

How to Qualitatively + Quantitatively Assess Concepts Maps: the case of COMPASS

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Abstract. This paper presents a scheme for the quantitative and qualitative assessment of concept maps in the context of a web-based adaptive concept map assessment tool, referred to as COMPASS. The propositions are characterized qualitatively based on specific criteria and on the error(s) that may be identified. The quantitative assessment depends on the weights assigned to the concepts/propositions and the error categories.

Introduction

In educational settings, where assessment is aligned with instruction, concept maps are considered to be a valuable tool of an assessment toolbox, as they provide an explicit and overt representation of learners' knowledge structure and promote meaningful learning [6]. A concept map is comprised of *nodes*, which represent concepts, and *links*, annotated with labels, which represent relationships between concepts. The triple *Concept-Relationship-Concept* constitutes a *proposition*, which is the fundamental unit of the map.

The assessment of a concept map is usually accomplished by comparing the learner's map with the expert one [7]. Two most commonly investigated assessment methods are the *structural* method [6], which provides a quantitative assessment of the map, taking into account only the valid components, and the *relational* method, which focuses on the accuracy of each proposition. Most of the assessment schemes proposed in literature either have been applied to studies where the evaluation of concept maps is human-based [7], [5] or constitute a theoretical framework [4], while the number of systems that have embedded a scheme for automated assessment and for feedback provision is minimal [1].

In this context, we propose an assessment scheme for both the qualitative and quantitative assessment of concept maps and subsequently for the qualitative and quantitative estimation of learner's knowledge. The assessment scheme has been embedded in COMPASS (COnccept MaP ASSessment tool) (<http://hermes.di.uoa.gr:8080/compass>), an adaptive web-based concept map assessment tool [3], which serves the assessment and the learning processes by employing a variety of activities and providing different informative, tutoring and reflective feedback components, tailored to learners' individual characteristics and needs.

1. The Assessment Scheme embedded in COMPASS

The proposed scheme is based on the relational method and takes into account both the presented concepts on learner's map and their corresponding relationship(s) as well as the missing ones, with respect to the expected propositions presented on expert map. The

propositions are assessed according to specific criteria concerning completeness, accuracy, superfluity, missing out and non-recognizability. More specifically, a proposition is qualitative characterized [3] as (i) *complete-accurate*: when it is the expected one, (ii) *incomplete*: when, at least, one of the expected components (i.e. the involved concepts and their relationship(s)) is incomplete or missing; the error categories that may be identified are incomplete relationship (IR), missing relationship (MR), missing concept and its relationship(s) (MCR) and missing concept belonging to a group and its relationship(s) (MCGR), (iii) *inaccurate*: when, at least, one component/characteristic of the proposition is inaccurate; the error categories that may be identified are incorrect concept (IC), incorrect relationship (INR), concept at different place (CDP) and difference in arrow's direction (DAD), (iv) *inaccurate-superfluous*: when, at least, one component of the proposition is characterized as superfluous; the error categories that may be identified are superfluous relationship (SR) and superfluous concept and its relationship(s) (SCR), (v) *missing*: when the expected proposition is missing (i.e. missing proposition (MP) error), and (vi) *non-recognizable*: when it is not possible to assess the proposition, due to a non-recognizable concept (NRC) and/or a non-recognizable relationship (NRR).

The qualitative assessment is based on the aforementioned qualitative analysis of the errors and aims to contribute to the qualitative diagnosis of learner's knowledge, identifying learner's *incomplete understanding/beliefs* (the errors "MCR", "IR", "MR", "CDP", "MCGR", and "MP" are identified) and *false beliefs* (the errors "SCR", "INR", "IC", "SR", "DAD" are identified). The quantitative analysis is based on the weights assigned to each error category as well as to each concept and proposition that appear on expert map. The weights are assigned by the teacher and reflect the degree of importance of the concepts and propositions as well as of the error categories, with respect to the learning outcomes addressed by the activity. The assessment process consists of the following steps (a detailed description is given in [3]):

- at first, the weights of the concepts, that exist in both maps (learner's and expert) and they are at the correct position, as well as the weights of the propositions on learner's map, which are characterized as complete-accurate, are added to the total score,
- for all the propositions/concepts, which are partially correct (i.e. errors "IR", "IC", "INR", "CDP", and "DAD"), their weights are partially added to the total score; they are adjusted according to the weights of the corresponding error categories and added to the total score,
- for all the propositions/concepts, which are superfluous or missing (i.e. errors "SCR", "SR", "MR", "MCR", and "MCGR"), their weights are ignored and the weights of the related concepts, which have been fully added to the score at the first step, are adjusted according to the weights of the corresponding error categories and subtracted from the total score,
- the total learner's score is divided by the expert's score (weights of all the concepts and propositions, presented on expert map, are added) to produce a ratio as a similarity index.

The results of the quantitative and the qualitative assessment are exploited for the provision of adequate personalised feedback according to the underlying error(s) identified, aiming to stimulate learners to reflect on their beliefs.

2. Empirical Evaluation

During the formative evaluation of COMPASS, an empirical study was conducted, aiming to investigate the validity of the proposed scheme, as far as the quantitative estimation of learners' knowledge is concerned. In particular, we investigated the correlation of the quantitative results obtained from COMPASS with the results derived from two other approaches: (i) the holistic assessment of concept maps by a teacher who assigned a score on a scale from 1 to 10, and (ii) the assessment of maps based on the similarity index algorithm of Goldsmith et al. [2]. The study took place during the school year 2004-2005, in the context of a

course on Informatics at a high school. Sixteen students participated in the study. The students were asked to use COMPASS and work on a “concept-relationship list construction” task, concerning the central concept of “Control Structures”. The results from the assessment of students’ concept maps, according to the three different approaches, are presented in Figure 1. The reader may notice that the quantitative scores obtained from COMPASS converge in a high degree with the scores obtained from the other two assessment approaches.

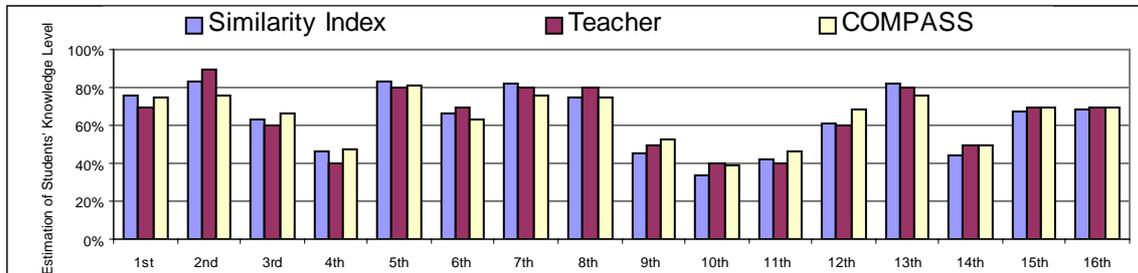


Figure 1. The results of the quantitative assessment of students’ concept maps.

3. Conclusions

The discriminative characteristics of the proposed scheme are: (i) the qualitative characterization of the propositions, (ii) the assessment process followed, which takes into account not only the complete-accurate propositions but also the identified errors, (iii) the qualitative diagnosis of learner’s knowledge, based on the qualitative analysis of the errors identified, (iv) the quantitative estimation of learner’s knowledge level, based on the complete-accurate propositions, on the weights assigned to the concepts, the propositions and the error categories, and (vi) the flexibility provided to the teacher in order to experiment with different weights and to personalize the assessment process. The validity of the proposed assessment scheme can be characterized as satisfactory, as the quantitative estimation of learner’s knowledge obtained from COMPASS are close with the estimation obtained from the human-based assessment and the similarity index algorithm.

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