USING WORKED EXAMPLE TO TEACH THE ROLE OF FOCUS QUESTION: BUILDING CONCEPTUAL UNDERSTANDING ABOUT CONCEPT MAPPING

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Abstract. Frequently, students fail to define a proper focus question (FQ) and, sometimes, even ignore it during the concept map (Cmap) elaboration. In this study, we propose the development and test of a process-oriented worked example (WE) to explain the concept of a focus question (FQ) to new mappers. Twenty-six graduate students were randomly assigned in Control Group (CG, did not study the WE, n = 12) and Experimental Group (EG, did study the WE, n = 14). A pairwise comparison was conducted for the performance in near- (questionnaires) and far-transfer tests (declaring a FQ). The results indicated that no effect existed for the near-transfer test when studying the WE; for the far-transfer test, studying the WE somewhat disturbed the conceptual understanding of FQ. Perhaps, the WE format caused an extraneous cognitive load and left only little working memory resources for germane load related to learn about the role of FQ. This process would be reflected in a poor performance during the tests. Moreover, the prior discussion about Cmap might negatively interfere in the training phase. Final considerations are teaching the role of FQ is not a trivial task and the use of WE might not be so proper for this purpose. Changes in the proposed WE format are under consideration to run future studies.
Keywords: Concept map, cognitive load theory, focus question, worked example.

1 Introduction

Concept maps (Cmaps) are powerful graphic organizers that represent knowledge and foster meaningful learning (Novak, 2010). Despite their benefits (Nesbit & Adesope, 2006; Novak & Cañas, 2010), teachers do not succeed in classroom implementation; one cause is the lack of training on elaborating Cmaps (Aguiar & Correia, 2013; Correia et al. 2008). The foundations of concept mapping are rarely discussed in classrooms, and those involved usually do not grasp the critical aspects of this knowledge representation technique (Cañas et al., 2014; Cañas & Novak, 2006). Our research group advocates that focus question is a central concept that must be understood to elaborate good Cmaps (Aguiar et al. 2014). Its role to hierarchize and select pertinent knowledge to be mapped is neglected in most Cmaps produced by students and researchers; only a few are concerned about the need of declaring it. In other words, any Cmap may seem appropriate without a focus question.

Any topic (e.g., environmental problems) can generate many different Cmaps, each one addressing specific aspects of it. The focus question helps the mapper keep his/her focus on during the selection of concepts and propositions to elaborate the Cmap. Moreover, the selection of a focus question allows the teacher to compare Cmaps produced by different students (Cañas et al., 2012) and to adjust the type of thinking to be fostered (descriptive or dynamic). Several papers have shown the effect of how-type focus questions in creating dynamic Cmaps with more interdependence among concepts (Derbentseva et al., 2006, 2007; Safayeni et al., 2005). Despite the relevance of the focus question, our experience has shown the students fail to define a focus question and, sometimes, even ignore it during Cmap elaboration.

Cmap elaboration is a cognitively demanding task that requires the content to be mapped and the technique of knowledge representation (e.g., the role of focus question to make good Cmaps). These cognitive processes may be overwhelming and impair the learning process (Correia & Aguiar, 2014). According to cognitive load theory (CLT), instructional design must pursue the optimization of the learning materials and tasks to avoid cognitive overload (Sweller, Ayres & Kalyuga, 2011). This theory offers several instructional guidelines; the use of worked examples (WE) is one of them.

1.1 Cognitive load theory and worked examples

CLT proposes that all information is processed by the limited working memory (WM) and learning achievement leads to the construction of schemas (by chunking) between new knowledge and information already organized in (unlimited) long-term memory. CLT assumes that WM might suffer interference of three types of cognitive loads: (1) intrinsic load, depending on content complexity; (2) extraneous load, depending on instructional methods and materials used during learning tasks; and (3) germane load, which is resources of WM that directly contributes to the learning process. Intrinsic and extraneous load are additives. If both require more resources than the limits of WM allow, we assume an overload situation. In this case, there are no resources left to enhance learning (Sweller, Ayres & Kalyuga, 2011).

Instructional design based on CLT considers the limits of WM and keeps the extraneous cognitive load as low as possible. This offers the opportunity to increase germane cognitive load and allows people to acquire schemas. Among the instructional strategies used for this purpose, WE is a method that guides the solution of a problem by presenting a systematic logic (Atkinson et al., 2000). In this study we propose a process-oriented WE that shows a problem, a goal state, and the steps to find a solution to the problem. WE imposes a low cognitive load in WM compared to the conventional solving problem because it scaffolds learning to reach task solution (van Gog, Paas & van Merriënboer, 2006).

2 Methods

2.1 Participants and materials

Twenty-six graduate students in the *EDM5103 Collaborative Learning and Concept Mapping: Fundamentals, Challenges and Perspectives* course offered at the University of São Paulo took part in this study (1st semester/2014). Participants were randomly assigned to either Control Group (did not study WE, CG, n = 12) or an Experimental Group (studied WE, EG, n = 14).

2.1.1 Worked Example

Figure 1 shows the process-oriented WE about focus question.

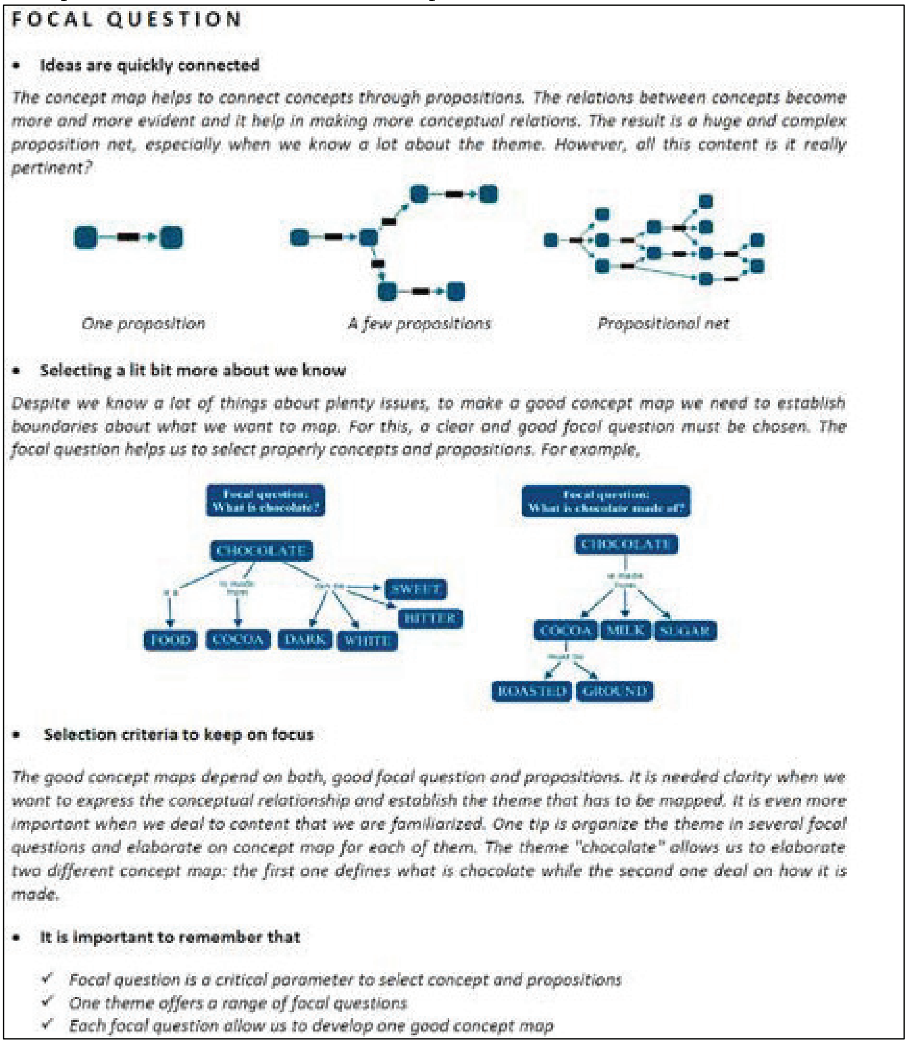


Figure 1. The process-oriented WE about focus question studied only by the EG. Each topic (in bold) was followed by an explanation and example (in italics).

Part 1 connects the idea of how a proposition can turn into a Cmap when one relates many propositions and, together, expresses declarative knowledge. However, it is easy to lose focus during the Cmap elaboration once everything may appear relevant to the mapper. Our knowledge structure is wide open, and we must select only information that is relevant for each Cmap. This is why a focus question is needed in a Cmap. Part 2 is a comparison of two Cmaps about 'chocolate.' The first Cmap is about 'what is chocolate,' whereas the second explains 'how chocolate is produced.' Although both involve the same topic, they answer different focus questions. The selection of concepts and propositions is discussed as a key part of the process of knowledge modeling. Topic 3 shows the focus question as a criterion to keep in focus on during the Cmap elaboration process. The last part summarizes the most important aspects of select a good focus question.

2.1.2 Near- and Far-Transfer Tests

Near-transfer tests closely resemble the content encountered during the study phase with WE, while the far-transfer test requires the application of the studied concept in a different context (Paas, 1992). In this study, the near-transfer tests consisted of the following:

- Near-transfer test 1: 11 statements using a 4-point Likert scale comparing two Cmaps on the same topic (Soccer):
  i. Concept map A answers the focus question 'What is soccer?'
  ii. Concept maps A and B have the same theme.
  iii. Concept maps, elaborated with the same focus question, will present the same concepts.
- Near-transfer test 2: 11 multiple-choice questions after reading a Cmap about 'cachaça' (Figure 2a). Students must choose a focus question for the Cmaps from the following options*:*
  a) What is cachaça?
  b) How is cachaça produced?
  c) What are the conditions needed to produce cachaça?
  d) What is cachaça made of?
  e) Which alcoholic beverages are typical from Brazil?

The far-test asked students to declare the focus question after reading a Cmap about 'Cmap and meaningful learning,' which was one topic in the EDM5103 course participants were enrolled (Figure 2b).

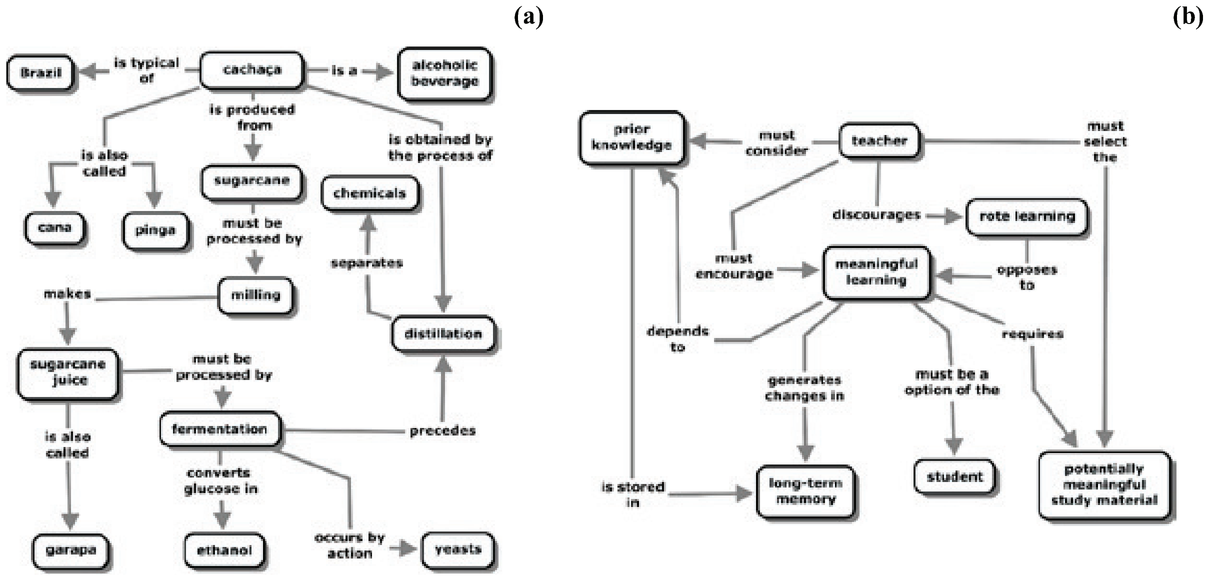


Figure 2. Cmaps applied during (a) near-transfer test (topic: 'Cachaça') and (b) far-transfer test (topic: 'Meaningful Learning').

2.2 Procedure

The data collection in the classroom was organized in six steps (Figure 3):

1. Students discussed a text previously provided by the teacher (Novak, 2010; see Chapter 2 and 3).
2. Students were randomly assigned to control (CG) and experimental (EG) groups.
3. EG studied WE for 10 min (CG stood outside the classroom).
4 & 5. Both groups completed the near- and far-transfer tests.
6. Teacher presented final comments about the WE for both groups.

All participants consented to participate in this research and declared their perceived mental effort during the tasks using a 7-point Likert scale from *very, very low* to *very, very high* (Paas, van Merrienböer, & Adam, 1994).

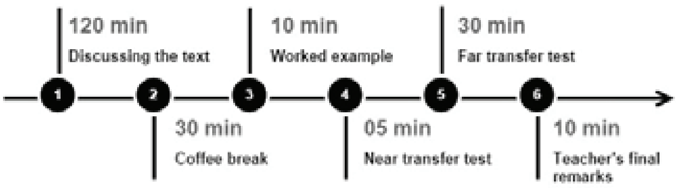


Figure 3. Steps for data collection in classroom.

2.3 Data analysis

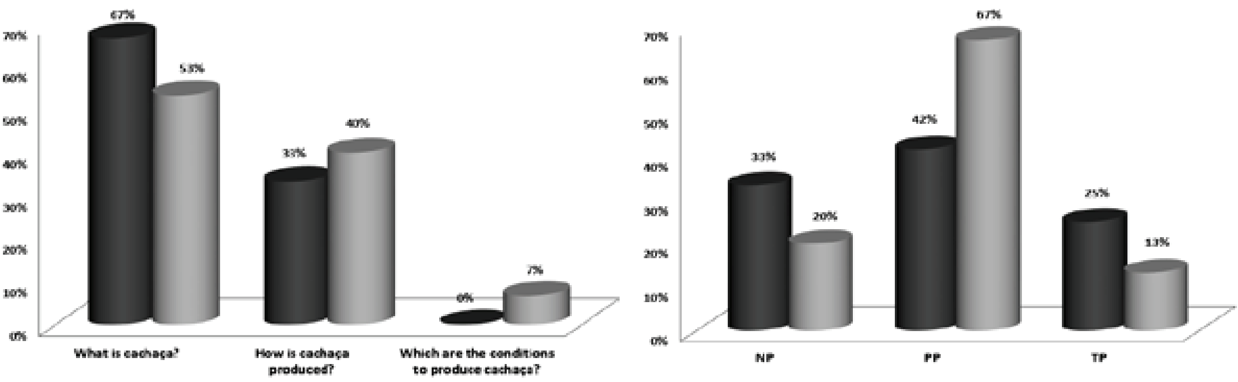
All statistical analyses were conducted using SPSS (v. 22.0, IBM, USA). Student-*t* test was used to compare the means obtained the answers for the near-transfer test 1. A frequency graph was made to compare CG and EG answers for the near-transfer test 2. For the far-transfer test, a pair evaluation was conducted for each declared focus question. The Cmap included elements that explicated the preconditions needed for meaningful learning and the role of teacher and learner in this process. The researchers categorized the focus questions independently. Categories were as follows:

- Not pertinent (NP): Do not have relationship with Cmap elements.
- Partially pertinent (PP): Presents a naive relationship with Cmap elements or valorizes only one part of the elements.
- Totally pertinent (TP): Includes all elements related to Cmap issue.

3 Results

The main results for first near-transfer test (questionnaire), followed by a pairwise comparison, showed that EG (M = 7.86, SD = .69) were statistically equal to CG (M = 7.30, SD = .77). The *t*-values were statistically equal for all mental efforts perceived for the task among all students. However, within the same group, the far-transfer test demand higher mental effort for EG ($t_{(24)} = 1.98, p < .05$) and CG ($t_{(24)} = 2.74, p < .01$) compared to the near-transfer test.

The evaluation of the second near-transfer test (Cmap about 'cachaça') was presented using the frequency graph in Figure 4a. Students chose three of the five focus questions presented in which 'How is cachaça produced?' was the correct one. A comparison between EG and CG indicated a higher percentage of correct answers for CG (40%) than for EG (33%). On the other hand, the focus question 'What is cachaça?' yielded the highest percentage of choice, which was greater for EG (67%) than for CG (53%). Finally, 'Which are the conditions to produce cachaça?' had the most similar subject to the correct answer; only CG students (7%) chose this option. In sum, it is possible to infer that CG outperformed the EG.



(a) **(b)**

Figure 4. Results for (a) second near-transfer test with the expected answer to the question, 'How cachaça is produced?'and (b) far-transfer test. EG and CG are represented in dark and light grey, respectively.

The main results for the declared focus question made by students about the 'Meaningful Learning' Cmap were presented using a frequency graph of categories according to their pertinence (Figure 4b). The EG presented a higher percentage of declared focus questions that were not pertinent (NP) to answer the Cmap (33%) than the CG (20%). In this case, most focus questions included descriptive features and, normally, evaded from the Cmap issue (e.g., *What is meaningful learning from Novak's point-of-view?*). For focus questions that were partially pertinent (PP), CG had the highest values (67%) compared to EG (42%). A closer look in this data illuminates a teacher overestimation in the process, and the meaningful learning as a final goal (e.g., *How should the teacher plan his/her class to achieve meaningful learning?*). Finally, EG had almost twice the percentage (25%) of totally pertinent (TP) declared focus questions compared to CG (13%). In this case, students perceived the conditions for occurrence of meaningful learning (e.g., *What conditions are necessary to achieve meaningful learning in the educational field?).*

4 Discussion

The main results for both near-transfer tests indicated no effect with WE. Additionally, perceived mental effort for these tasks was the same in both groups. Some possible explanations for these findings concern the methodology and the CLT effects adopted for this study. We assumed WE was a training phase; however, a 120-min discussion with the EDM 5103 teacher about concept mapping might scaffold the schema acquisition about the role of the focus question during Step 1 of the data collection for all students (Figure 3). Therefore, it is necessary to minimize the interfering effect caused by the text discussion to make a precise evaluation of the WE effect on learning. Two options are under consideration: (i) the use of the WE before Step 1 and (ii) the use of the WE in a different course that is not about meaningful learning and concept mapping.

A general overview of the results for the far-transfer test indicated that CG was slightly better than EG. It is worth mentioning that partially pertinent focus questions have very good qualities and fit on the Cmap theme, but some deviations or naive considerations about the Cmap content may exist. The task of declaring a focus question may be overwhelming for beginner mappers, which could explain why students from both groups failed in most tasks. The WE strategy is supposed to reduce the extraneous load imposed on the WM compared with conventional solving problem because of scaffolds when learning the task solution. However, sometimes, the WE is likely to be ineffective because its format itself might impose an extraneous load. This is the case of the *split-attention effect*, which occurs when learners must divide their attention between at least two sources of information that have been spatially or temporally separated. For maximum learning to occur, all disparate sources of information must be mentally integrated (Sweller, Ayres & Kalyuga, 2011). In this scenario, the EG learners studied the WE using resources from WM to integrate the contents presented in WE, thus, splitting their attention during the test phase. On the other hand, the CG did not study the WE, which left resources of the WM free to deal with the demanding task. It is worth mentioning that the application of WE to teach about propositions and semantic clarity under similar conditions was also investigated by our research group (Rocha et al., 2014).

5 Acknowledgments

The authors thank CNPq (Grant #486194-2011-6, National Counsel of Technological and Scientific Development) and FAPESP (Grant # 2012/22693-5, São Paulo Research Foundation) for funding our research group. A.O.P. thanks NP-NAP (Research Center on New Pedagogical Architectures) for her scholarship. R.L.R. thanks CNPq (#149754/2013-2) for his scholarship. J.G.A. thanks CAPES (Coordenação de Aperfeiçoamento de Pessoal de Nível Superior) for her scholarship.

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