Fostering Concept Maps Awareness as a Means to Learning

Fabian Kneissl and François Bry
Institute for Informatics
University of Munich
Munich, Germany

***Abstract*—A concept map is a visual representation of concepts as nodes and of relationships between concepts as edges as a diagram consisting of nodes linked with each other. Concept maps support the learning process inasmuch that they make learners aware of their own progresses. We propose a game-like e-learning tool named *Termina* to be used for assessing learners' progresses using which learners can build up their own concept maps and compare them with that of the learners' community. Deploying Termina within the audience of a university course yields snapshots of the concept maps built while participating in the lecture for both each student as well as for the student's community. These concept maps are build from the associations that the students provide through participating in Termina sessions. Learners profit from the concept maps' availability, learn from their fellows and can track their learning process. Lecturers gain insights into the knowledge and ignorance of their students.**

Keywords*—*Concept Maps, Crowdsourcing, E-Learning, Knowledge Representation

I. INTRODUCTION

Concept maps are designed as a visual tool for organizing concepts and relating them with each other. They support active, meaningful learning and therefore represent a good way to get students to think about topics and to gain knowledge that is interconnected with existing knowledge the students have [1]. It is thus natural that (successful) attempts have been made to include concept maps into students' learning processes (see, e.g., [2]).

Rather than constructing concept maps directly in class or in groups as it has been suggested, e.g., in [1] we propose to generate related concepts while using a game-like e-learning tool, called *Termina*, and constructing a concept map through the data gathered that way. Termina can be used without any knowledge of concept maps. Some knowledge of the issues of the lecture suffice for participating in Termina sessions. During a Termina session a term representing a concept is displayed to the student and she is asked to enter terms related to the displayed term, or concept. After giving associations for several concepts a summary of the terms proposed by the student is displayed, including answers of other students to show deficits in knowledge. Lecturers can classify associations into *close* and *far*, resembling the closeness of the associations to their original concepts. From the knowledge gathered this way concept maps (with unlabeled relations) are constructed automatically for the students' and lecturers' investigations.

The contributions of this article are as follows.

- A game-like e-learning tool, called Termina, gathering concepts and the relations between concepts so far learned, is presented.
- The construction of single learners' or multi learners' concept maps from data gathered with this tool is described.
- An example of a multi learners' concept map generated from data gathered during a university course is evaluated.

II. RELATED WORK

Concept maps were first developed by Novak for fostering children's and students' understanding of science concepts and evaluating their progress in a twelve year long study [3]. Concept maps are graphical tools for organizing and representing knowledge [1] and consist of concepts –visualized as text in boxes or circles– and relationships between them –indicated by lines– which are usually specified with one or more words. Concept maps have proven to be useful not only for evaluation but also for, e.g., brainstorming and learning [1]. An approach of employing computer-based concept mapping in schools as learning environment shows encouraging results [2].

Crowdsourcing is the collaboration of many humans to solve a certain problem [4]. Numerous crowdsourcing systems have been proposed, including approaches for gathering semantically linked data. For example the online game "JeuxDeMots" gathers terms and typed relations between terms for knowledge acquisition [5], however without relating to useful concept maps. A taxonomy of similar terms like "human computation", where human processing power is employed for solving problems computers can not yet solve, which are related to crowdsourcing is given in [6].

E-learning denotes the use of technology for learning [7] and it appears in many facets, e.g., using computer programs for experiments, online training, or even massive open online courses (MOOCs) [8]. E-learning tools often include game-like elements for encouraging the user's participation. An example combining e-learning with crowdsourcing is Duolingo[1], where people learn foreign languages while collaboratively translating documents on the Web. A crowdsourced creation of e-learning content in a wiki has been proposed in [9].

[1]Duolingo, available at http://www.duolingo.org

To the authors' best knowledge no previous work employs a game-like e-learning tool fostering the awareness of concept maps and generating them.

III. Gathering Semantically Related Concepts

A. Deploying Seed Data

Termina focuses on relations between concepts and is thus suited to give an overview over a topic as well as to generate links between topics, facilitating cross-linked learning. To this aim, Termina is always based on one specific topic, in this article the topic of a course at university. Seed data, which is needed in order that students can participate in Termina sessions, is imported into Termina by lecturers. This data consists of concepts that are important for this course, their difficulty, a set of important associated terms for each concept, and concept subsets. The concepts and associated terms imported by lecturers are the basis for Termina sessions. During further sessions students add more associated terms to the existing ones. The difficulty of concepts is represented as number –we use numbers one to three– and it affects the score students can achieve in Termina sessions: the higher a concept's difficulty the higher the achievable score. Lecturers can therefore award students more points for naming associated terms for difficult concepts than for easy concepts. Concept subsets are, e.g., chapters or smaller topics of the course containing a subset of all concepts. Students employing Termina can then focus on learning concepts of one chapter in addition to all concepts of the whole course.

For generating the seed data itself several options exist. In the simplest case, lecturers manually enter concepts, difficulties, and sets of associated terms. Here, the lecturer has full control over all data. Seed data can also be generated from notes or slides accompanying the course employing an algorithm which extracts highlighted words as concepts and words on the same slide as associated terms. Before importing seed data generated this way the lecturer should review it and set the concepts' difficulties.

B. Operation of a Termina Session

Upon starting a Termina session students can optionally adjust the default level of difficulty which consists of the time they have for each concept and the number of associated terms to be named for each concept. Students can therefore learn according to their current learning progress which might be at the beginning or already advanced. Students can also opt to be faced with a subset of all concepts, e.g., to revise just the first chapter of the course.

During a Termina session a normal mode alternates with a choice-based mode, which is displayed every three rounds to add some variety. In the normal mode one concept, chosen at random within the current topic or subset, is presented to the student and she is prompted to enter associated terms to this concept (see Figure 1 for a screenshot). In the choice-based mode one random concept is shown together with close and far associated terms where the student has to choose the closest ones in order to gain points.

For each entered (or chosen) term the student either gains points (in case it is classified as *close* by lecturers), or looses points (in case it is classified as *far* by lecturers), or gains no points (in case it is *unclassified*, i.e., has not yet been classified). The number of points depends on the concept's difficulty as well as the session's level of difficulty. The formula for calculating the points for a student's associated terms for one concept is:

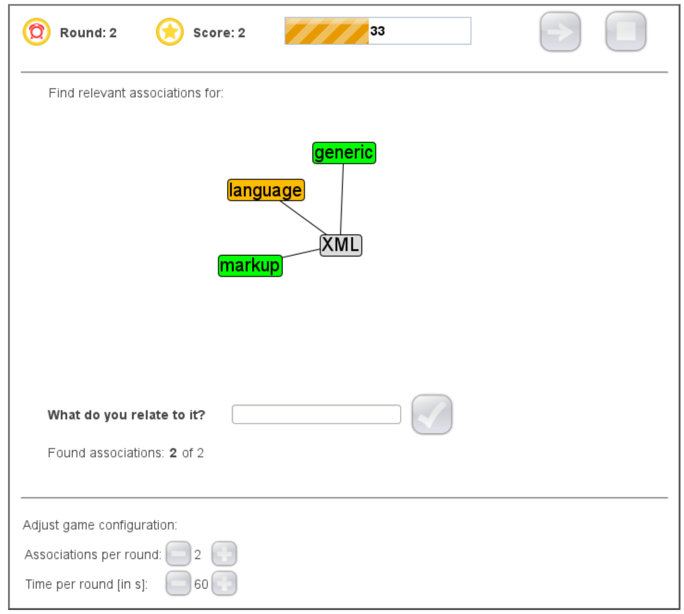

Fig. 1. This screenshot depicts a Termina session in progress where the student already mentioned two close associated terms "markup" and "generic" and an unclassified associated term "language" for the concept "XML".

$$points = (2 \cdot a_{close} - n) \cdot d_c \cdot t - a_{far} \quad (1)$$

where

a_{close}	number of close associated terms
a_{far}	number of far associated terms
n	number of associated terms to be named
d_c	difficulty of the concept
t	time factor, increasing with decreasing time

Therefore if no associated term is entered or if all associated terms entered are unknown the number of points is negative, giving the feedback that the student does not know enough for this concept. As soon as half of the required number of close associated terms have been entered the number of points is zero, becoming positive with a higher number of close associated terms. Penalty points are deducted when entering far associated terms. The points therefore serve the purpose of reflecting how well students know associated terms for a concept.

The next concept is shown if the time is up or if as many verified associated terms as chosen in the level of difficulty have been entered. A session finishes if either associations for all concepts have been given or the student's total points become negative.

At the end of the session, a summary of the concepts and associated terms is displayed in the form of concept maps. Terms entered by other students are displayed as well as the ones by the student herself. Therefore she can monitor her

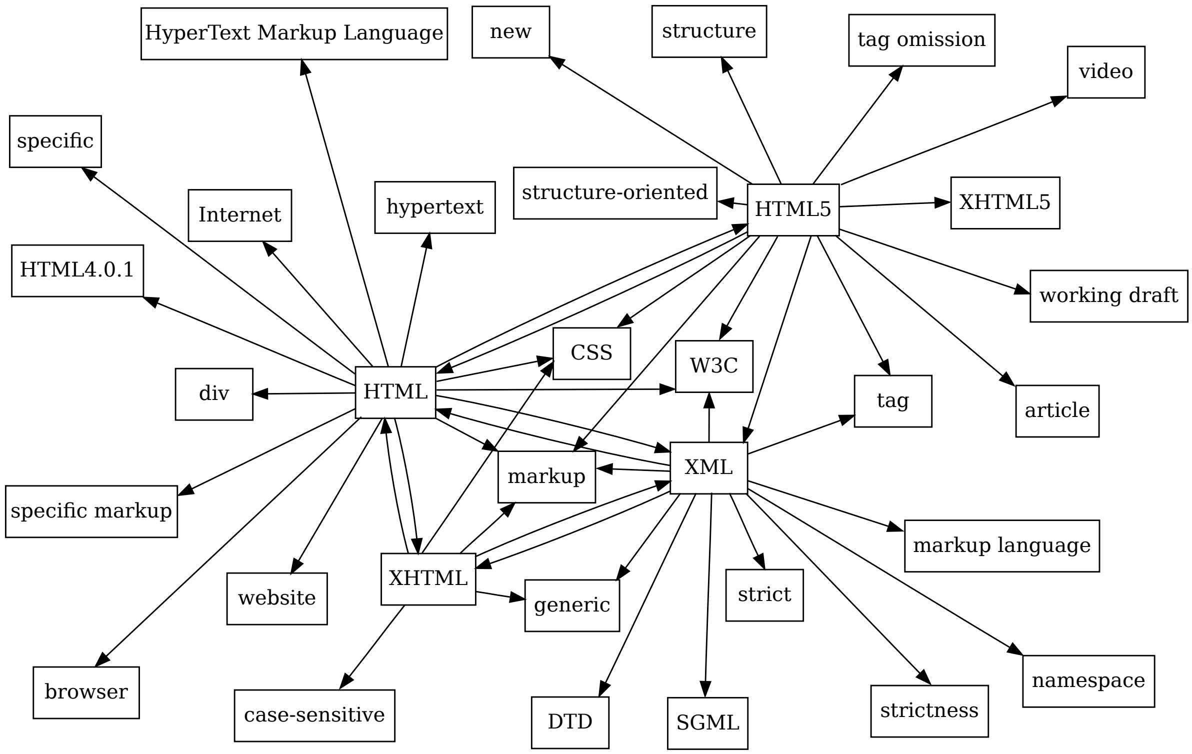

Fig. 2. An example of a multi learners' concept map (with unlabeled relations) generated from data gathered with Termina at the beginning of a course on markup languages and Web information systems.

progress, see gaps in her knowledge, and discover where she should learn more. She can compare her contribution to terms by the community of all students and learn associations which she did not realize that existed before.

C. Classification of Associated Terms

From the lecturers' point of view the status of associated terms is an important issue. No associated terms that are wrong or do not closely match to the concept should be classified as *close* because students must not be incited to learn possibly wrong associations. Therefore all new associated terms entered by students, which are by default *unclassified*, are presented to lecturers for classification into either *close* or *far*. The naming of *close* and *far* resembles the fact that with associations there usually is no right and wrong because every concept is (more or less directly) associated with each other.

IV. Construction of Concept Maps

The construction of concept maps happens in a crowd-sourced process where both students and lecturers are involved. Lecturers define the concepts and an initial set of associated terms. Students extend the number of associated terms in Termina sessions. Lecturers classify these as close or far.

We distinguish between single learners' and multi learners' concept maps, where single learners' concept maps contain associated terms just from one learner and multi learners' concept maps contain associated terms from all learners taking part in Termina sessions. In single learners' concept maps, including close as well as unknown and far associated terms can help learners to identify where they misunderstand a certain topic. Such concept maps are employed during Termina sessions. For multi learners' concept maps, only close associations are included in order to generate "correct" concept maps and also to decrease the concept map's complexity. They are constructed for learners reviewing their progress. For displaying the results after a Termina session, a concept map combining both approaches is displayed where associated terms from the learner herself –these terms are highlighted in order to be easily identifiable– as well as from other learners are displayed. This incorporates the advantages of both, single learners' and multi learners' concept maps.

In general a multi learners' concept map cannot contain all close associated terms that have ever been named by learners because its sheer number would overwhelm anybody looking at the concept map. A good way to filter associated terms is to look at the number of times an associated term has been named by different learners, the *strength* of the association, and discard all associations with a strength lower than a certain threshold. The threshold needs to be set depending on the number of learners taking part in Termina, for a low number of learners a reasonable number is 2. Associations with a strength equal to or greater than the threshold value are included in the concept map, all others disregarded.

Concept maps can be generated separately for each topic subset as smaller maps or for the whole topic of a course as a big overview map. Depending on the desired level of detail different thresholds might be specified for these two concept maps.

V. Evaluation

Termina's design has been improved employing usability studies and iterative improvements in order to be as intuitive to use as possible. Results of a user study show that Termina is easily understandable and that students would appreciate Termina being used in lectures [10].

After these motivating results, we employed Termina in a realistic setting in a university course about markup languages and Web information systems. Students engaged in Termina which lead to manifold associations. An extract of the concepts and the gathered associated tags is depicted in Figure 2. The concepts HTML, HTML5, XHTML, and XML are well connected, important associated tags as "generic" and "specific" markup language, "strictness", and features of HTML5 are stated. This yields a valuable concept map of a part of the course's topic, for example useful for learning and revising the topic.

One longer term goal of Termina is a contribution towards collecting data for learning analytics, the collection and analysis of data about learners for improving learning [11]. This may have impact on the way students learn. To this aim, Termina has to be in use for several years. The evaluation presented here is thus just at the beginning.

VI. Conclusion and Future Work

In this article the game-like e-learning tool Termina is presented that can promote concept maps as a means to learning for students. Termina's data gathering process is described and a method for generating concept maps from the data gathered proposed. Furthermore, an exemplary concept map generated during the beginning of a university course is evaluated.

Further improvements include gathering seed data with an algorithm that, e.g., parses lecture slides and furthermore the deployment of a second game-like tool on the same platform for gathering labels for the associations between concepts and associated tags. By labelling the associations students learn on a meta-level yielding better insight into the topic. Also the concept mapping can then be extended with labeled relations.

Acknowledgment

The authors would like to thank Katharina Krug, Romy Buchschmid, and Niels Becker for helping in the implementation of Termina.

This research has been funded in part by the German Foundation of Research (DFG) within the project Play4Science number 578416.

References

[1] J. D. Novak and A. J. Cañas, "The Theory Underlying Concept Maps and How to Construct and Use Them," Florida Institute for Human and Machine Cognition, Technical Report IHMC CmapTools 2006-01 Rev 01-2008, 2008.

[2] A. J. Cañas and J. D. Novak, "Facilitating the Adoption of Concept Mapping Using CmapTools to Enhance Meaningful Learning," in *Knowledge Cartography, Software Tools and Mapping Techniques*, A. Okada, S. J. Buckinham Shum, and T. Sherborne, Eds. Springer, 2008.

[3] J. D. Novak and M. Dismas, "A Twelve-Year Longitudinal Study of Science Concept Learning," *American Educational Research Journal*, vol. 28, no. 1, pp. 117–153, 1991.

[4] A. Doan, R. Ramakrishnan, and A. Y. Halevy, "Crowdsourcing Systems on the World-Wide Web," *Communications of the ACM*, vol. 54, no. 4, pp. 86–96, 2011.

[5] M. Zarrouk, M. Lafourcade, and A. Joubert, "Inference and Reconciliation in a Crowdsourced Lexical-Semantic Network," in *Proceedings of the 14th International Conference on Intelligent Text Processing and Computational Linguistics (CICLing)*, 2013.

[6] A. J. Quinn and B. B. Bederson, "Human Computation: A Survey and Taxonomy of a Growing Field," in *Proceedings of the 29th Annual Conference on Human Factors in Computing Systems (CHI)*, 2011.

[7] E. T. Welsh, C. R. Wanberg, K. G. Brown, and M. J. Simmering, "E-learning: emerging uses, empirical results and future directions," *International Journal of Training and Development*, vol. 7, no. 4, pp. 245–258, 2003.

[8] J. Daniel, "Making Sense of MOOCs: Musings in a Maze of Myth, Paradox and Possibility," *Journal of Interactive Media in Education*, vol. 3, 2012.

[9] D. Tarasowa, A. Khalili, S. Auer, and J. Unbehauen, "CrowdLearn: Crowd-sourcing the Creation of Highly-structured E-Learning Content," in *Proceedings of the 5th International Conference on Computer Supported Education (CSEDU)*, 2013.

[10] R. Buchschmid, "Development and Evaluation of a User Interface for an E-Learning Game," Bachelor Thesis, 2012.

[11] G. Siemens and P. Long, "Penetrating the Fog: Analytics in Learning and Education," *Educause Review*, vol. 46, no. 5, 2011.