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Finding factors influencing students’ preferences to concept mapping tasks: literature review

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Abstract

There is a broad set of concept mapping tasks which can be used by teachers for assessing students’ knowledge structures but there are no known works of research studying their adaptation to students’ individual differences and preferences in relation to different tasks. The paper reports first results of activities which aim to offer a solution of the abovementioned problem. It is based on extensive review of theoretical and empirical studies and focuses on: a) identification of advantages and drawbacks of different concept mapping tasks, and b) finding factors which may affect students’ concept mapping ability.

Keywords: concept map; knowledge assessment; concept mapping task; cognitive style; learning style

1. Introduction

Knowledge structure (also called structural knowledge or cognitive structure) refers to the way how individuals relate and organize domain-specific concepts and ideas in their long-term memory (Davis, Curtis, and Tschetter, 2003; Clariana, 2009). Structural knowledge is important because it allows for fluency in cognitive activity (Clariana, 2009) and accounts for high-level problem-solving performance by experts (Davis et al., 2003). Assessment of knowledge structure should be an integral part of regular assessment of learning outcomes (Clariana, 2009; Davis et al., 2003). Concept mapping is a pedagogical tool which can be used for assessment and elaboration of students’ knowledge structures. It allows students to externalize their cognitive structure which further can be analyzed with aim to identify unknown concepts, false beliefs, and misconceptions. Using a concept map (CM), knowledge is represented in the form of a graph which labeled nodes display concepts in a knowledge domain and

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arcs with linking phrases show relations between pairs of concepts. The main semantic units of CMs are propositions which include one or more interrelated concepts.

A broad set of concept mapping tasks (CMTs) can be used by teachers. Their possible taxonomy is described in (Anohina-Naumeca and Graudina, 2012). Taking into account the author’s 7-years experience of usage of CMs in computer-aided assessment, the following important problems have been identified (Anohina-Naumeca, 2012): a) students usually have difficulties in completion of CMTs, b) different students prefer different CMTs, and c) students tend to change the difficulty degree of a CMT (such option is provided in the software used by the author) if a teacher sets the same difficulty degree for all students. These facts allow thinking of necessity to carry out adaptive CM based assessment. However, so far there are no known works of research studying students’ preferences in relation to CMTs and adaptation of tasks to students’ individual differences.

The study presented in this paper is a part of the larger research which seeks to develop models and tools for formative assessment of students’ knowledge structures in adaptive manner. As the first step of this research the previously mentioned taxonomy of CMTs was developed. The paper reports initial results of the second step which aims at identification of factors influencing students’ preferences in regard to CMTs. Therefore, the paper presents an extensive literature review which was performed with the goal to make conclusions and to find further research directions, taking into account the problem described above. It considers both theoretical and empirical studies and focuses on two research questions: a) what are the main advantages and drawbacks of different CMTs? and b) what factors may affect students’ concept mapping ability?

The paper is organized as follows. The next section examines advantages and drawbacks of CMTs. After that an overview of existent research concerning different factors and students’ concept mapping ability is presented. Discussion points, conclusions, and directions of future work are given at the end of the paper.

2. Concept Map Based Assessment Tasks: Advantages and Drawbacks

The study focuses on simple CMTs related to externalization of students’ knowledge structures (Anohina-Naumeca and Graudina, 2012). These tasks can be divided in two main groups: “fill-in-the-map” tasks where students must operate with the already provided structure of a CM taking into account constraints on other elements of the CM (concepts, linking phrases, arc direction, and arc weights) and “construct-the-map” tasks where structure of a CM is not provided and students must create it within the framework of constraints on other elements. From one side, in practice “construct-the-map” tasks are used more often than “fill-in-the-map” tasks (Strautmane, 2012). From another side, “fill-in-the-map” tasks most correlate with traditional assessment methods like different kinds of tests (Himangshu and Cassata-Widera, 2010). A number of advantages and drawbacks of CMTs have been found in scientific publications. These findings are presented in the following sub-sections.

2.1. “Fill-in-the-map” tasks

The principal ideologists of the concept mapping theory – Novak and Cañas – do not recommend using “fill-in-the-map” tasks (Cañas and Novak, 2012). They explain that these tasks promote rote learning because it is not obvious for students where to place a specific concept. The contradictory assertion is provided in (Himangshu and Cassata-Widera, 2010) where an ability to distinguish rote learning from conceptual learning is mentioned as an advantage of “fill-in-the-map” tasks. The authors have viewpoint that rote learning is readily forgotten, but conceptual understanding (even superficial) is needed for creation of propositions. Other research gives evidence that tasks where students need to fill-in empty nodes of a CM and missing linking phrases with items from a given list provide both an adequate degree of structure and sufficient potential for self-construction of a CM (Ryssel, Sommer, Fürstenau, and Kunath, 2008).

In general, the following advantages of “fill-in-the-map” tasks are mentioned by different researchers: a) students learn to complete “fill-in-the-map” tasks quickly and like completing them (Schau, Mattern, Zeilik, Teague, and Weber, 2001), b) a simple accepted scoring system exists (Himangshu and Cassata-Widera, 2010; Schau et al., 2001), so tasks can be easily and quickly administered (Albert and Steiner, 2005), c) students with lower levels of
communication skills can complete tasks where concepts should be inserted in a CM (Schau et al., 2001), d) “fill-in-the-map” tasks allow validation of specific parts of a CM, for example, only relations (Albert and Steiner, 2005), e) tasks where students should provide only linking phrases reduce cognitive load and uncertainty (Gurlitt, Renkl, Motes, and Hauser, 2006), f) “fill-in-the-map” tasks most correlate with traditional assessment methods like standardized tests, multiple choice tests, and instructor designed tests (Himangshu and Cassata-Widera, 2010), and g) students with lower levels of expertise benefit more from tasks where they need to provide linking phrases (Gurlitt, Renkl, Faulhaber, and Fischer, 2007).

However, the fact that the structure of a CM is already given to students underlies the main drawback of these CMTs. Students do not represent their unique cognitive structure (Albert and Steiner, 2005; Schau et al., 2001). Therefore, only a part of knowledge can be queried because the other part is already given in a task (Albert and Steiner, 2005). As a result, some information about students’ knowledge is lost, for example, misconceptions (Himangshu and Cassata-Widera, 2010). In this context, a conclusion given in (Albert and Steiner, 2005) that validity (ability to adequately represent knowledge under assessment) of a task is likely to be overestimated seems quite reasonable. “Fill-in-the-map” tasks due to their restrictions may not provide the potential for students to make links to a larger conceptual framework within the science domain, to other academic domains, or to personal experience (Himangshu and Cassata-Widera, 2010).

Few authors have studied different sub-types of “fill-in-the-map” tasks. It was found that tasks where students should fill-in empty nodes of a CM and tasks where students should provide linking phrases could not be considered equivalent forms of “fill-in-the-map” tasks because the former was easier for students than the latter (Ruiz-Primo, 2000). Other study (Wang and Dwyer, 2004) showed that tasks where some linking phrases are missing and students need to define them could be confusing for those learners who have limited prior knowledge because there can be a broad set of linking phrases that can be inserted and this leads to ambiguity. Tasks where students fill-in only some empty nodes could be effective for students with low prior knowledge.

2.2. “Construct-the-map” tasks

“Construct-the-map” tasks do not restrict students in the structure and, depending on a task type, in the content of a CM. As a result, they are process open, allow students to construct more enriched CMs, and students, completing them, use strategies that do not include guessing, but elicit more content-relevant explanations (Gouli, Gogoulou, and Grigoriadou, 2003; Ruiz-Primo, Shavelson, and Schultz, 2001). Moreover, they better highlight differences in students’ knowledge (Ruiz-Primo, 2000) and reveal preconceptions, misconceptions, and overall picture of students’ knowledge structures (Himangshu and Cassata-Widera, 2010).

Two “construct-the-map” tasks are compared in (Yin, Vanides, Ruiz-Primo, Ayala, and Shavelson, 2005). The following conclusions are made in relation to construction of a CM from given concepts: a) it more accurately reflects differences of students’ knowledge structures, b) it provides greater latitude for demonstrating students’ partial understanding and misconceptions, c) it supplies students with more opportunities to reveal their conceptual understanding, d) it elicits more high-order cognitive processes, such as explaining and planning, e) it is more suitable for formative assessment, and f) students create CMs with a complex structure because the task allows students to show more of what they know. In relation to construction of a CM from given concepts and linking phrases, the authors have made the following conclusions: a) it is cost and time efficient, b) it can be scored more efficiently than the task where only concepts are used because linking phrases are restricted, c) it is more suitable for large-scale assessment, and d) students construct propositions more slowly because there is the mediating selection process of suitable linking phrases.

In the experimental study presented in (Gouli et al., 2003), a task where initially students freely construct a CM and then extend it with the given concepts had the most effective result as it helped the majority of the students to check their thinking, to correct their errors, and to restructure their maps. In (Gurlitt et al., 2007), it is found that students with higher levels of expertise benefit more from construction of a CM from given concepts.

The main drawbacks of “construct-the-map” tasks are the following: a) these tasks impose high cognitive demand (Wang and Dwyer, 2004), b) it is necessary to learn how to construct CMs and then actually construct them,
processes that are time-consuming and can be tedious and frustrating (Schau et al., 2001; Wang and Dwyer, 2004),
c) there is no universally accepted and simple scoring system (Albert and Steiner, 2005; Himangshu and Cassata-Widera, 2010; Ruiz-Primo, 2000; Schau et al., 2001; Yin et al., 2005) because each CM can contain a unique set of concepts and linking phrases, d) the quality of student’s CMs depends heavily on the individual’s communication skills (Schau et al., 2001), e) construction of a CM from given concepts can restrict students to the given list and prevent them from thinking of any additional concepts, so such tasks are not effective for eliciting students’ prior knowledge because students try to represent on their maps almost all the given concepts, sometimes completely without clear understanding of their meaning (Gouli et al., 2003). In another study, students completing free construction tasks provided related, but irrelevant to the topic concepts and produced accurate, but irrelevant relations which led to artificially high scores in a task (Ruiz-Primo, 2000).

3. Factors Influencing Students’ Concept Mapping Ability

Existence of a link between students’ cognitive style and their concept mapping ability is examined in (DeFranco, Jablokow, Bilen, and Gordon, 2012). Kirton Adaption–Innovation Inventory (http://www.kaicentre.com/) was used for determination of the cognitive style. It represents the cognitive style on a bipolar continuum that ranges from high adaptive individuals (they prefer problem solving in the framework of existing guidelines/rules/structure) to high innovative individuals (they prefer to solve problems in free style). The authors found that if an individual is more innovative than adaptive, then the number of concepts and the number of relations in a CM tends to increase. They explained that innovative individuals tend to offer more ideas (than adaptive individuals) and this leads to the increasing number of concepts.

Novak and Cañas (Novak and Cañas, 2007) acknowledge that some students and even some teachers can have difficulties in construction of CMs at least early in their experience. However, they explain these difficulties by years of rote learning practice in school settings rather than as a result of brain structure differences per se. They also relate differences in the learning style to differences in the patterns of learning that students have employed varying from high commitment to continuous rote-mode learning to almost exclusive commitment. In (Kostovich, Poradzisz, Wood, and O’Brien, 2007), no significant difference was found between learning style preference and CM grades. The conclusion was made that the learning style does not play a role in students’ ability to perform well on CMs and concept mapping can be effective for students with all kinds of learning style. In (Pelley, 2006), effect of concept mapping on Myers-Briggs personality types is studied. The conclusion is that the process of constructing a CM is approached differently by each of the personality types because these types are characterized by different preferences for information processing. Concept mapping benefits each of the Myers-Briggs personality types by helping to develop the use of their non-preferred mental functions.

In (Bello and Abimbol, 1997), there was not identified gender influence on students’ concept mapping ability in general and ability to develop good CMs in particular. In (Laight, 2006), gender was not associated with attitude to CMs. Other authors, considering cognitive demands of CMTs, give an advice to provide a list of concepts associated with a particular topic for novice learners, but experienced learners can construct their maps in free manner relying on their own knowledge (Himangshu and Cassata-Widera, 2010). One of the factors contributing to students’ difficulties in usage of CMs could be an unfamiliar knowledge domain. As a result, students may not have prior knowledge which can be used to relate and make sense of newly acquired information (De Simone, 2007). Different conditions on CM structure and content has strong effect on quality and type of students’ CMs, so different conditions should be used for different purposes (Cañas and Novak, 2012).

4. Discussion, Conclusion, and Future Work

Regardless of the 40-years history of research in the field of concept mapping, CM based assessment mainly has been considered from the viewpoint of finding the most effective scoring mechanism for students’ CMs, but a number of important questions such as effectiveness of different CMTs in relation to assessment of learning outcomes or elicitation of different cognitive processes, impact of availability of different elements of CMs on the
difficulty degree of CMTs, students’ preferences, or suitability of different CMTs for different purposes have been left disregarded. Those few works of research which exist at the moment consider a very restricted sub-set of CMTs: construction of CMs from only given concepts or from given concepts and linking phrases and filling nodes of a CM with provided concepts or with freely chosen concepts and/or filling linking phrases. The developed taxonomy of CMTs provides the greater number of potential tasks. Moreover, such elements of CMs as weights of arcs and direction of arcs have not been taken into account in known studies at all.

The research shows that drawbacks and advantages of different CMTs have been studied poorly. Mainly they are defined taking into account only a few sub-types of two main categories of tasks. At the same time, the obvious fact is that the main problem of “fill-in-the-map” tasks is related to their validity due to the given structure of a CM which is the distinctive feature of this type of CMTs. Therefore, it is not reasonable to use them for assessment where grading is important. However, “fill-in-the-map” tasks seem quite suitable for formative assessment (assessment for learning), at least in two situations: at early stages of introduction of CM-based formative assessment in a group of students and for working with students who have lower levels of communication skills and prior knowledge. In the former case, these tasks can serve as “a launching pad” for subsequent transition to “construct-the-map” tasks: a) students can learn quickly the idea of concept mapping without spending additional cognitive load, b) different sub-types of these tasks allow practicing different elements of CMs, and c) students can be easily introduced in the scoring schema of CMs and further they can use this knowledge for peer evaluation of “construct-the-map” tasks, shifting assessment process from the teacher to students. When students will reach some proficiency in concept mapping, the teacher could start to offer them different sub-types of construction tasks allowing incrementally to achieve the level when students will be able to construct their CMs from scratch and to evaluate CMs of their peers.

The literature review allowed finding the following factors which may influence students’ concept mapping ability: cognitive style, learning style, experience in usage of CMs, volume and quality of prior knowledge, familiarity with a knowledge domain, and gender. It is quite obvious that the cognitive style can play an important role in students’ preferences of CMTs, because it is directly related to the way how individuals process information and acquire knowledge. Moreover, Kirton Adaption–Innovation Inventory used in one of the studies seems very suitable for determination of students’ cognitive style in relation to CMTs because “fill-in-the-map” tasks provide students with a pre-defined structure of a CM, so supporting adaptive individuals. “Construct-the-map” tasks support innovative individuals, as they allow constructing a CM in free manner.

There are no studies examining influence of learning style and gender to students’ preferences of CMTs. Only few works of research consider linkage between the learning style/gender and the general concept mapping ability. Therefore, it is not correctly to exclude these two factors from further analysis. Previous experience in usage of CMs obviously is important because CMs demand changes in the way of thinking since the whole picture of a knowledge domain should be seen. This can be difficult if previous learning experience mostly includes rote learning. Construction tasks could be offered to students who are quite experienced in concept mapping. Concept mapping games (Cañas and Novak, 2012) can be suitable for novices when introducing them idea of CMs. Students with little experience could benefit from “fill-in-the-map” tasks. Importance of volume and quality of prior knowledge is coming from the general theory of concept mapping. Students with little prior knowledge definitely will have problems with integration of new concepts into their knowledge structure and externalization of their structure due to knowledge gaps and inconsistencies. Therefore, “construct-the-map” tasks may not be the best solution for them.

Actually, all factors mentioned in this section provide potential for further research. In future work it is planned to focus on students’ cognitive style as a factor that should be taken into account making adaptation of CMTs to a particular student.

References


