPASS is based on the notion of the *assessment goals* that the learner can select. A goal corresponds to a fundamental topic of the subject matter and is associated with a set of concepts, called *fundamental concepts*. Each goal is further analysed to specific *assessment outcomes*, which are realised through various *assessment activities*. The outcomes may address the *Comprehension level* (Remember + Understand), the *Application level* (Apply), the *Checking-Critiquing level* (Evaluate), and the *Creation level* (Analyse + Create) (Gogoulou et al., 2004). The feedback, aiming to support the learning and the reflection process, is divided into *domain dependent feedback* and *task dependent feedback*. The constituent parts of the domain knowledge are illustrated in Figure 4.

Assessment Activities. The design of the activities is based on the *AssessToLearn* framework, which is proposed in (Gouli et al., 2003), following a three-step process. According to the steps of the framework, an assessment activity accomplishes specific *assessment functions,* such as:

- *Ascertaining the Learners' Prior Knowledge - Activating Knowledge*: the assessment activity aims to enable (a) the teachers to (i) elicit learners' prior knowledge, (ii) identify learners' initial knowledge level as far as the new concepts are concerned, and (iii) diagnose learners' unknown concepts, incomplete understanding, and false beliefs, and (b) the learners to activate their existing knowledge,
- *Promoting Knowledge Construction & Identifying Conceptual Changes - Constructing & Enriching Knowledge*: the assessment activity aims to enable (a) the teachers to (i) monitor/assess learners' progressive changes during the instruction, (ii) promote learners' knowledge construction and the development of high level cognitive skills such as reflection, revision and critical thinking, and (b) the learners to monitor how their learning progresses, and whether their knowledge is revised and/or enriched with and incorporates effectively new knowledge, and
- *Assessing Knowledge Construction - Refining Knowledge*: the assessment activity aims to enable (a) the teachers to (i) capture the growth in learners' overall understanding, and (ii) identify how learners' knowledge has been constructed after the completion of instruction, and (b) the learners to refine their knowledge and draw conclusions about the degree of achieving the expected assessment outcomes.

Depending on the outcomes and the functions that the assessment activities address, the activities may employ various concept mapping tasks such as (i) the construction of a map either from scratch ("*free construction*"), or using a list of concepts ("*concept list construction*"), or using a list of concepts/relationships ("*concept-relationship lists construction*"), (ii) the evaluation of a map (i.e. the evaluation and consequently the

correction of the map in case of the identification of any errors) either from scratch ("*free evaluation*"), or using a list of concepts/relationships ("*concept-relationship lists evaluation*"), (iii) the extension of a map either from scratch ("*free extension*"), or using a list of concepts ("*concept list extension*"), or using a list of concepts/relationships ("*concept-relationship lists extension*"), (iv) the completion of a map (i.e. the construction of a map by filling the requested concepts and relationships) either from scratch ("*free completion*"), or using a list of concepts ("*concept list completion*"), or using a list of relationships ("*relationships list completion*"), or using a list of concepts/relationships ("*concept-relationship lists completion*"), and (v) a combination of the abovementioned tasks such as the completion and evaluation of a map using a list of concepts/relationships ("*concept-relationship lists completion/ evaluation*").

The assessment activities may have different difficulty level and different degree of importance for the accomplishment of a goal, depending on the addressed assessment outcomes and assessment functions. An activity is related with various concepts that may be represented on the concept map. These concepts have different degree of importance for the accomplishment of the activity. The concepts that are basic concepts for the specific task/map and should be represented on the map, are named *fundamental concepts of the task/map*. Concepts that analyse and/or clarify the fundamental concepts are named *useful concepts of the task/map* while concepts that are not included in the above categories but they may be represented on the map (i.e. their meaning is correct and they are related to the central concept of the map and to the fundamental/useful concepts) are named *related concepts of the task/map*. For example, for the concept map depicted in Figure 2, the concepts "Magnetic Storage Units", and "Optical Storage Units" are characterized as fundamental concepts, the concept "Formatting" is a useful concept, while the concept "Common Centre Circles" is a related concept. It is important to mention that the categorisation of the concepts depends on the assessment activity; the same concepts in the context of other activities may be characterized differently. This categorization of concepts plays significant role in the assessment process; different assessment criteria may be defined based on this categorization (e.g. completeness of fundamental concepts of the task/map) and different weights may be assigned to the concepts according to their degree of importance. Furthermore, an activity is related with the propositions that are represented on the map constructed by the teacher (expert's concept map). For these propositions, different weights may be assigned denoting their degree of importance for the accomplishment of the activity.

Summarizing, an assessment goal is realised through various assessment activities for which the domain knowledge of COMPASS keeps information about (i) the addressed assessment functions, (ii) the level of the addressed assessment outcomes, (iii) the type of the concept mapping task employed, (iv) the lists of concepts and/or relationships that may be available according to the mapping task, (v) the difficulty level, (vi) the degree of importance for the accomplishment of the assessment goal, (vii) the assessment criteria employed, (viii) the concepts that may be represented on the concept map, their categorization and their weights, and (ix) the propositions that are represented on the expert's concept map and their weights.

Feedback. Feedback is considered as one of the most important sources of information to assist learners in restructuring their knowledge (Mason & Bruning, 2001). Several research efforts provide feedback to learners according to specific common errors identified on their concept maps (Cimolino et al., 2003; Chang et al., 2001), without taking into account any learner's individual characteristics or needs. More specifically, in (Cimolino et al., 2003), the system analyses the learner's map by comparing it with the expert's map and provides hints (feedback strings defined by the teacher) about specific errors such as missing propositions. In (Chang et al., 2001), the system gives appropriate hints to the learner in the form of partial propositions. Having as an objective to provide individualized feedback, which tutors and guides the learners and subsequently enables them enrich/reconstruct their knowledge structure, COMPASS offers different informative and tutoring feedback components (ITFC). The ITFC include (i) an initiating question (IQ) consisting of the learner's belief, and a prompt to think of the concepts included in the proposition and to write any keywords describing the concepts, (ii) specific error-task related questions (E-TRQ) aiming to redirect the learner's thinking and give a hint for correcting the error and completing the task, (iii) tutoring feedback units (TFU) relevant to concepts/relationship included in the map, aiming to allow the learner to review educational material relevant to the attributes of the correct response, and (iv) the knowledge of correct response (KCR), which is the correct proposition as it appears on the expert's map. The ITFC concerning the E-TRQ and/or the TFU are provided according to the learner's individual characteristics and needs (i.e. learners' knowledge level, preferences and interaction behaviour).

The DK of COMPASS incorporates the error-task related questions (task dependent feedback) as well as the tutoring feedback units (domain dependent feedback). Regarding the error-task related questions, the DK includes the form of the questions, providing flexibility to the teacher in case of any modifications. The form of the questions is differentiated according to the error categories that may be identified on the learner's map. For

example, in case of a "missing relationship" error, the question has the form "Do you consider that you could add a relationship between the concepts of [C1] and [C2]?", while in case of a "superfluous relationship" error, the question has the form "Do you really believe that the concepts [C1] and [C2] are related with the specific relationship?", where [C1] and [C2] are concepts represented on the learner's map. The form of the questions that is associated with each error category (Table 1) as well as examples of the questions are presented in (Gouli et al., 2004).

The tutoring feedback units, included in the DK, concern (i) the concepts represented on the expert's concept map and/or the concepts included in the provided list of concepts (if a list of concepts is provided according to the mapping task) (TFUC), and (ii) specific propositions that the teacher anticipates errors/false beliefs (TFUP). TFUC are organised in two levels, TFUC1 and TFUC2 differing on the level of detail of the feedback information. TFUC1 present the corresponding concept in general and they are independent of the mapping task (i.e. the same TFUC1 can be provided for different mapping tasks, which include the specific concept). TFUC2 present the corresponding concept in more detail, focusing on the relationships of the concept with the other concepts of the map. Thus, TFUC2 depend on the concepts that may be represented on the particular concept map. The definition of TFUC2 is optional, depending on the definition of TFUC1 and the degree of importance of the specific concept. The feedback units (TFUC1 and TFUP) are associated with educational material consisting of knowledge modules, which constitute multiple representations of the concepts included in the proposition (i.e. a definition/description, an example, and/or an image of the concepts). The TFUP have the following form: "*Educational Material*. You believe that [C1] R [C2]. If it is true then *Consequence Text*. Do you insist on your belief?", where (i) *Educational Material* (optionally defined by the teacher) is consisted of knowledge modules (i.e. definition/description, example, image) and concerns information about the concepts [C1] and/or [C2] included in the false proposition, (ii) the triple [C1] R [C2] is the false proposition which appears on the learner's map, and (iii) *Consequence Text* is information that describes a possible consequence of the learner's false proposition (defined compulsory by the teacher). The DK includes for specific propositions, represented on the expert's map, the educational material and the consequence text. An example of TFUP, after its generation by the AFGM, for the false proposition "[Capacity] of the peripheral storage units is lower than that of [Main Memory]" represented on the learner's map in Figure 2, is the following: "*The capacity of the hard disk is usually more than 30 Gigabytes*. You believe that [Capacity] of the peripheral storage units is lower than that of [Main Memory]. If it is true then *it is possible to store your favourite games in Main Memory*. Do you insist on your belief? ".

Summarizing, the domain knowledge of COMPASS, as far as the feedback is concerned, keeps information about (i) the form of the E-TRQ, and (ii) the TFU concerning the TFUC1, TFUC2 and TFUP and subsequently the supported corresponding knowledge modules.

3.1.2   The Learner Model

The LM reflects specific characteristics of the learner and thus it is used as the main source of the adaptive behaviour of COMPASS. The information held is divided into *domain dependent information* and *domain independent information*. As far as the domain dependent information is concerned, the LM keeps information about: (i) the learner's knowledge level (qualitative and quantitative estimation) with respect to the assessment goals/activities that s/he selects, (ii) the learner's errors identified on his/her map, and (iii) the learner's behaviour during his/her interaction with the tool in terms of the number of times that feedback was asked, ITFC proposed/selected, frequency of errors made, time of response, etc. As far as the domain independent information is concerned, the LM keeps general information about the learner such as username, profession, learner's favourite feedback components and knowledge modules (i.e. definition/ description, example, image), last time/date the learner logged on/off. The LM is dynamically updated during the learner's interaction with COMPASS in order to keep track of the learner's "current state".

3.2   Diagnosis of Learner's Knowledge: the Diagnostic Module

The DM receives input from the IMM, which gathers information about the learner's interaction with COMPASS and updates the LM as far as the learner's knowledge level and the learner's errors identified on the map are concerned. In more details, the DM is responsible for (i) the *error diagnosis,* i.e. the identification of errors on the learner's map (based on the similarity of the learner's map with the expert's one) and their qualitative analysis, in order to identify learner's unknown concepts, false beliefs and incomplete understanding, (ii) the *qualitative diagnosis of the learner's knowledge* based on the error categorization proposed in Table 1, and (iii) the *quantitative estimation of the learner's knowledge level* on the central concept of the map and subsequently on the assessment activity, which is further exploited by the AFGM for generating individualized feedback.

Qualitative Diagnosis of Learners' Knowledge	Categories of Learners' Errors
Unknown Concepts	*Missing concept and its relationships:* specific concepts, which should be represented on the map and have been defined as fundamental concepts for the specific task/map, are missing.
Incomplete Understanding	*Incomplete relationship:* the relationships between two concepts are incomplete, as several relationships are missing (e.g. concepts [C1] and [C2] are related with m relationships on the expert's map, while on the learner's map n relationships appear, where n<m).
	Missing relationship: the relationship between two concepts that should be related is missing.
False beliefs	*Superfluous relationship:* two concepts are related although they should not.
	Incorrect relationship: two concepts are related with an incorrect relationship, which should be substituted.
	Incorrect concept: a concept is related to an incorrect concept, which should be replaced with another concept.
	Superfluous concept: a superfluous concept appears, which should be deleted.
	Incomplete propositions: a concept (presented on the learner's map) is not related to all the required concepts because the related concepts are missing.

Table 1: Qualitative Diagnosis of learners' knowledge based on different categories of errors

In order to formulate a framework for the qualitative diagnosis of learners' knowledge, we analysed a sample of learners' concept maps resulted from the accomplishment of various concept mapping tasks (Gouli et al., 2003). In particular, we investigated repeated patterns of valid and invalid propositions and identified several common errors that led us draw conclusions about their knowledge. The identified errors are classified to the categories (qualitative analysis) presented in Table 1 and address the entire aforementioned concept mapping tasks (e.g. the categories of incorrect relationship, incorrect concept, and superfluous concept may be identified in a "concept-relationship completion" task, while all the categories of errors may be identified in a "free-construction" task).

The qualitative diagnosis of the learners' knowledge on an assessment activity concerns the identification of the unknown concepts, incomplete understanding and false beliefs. The learner's knowledge level is quantitatively estimated according to assessment criteria defined by the teacher. COMPASS provides flexibility to the teacher in terms of (i) defining different assessment criteria, and (ii) assigning weights to these criteria denoting their relative degree of importance for the specific assessment activity taking into account several factors such as the addressed assessment outcomes and the difficulty level of the activity. Indicative assessment criteria may be: (i) the completeness of fundamental concepts of the task/map, (ii) the completeness of relationships among the fundamental concepts of the task/map, (iii) the validity of specific weighted propositions, (iv) the error categories identified on the map (taking into account the weights that may be assigned to the different error categories). Based on the assessment criteria, the learners' knowledge level on a specific assessment activity is assigned to one of the characterizations {Insufficient (Ins), Rather Insufficient (RIns), Average (Ave), Rather Sufficient (RSuf) and Sufficient (Suf)}. For the quantitative estimation of the learner's knowledge level on an assessment goal, the degree of importance of the activities for the accomplishment of the goal is taken into account.

3.3 *Generating Adaptive Feedback: the Adaptive Feedback Generation Module*

The AFGM is responsible for the generation of feedback, tailored to each individual learner. More specifically, the AFGM determines which one of the ITFC (E-TRQ and TFU+E-TRQ) should be provided to the learner, according to his/her interaction behaviour, and/or preferences and/or knowledge level. The AFGM receives the content of the TFU as well as the form of the E-TRQ from the DK. In case of the TFU+E-TRQ, the TFU included in the DK in conjunction with the E-TRQ (according to the error categorization) are provided to the learner. For example, for the false proposition "[Capacity] has as basic measurement unit [Gigabytes]" ("incorrect concept" error), which is represented on the learner's map of Figure 2, the AFGM uses the available knowledge modules of TFU (i.e. (i) a description for each one of the concepts included in the proposition, defining their meaning, and (ii) an example concerning the specific concepts, such as an example giving the capacity of several storage units, comparing the storage units as far as their capacity is concerned, and explaining the different measurement units) in conjunction with the E-TRQ "Do you really believe that the [Capacity] has as basic measurement unit [Gigabytes]?", in order to generate the TFU+E-TRQ feedback.

The AFGM uses an adaptation scheme (Gouli et al., 2004) including several rules for planning/deciding the type and the content of the feedback that should be provided to the learner. AFGM exploits information from (i) the learner model (i.e. learner's knowledge level, preferences (i.e. preferences on ITFC and on knowledge modules) and interaction behaviour (i.e. knowledge modules of TFUC1 or TFUP more often provided, ITFC more often provided and frequency of errors made), (ii) the DM, concerning the errors identified on the learner's map and their qualitative analysis (categories of errors), and (iii) the DK concerning the content of the TFU. Indicative rules that have been adopted in the adaptation scheme are (for more details see (Gouli et al., 2004)):

(i) If the knowledge level of the learner has been evaluated as (Ins) or (RIns) on the assessment activity, then both TFU and E-TRQ are provided (TFU+E-TRQ).

(ii) If the knowledge level of the learner has been evaluated as (Suf) or (RSuf) on the assessment activity, then E-TRQ is provided.

(iii) If the knowledge level of the learner has been evaluated as (Ave) on the assessment activity, then according to the learner's preferences (ITFC preferred) and interaction behaviour (ITFC more often provided/selected and frequency of errors made), E-TRQ or TFU+E-TRQ is provided. For example, (a) if the learner's favourite ITFC is E-TRQ but TFU+E-TRQ is more often provided, then TFU+E-TRQ is provided, (b) if the frequency of a specific error identified on the learner's map is minimal (e.g. the learner's map includes very few incorrect relationships), then E-TRQ is provided.

The design of the functionality of the AFGM was carried out in parallel to two empirical studies that we conducted as a pilot evaluation. The two studies were carried out during the winter semester of the academic year 2003-2004, in order to investigate whether the design of the feedback components, as well as the adopted adaptation scheme, could stimulate learners to reflect on their beliefs and appropriately revise their maps (Gouli et al., 2004). The results, even performed on a limited number of subjects, have been encouraging, indicating that the feedback provided led the majority of the students to reconstruct/refine their knowledge and accomplish successfully the assessment activity.

4   Conclusions and Further Research

COMPASS is an adaptive web-based concept map tool, aiming to support learning through the assessment process. In this paper, we presented the architecture of COMPASS and its modules, focusing on the representation of the domain knowledge and the learner model, the diagnosis of the learner's knowledge and the generation of the adaptive feedback. The discriminative characteristics of COMPASS are: the conceptual structure of its domain knowledge, which is based on the notion of assessment goals that the learner can select, the qualitative diagnosis process and the quantitative estimation of the learner's knowledge level, the adoption of multiple informative and tutoring feedback components and the stepwise feedback presentation, the adoption of error-task related questions based on a categorization of learners' common errors, the adoption of the two levels of the tutoring feedback units and the adaptation of feedback to the learner's knowledge level, preferences and interaction behaviour.

As the development phase of COMPASS is in progress, our near future plans include the completion of the implementation of the Diagnostic Module and the Adaptive Feedback Generation Module. Afterwards, we plan to carry out a series of empirical studies in classroom environment, in order to evaluate COMPASS regarding the effectiveness of the diagnosis process, the provided feedback components and the adaptive feedback scheme. Also, further research is in progress concerning (i) the enrichment of the tool's functionality with more adaptive capabilities concerning the provision of the activities of a specific assessment goal gradually according to the learner's knowledge level and his/her expertise in constructing concept maps, (ii) the development of an authoring tool for the administration of the domain knowledge, and (iii) the provision of visual feedback (graphical annotation of the errors, following the proposed error categorization).

5   References

Cañas, A., Coffey, J., Carnot, M., Feltovich, P., Hoffman, R., Feltovich, J., & Novak, J. (2003). *A Summary of Literature Pertaining to the Use of Concept Mapping Techniques and Technologies for Education and Performance Support.* Final report to CNET. Retrieved 2004 from http://www.ihmc.us/users/acanas/Publications/ConceptMapLitReview/IHMC%20Literature%20Review%20on%20Concept%20Mapping.pdf

Cimolino, L., Kay, J., Miller, A. (2003). *Incremental student modelling and reflection by verified concept-mapping*. In Supplementary Proceedings of the AIED2003: Learner Modelling for Reflection Workshop, 219-227.

Chang, K., Sung, T., Chen, S-F. (2001). Learning through computer-based concept mapping with scaffolding aid. *Journal of Computer Assisted Learning,* 17(1), 21-33.

Gogoulou, A., Gouli, E., Grigoriadou, M., & Samarakou, M. (2004). *Adapting the "Communication-Scaffolding" Tools in a Web-based Collaborative Learning Environment*. In Proceedings of the ED-MEDIA 2004, Vol. 2004 (1), 1153-1161.

Gouli, E., Gogoulou, A., & Grigoriadou, M. (2003). A Coherent and Integrated Framework Using Concept Maps for Various Educational Assessment Functions. *Journal of Information Technology Education,* 2, 215-240.

Gouli. E., Gogoulou, A., Papanikolaou, K., & Grigoriadou, M. (2004). *Designing an Adaptive Feedback Scheme to Support Reflection in Concept Mapping*. In Proceedings of the Adaptive Hypermedia Conference 2004: Workshop on Individual Differences in Adaptive Hypermedia (to appear).

Mason, B., Bruning, R. (2001). *Providing Feedback in Computer-based Instruction: What the research tells us*. Retrieved 2004 from http://dwb.unl.edu/Edit/MB/MasonBruning.html

Novak, J., & Gowin, D. (1984). Learning How to Learn. New York: Cambridge University Press.