Concept Mapping: Connecting Educators
Proc. of the Third Int. Conference on Concept Mapping
Tallinn, Estonia & Helsinki, Finland 2008

TWO FIDDLES DON'T MAKE A STRADIVARI, BUT TWO MAPPERS ARE SOMETIMES BETTER THAN ONE: INDIVIDUAL AND COLLABORATIVE USE OF CONCEPT MAPPING AS A LEARNING STRATEGY IN SECONDARY LEVEL ECONOMICS AND BUSINESS EDUCATION[1]

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Abstract. Current research suggests that concept mapping and other forms of learner-generated graphical representations can be effective strategies for sustaining knowledge acquisition in various domains of learning. Moreover, contemporary scholars assume that the beneficial effects of these strategies might be increased if they are embedded within a collaborative learning environment. To further investigate these suggestions within the domain of economics and business education, an experimental study with 169 secondary level business school students was conducted. In this study, cognitive achievements of subjects from three treatment groups (text plus experimenter-provided graphic group, individually mapping group, and collaboratively mapping group) were contrasted. The results of this study indicate that learner-generated graphical representations are of specific use for promoting long-term retention of central text ideas. Furthermore, the collaborative learning setting is most profitable for students who can be considered as low-achievers in terms of prior economic knowledge.

1 Introduction

Subject-generated graphical representations such as concept maps, knowledge maps and mind maps do not only play a prominent role in sustaining knowledge management and performance in economics and business settings (e.g. Basque et al., 2004; Fourie, Schilawa & Cloete, 2004; Hampden-Turner, 1990) but are also receiving increasing interest with respect to educating people to become proficient in these domains. However, while in most of the research done here concept maps are used as a teacher-provided text adjunct or as an assessment device (e.g. Lawless, Smee & O'Shea, 1998), scholars in economics and business education have more recently begun to study concept mapping as a learning strategy for supporting the process of knowledge acquisition. This latter scope of application is the focus of the research study that will be presented in this paper. The purpose of the study was twofold: Based on the results of our prior research (e.g. Aprea & Ebner, 1999; Ebner & Aprea, 2002), our first intention was to further investigate the impact of learner-generated concept maps in the domain of secondary level economics and business education. Secondly, we sought to examine whether the effectiveness of these tools can be enhanced if they are embedded within a collaborative learning environment.

The paper on hand is organized as follows. In the next section, benefits and difficulties of using concept mapping as a learning strategy are delineated briefly, including a short justification of why collaborative map generation might be helpful in sustaining adequate strategy use. The method and the results of the study are then described. The paper ends with a discussion of the results and suggestions for future research.

2 Benefits and difficulties of using concept mapping as a learning strategy

Most of the inquiry pertaining to the use of graphical representations as a learning strategy is inspired by the ideas of Novak and his colleagues (e.g. Novak, 1998; Novak & Gowin, 1984), who invented the concept mapping technique. These authors highlight the constructive momentum of concept mapping in promoting what Ausubel (1963) has described as meaningful learning. In their view, student-generated concept maps are beneficial because they facilitate a reflective understanding of concepts and their relationships, and support deep and idiosyncratic elaboration of the material to be learned. Similarly, Weinstein and Mayer (1986) suggest that concept mapping may be of particular help for promoting cognitive processes such as organization and integration of incoming information. In our own research (e.g. Ebner & Aprea, 2002; Stern, Aprea & Ebner 2003), we - along with others (e.g. De Simone, Schmid & McEwen, 2001; Hanf, 1971) – additionally emphasize the metacognitive functions of generating a map. Based on an activity theoretical conceptualization of learning and instruction, we assume that 'modus transformation', i.e. the task of converting textual information into a graphical representation, not only helps students to focus their attention but also triggers planning and control processes, and thus supports self-regulation and learning. However, as with other learning methods, students' success in this kind of learning depends on the interaction of individual prerequisites (e.g. prior knowledge, motivation) and contextual factors (e.g. difficulty of text material, social organization of learning).

[1] The research presented in this paper was funded by the German Science Foundation (DFG).

With the adoption of concept mapping and other spatial learning strategies (e.g. Holley & Dansereau, 1984) in educational practice and research, much empirical work to investigate their impact has been conducted within the last three decades. These studies encompass different groups of learners (e.g. primary school children, high school students, adults) and are mainly located in the domain of science learning (e.g. Ault, 1985; Fraser & Edwards, 1987; Heinze-Fry & Novak, 1990; Novak & Musonda, 1991; Schmid & Telaro, 1990) but also in a variety of other fields such as teacher education (e.g. Beyerbach 1988) or (foreign) language acquisition (Chularut & DeBacker, 2004)[2]. The results of this research, including a meta-analysis by Horton et al. (1993), mainly confirm the supposed benefits of learner-generated maps. For instance, Barenholz & Tamir (1992) compared cognitive achievements of high school students (grades 10 and 11) who used mapping as a regular learning activity during the study of a new biology program with those of a non-mapping control group and found strong evidence in favor of the mappers. Similarly, other studies seem to indicate that concept mappers outperform learners who use alternative study techniques such as note-taking (Reader & Hammond, 1994) or outlining (Robinson & Kiewra, 1995). Moreover, some of the studies (e.g. Chularut & DeBacker 2004; Jegede, Alaiyemola & Okebukola, 1990) suggest that generating a graphical representation is not only advantageous in terms of cognitive learning outcomes but that learners seem to appreciate this strategy with respect to outcome variables that can be categorized as affect (e.g. anxiety, frustration, satisfaction), self-efficacy, and motivation.

However, apart from the delineated benefits of student-generated maps, the research literature is not conclusive and also reports some difficulties in using mapping as a learning strategy. For example, Lehman, Carter & Kahle (1985), in contrast to the above mentioned research, did not find any significant differences between students who used mapping strategies for biology learning and those who used outlining as a comparison study aid. The authors suppose that one reason that might have prevented success of the mapping group is students' (and teachers') lack of familiarity with spatial learning strategies. Thus, beginners are easily overwhelmed by the demands of the concept mapping task. This presumption is corroborated by several other studies (e.g. Reader & Hammond, 1994; Wandersee, 1988) and also reflects results that we have obtained in prior work (e.g. Aprea & Ebner, 1999). All in all, these findings give rise to the conclusion that there is no such thing as a 'concept mapping finger-tip effect', but that some form of scaffolding might be needed in order to ensure adequate strategy use. One way of addressing this need is to provide students with a mapping training. However, results of training studies, including our own research (e.g. Chang, Sung & Cheng, 2002; Ebner & Aprea, 2002), suggest that the success of this direct scaffolding method seems to be limited. At least for short time interventions, it proved helpful only for learners with high prior (domain and strategic) knowledge prerequisites. On the other hand, learners who do not already posses these prerequisites seem to need additional support. Given the current debate on the social construction of cognition and learning (e.g. O'Donnell, Hmelo-Silver & Erkens, 2006), one promising candidate for such an additional support is to embed the concept mapping task within a collaborative learning environment. For example, McThighe (1992) argues that this indirect form of scaffolding might enhance knowledge elaboration and metacognition mainly because it encourages students to expand their own points of view and helps to render the invisible processes of thinking visible. Similarly, Roth and Roychoudhury (1993) assume that collaboratively constructed maps may provide an ideal context for overt negotiation of meaning and construction of knowledge because they require individuals to externalize their propositional frameworks. Others (e.g. Nichols & Miller, 1994) have highlighted the motivational and affective support of collaborative learning. These suggestions concerning the collaborative use of concept maps seem to be supported by empirical research. For example, Basque & Lavoie (2006), who completed a concise review of research on collaborative concept mapping in education, conclude that "[c]ompared to individual CM or to other types of collaborative activities (e.g. producing an outline or a matrix representation) CCM has been found to be more beneficial for learning." In addition, this type of scaffolding seems to be particularly promising since some of the studies (e.g. Okebukola & Jegede 1988) indicate that collaborative map construction is specifically helpful for low level learners.

3 Method

The research reported in the former section raises the question of whether and to what extent the effects of individually and collaboratively generated concept maps might be transferable to the domain of secondary level economics and business education. In order to address this question, an experimental study – as one part of a larger research program (cp. Ebner & Aprea, 2002; Stern, Aprea & Ebner, 2003) - was carried out. The participants, design, materials, instruments and procedures of this study will be described next.

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[2] For an extensive review of the research literature on concept mapping and its various applications also see Cañas et al., 2003 as well as Nesbit & Adesope, 2006.

3.1 *Participants and design*

169 students from two urban secondary level business schools in Mannheim and Karlsruhe (Germany) participated in this study. They were completing their second year of a traineeship as bank employee (78 subjects) or as financial assistant (91 subjects), respectively. Fifty five percent of the students in the sample were female and the mean age was 20 years. Approximately one half of the students held a certificate of "Allgemeine Hochschulreife"[3], while the remainder had at least the so-called "Mittlere Reife".[4] In order to address the research issues mentioned, students were randomly assigned to one of the following three instructional treatment groups:

1. Subjects of the first group (text plus experimenter-provided graphic group; n = 52) received a text passage in combination with an already elaborated graphical representation. This experimental condition was intended to control for the general dual-coding effect of verbal and visual information provision (e.g. Clark & Paivio, 1991).
2. Subjects of the second group (individually mapping group; n = 59) received the same text passage without any visual adjunct. After a short mapping training (Aprea & Ebner, 2003) they were asked to individually read the text, identify the main ideas of the text and then to re-construct its content diagrammatically.
3. Like in the individually mapping group, subjects in the third group (collaboratively mapping group; n = 58) received a short mapping training and a text passage without any visual adjunct. They then were asked to first read the text alone and make a preliminary sketch. After that, they were requested to discuss their sketches with a learning partner and to draw up a shared concept map of the verbal information.

According to our assumptions, we hypothesized that the collaborative mapping treatment might lead to the best results in terms of cognitive learning outcomes, followed by the results of the individually mapping group and the results of the text plus experimenter-provided diagram group. Given the findings of our former studies (Aprea & Ebner, 1999; Ebner & Aprea, 2002), we additionally considered students prior economic knowledge as an important covariate.

3.2 *Materials*

In the study, the following materials were used: As instructional text, a passage of about 1.000 words was used. The passage dealt with the topic of environmental economics and introduced students to the core problem of external costs as well as to different principles and measures that national environmental policy can adopt against them. As far as content and style are concerned, the text was based on a currently available study book in business education. It was, however, condensed and modified in order to achieve more coherence. It contained 3 subheadings, but no other textual cues were given. For the text-plus-provided-graphic group, three expert-maps based on the text passage were developed. Out of these, one diagrammatical map was chosen and added to the text passage. The training materials for the two mapping groups consisted of the following components:

(1) *A list of steps that provides students with an algorithm of how to construct a map*: The conception of this algorithm has been inspired by a top-down mapping approach, which encourages students to first construct a gist of the text and then add relevant details.
(2) *A short text passage with a pre-made example map:* This text passage of approximately 170 words is supposed to illustrate the mapping procedure. It deals with different kinds and purposes of adverts in newspapers. The main idea and the central concepts are highlighted by bold print. From this passage, an example map was developed and printed on a separate sheet of paper.
(3) *A training text passage*: This passage consists of about 150 words and describes various forms and symptoms of inflation. In addition, the reader is informed about the distinction between causes and effects of inflationary phenomena. The text is a modified version of a study book passage. However, no further markings are given. None of the training materials contained information related to the test materials used for evaluation.

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[3] Comparable to a senior high school diploma; German higher education entrance certificate.
[4] German intermediate high school certificate.

3.3 *Instruments*

In order to assess cognitive learning outcomes, an achievement test and a free recall test were used. The achievement test (*Knowledge Acquisition Test*; KAT) included six mixed-format (i.e. multiple choice and open-ended) questions. These questions mainly addressed detailed text recognition and encompassed content from the whole passage. As will be further described in the procedure section of this paper, the KAT was administered twice, namely immediately after the instructional treatments (subsequently referred to as KAT1) and approximately three weeks later (subsequently referred to as KAT2). For both test passes total sum scores were calculated. These sum scores took values between 0 and 9. Likewise about three weeks later, students were asked to write down all they could remember about the text content. This *free recall test* (FRT) was scored on the basis of a six degree rating scheme which ranged from "no recall at all" (= 0) to "very detailed and elaborated reconstruction of text content" (=5). All criterion measures mentioned before (i.e. KAT1; KAT2; FRT) were submitted to one-way ANOVAs and post-hoc tests, respectively. In addition to cognitive learning outcomes, students' prior economic knowledge was measured by using several items from the Test of Economic Literacy (TEL) (Soper & Walstad 1987). As with the KATs, total sum scores were calculated for these items. The sum scores for the TEL items ranged between the values 0 and 5.

3.4 *Procedure*

As already mentioned, the experiment consisted of two sessions. The first session lasted approximately 90 minutes, whereas the second session took about 45 minutes. At the beginning of the first session, students were briefly informed about the subject, duration and procedure of the experiment and assigned to the treatment groups. Students from the text-plus-diagram group were then asked to go to a separate classroom, whereas students from both mapping groups received the mapping training. The training consisted of the following steps.

(1) Initially, participants were briefly informed about the use and benefits of spatial learning devices for text comprehension and retention.
(2) Then, the advert text passage and the algorithm for applying the technique were handed out. Students were asked to start by skimming the single steps of the algorithm, to carefully read the text passage and then to imagine how a map might be constructed. After ensuring that each student had read the passage, the example map was administered to the students and they were invited to compare both representation formats. Additionally, the diagram was presented on an OHP transparency and the experimenter made some annotations indicating how it was created.
(3) Subsequently, students read the inflation passage. This passage was displayed on the OHP as well, and a concept map was constructed jointly according to the provided procedure. Finally, this map was compared to the text and alternative ways to see the meaning of the text were discussed. In addition, the experimenter pointed out to the students that at least one, sometimes two or three reconstructions of the map may be needed to show a good representation of propositional meanings as they understand them.

After the training activities the text passage and the corresponding task instructions were administered. Students were given 50 minutes to read the text and accomplish the task. As soon as the students had completed their respective instructional tasks, the experimenter marked the time on task, collected the text passages as well as students' notes and diagrams. Next the achievement test (in the following referred to as KAT1) was handed out. Approximately three weeks later, students were again asked to complete the achievement test (in the following referred to as KAT2). Furthermore, the free recall test (FRT) as well as the TEL-items were administered.

4 Results

A whole sample statistical analysis of the three criterion measures (KAT1, KAT2, and FRT) yields the following results (cp. Table 1):

- With respect to <u>KAT1</u>, only slight and statistically not significant differences between the treatment groups are identified, with the text-plus-graphic group in the first place followed by the collaborative mappers.
- In contrast, the hypothetical rank order is reflected by the data from <u>KAT2</u> and <u>FRT</u>. In addition, post-hoc comparisons have revealed that collaborative mappers tend to outperform subjects from the text plus graphic group on the KAT2 ($p = .08$) as well as subjects from the individually mapping group on the FRT ($p = .10$), respectively. Furthermore, a significant effect ($\alpha = .05$) has been found for mean differences between the FRT scores of collaborative mappers and subjects from the text-plus-graphic group.

		KAT1			KAT2			FRT		
R^{exp}	TG	M[1)]	(SD)	R^{emp}	M[1)]	(SD)	R^{emp}	M[2)]	(SD)	R^{emp}
1	**Collaboratively mapping group**	4,78 (n = 58)	(2,16)	2	4,08 (n = 49)	(1,91)	1	2,14 (n = 49)	(1,19)	1 s*
2	**Individually mapping group**	4,63 (n = 59)	(2,21)	3	3,63 (n = 51)	(2,02)	2	1,76 (n = 50)	(1,27)	2
3	**Text + graphic group**	4,85 (n = 52)	(2,24)	1	3,37 (n = 46)	(1,82)	3	1,65 (n = 46)	(1,02)	3

Tab. 1: Mean test scores, standard deviations and empirical rank orders (whole sample)

KAT = Knowledge Acquisition Test
FRT = Free Recall Test
R^{exp} = Expected rank order (according to hypotheses)
R^{emp} = Empirical rank order (according to data)

1) Note that KAT 1 and KAT 2 could take values between 0 and 9.
2) Note that FRT could take values between 0 and 5.

The picture changes somewhat if one differentiates the sample with respect to prior economic knowledge as indicated by the Test of Economic Literacy (TEL) items. The results for subjects with high prior economic knowledge (i.e. TEL-scores of 4 or better) are displayed in Table 2.

- With respect to KAT1, individual mappers with high prior knowledge significantly outperform subjects from the collaborative mapping group (α = .05). Furthermore, they tend to achieve higher scores on this criterion measure than the text-plus-graphic group (p = .07).
- Regarding the KAT2, individual mappers with high prior knowledge come first again, followed by the collaborative mapping group. None of the mean differences proved to be significant, however.
- As regards the FRT, the empirical rank order in the high prior knowledge subgroup shifts in favor of collaborative mapping for the first and the provided graphic treatment for the second place, but as with the KAT2 no significant effects were found.

		KAT1			KAT2			FRT		
R^{exp}	TG	M[1)]	(SD)	R^{emp}	M[1)]	(SD)	R^{emp}	M[2)]	(SD)	R^{emp}
1	**Collaboratively mapping group**	5,20 (n = 10)	(1,99)	3 s*	4,40 (n = 10)	(2,50)	2	2,30 (n = 10)	(1,70)	1
2	**Individually mapping group**	6,91 (n = 11)	(1,30)	1	4,55 (n = 11)	(1,92)	1	1,91 (n = 11)	(1,51)	3
3	**Text + graphic group**	5,43 (n = 7)	(1,62)	2	3,57 (n = 7)	(1,81)	3	2,00 (n = 7)	(1,29)	2

Tab. 2: Mean test scores, standard deviations and empirical rank orders (high prior economic knowledge)

KAT = Knowledge Acquisition Test
FRT = Free Recall Test
R^{exp} = Expected rank order (according to hypotheses)
R^{emp} = Empirical rank order (according to data)

1) Note that KAT 1 and KAT 2 could take values between 0 and 9.
2) Note that FRT could take values between 0 and 5.

For subjects with low prior economic knowledge (i.e. TEL-scores of 2 or worse), the data show a strong trend in favor of the collaboratively mapping group. In particular, the following results are obtained (cp. Tab. 3):

- With respect to KAT1, collaborative mappers with low prior knowledge tend to achieve higher scores than the text plus graphic subjects and significantly outperform the individual mappers (α = .05).
- However, the relationship between individual mappers and text-plus-graphic subjects turns around with respect to KAT2 and FRT. Moreover, post-hoc comparisons have demonstrated that low prior knowledge

collaborative mappers tend to achieve higher KAT2 scores than subjects from the text-plus-graphic group (p = .08), and significantly excel this group on the FRT (α = .05).

		KAT1			KAT2			FRT		
R^{exp}	**TG**	$M^{1)}$	(SD)	**R^{emp}**	$M^{1)}$	(SD)	**R^{emp}**	$M^{2)}$	(SD)	**R^{emp}**
1	**Collaboratively mapping group**	4,70 (n = 27)	(2,11)	s* **1**	3,81 (n = 27)	(1,39)	**1**	2,07 (n = 27)	(0,92)	s* **1**
2	**Individually mapping group**	3,42 (n = 24)	(2,22)	**3**	3,21 (n = 24)	(1,98)	**2**	1,88 (n = 24)	(1,30)	**2**
3	**Text + graphic group**	4,00 (n = 30)	(2,32)	**2**	2,97 (n = 30)	(1,63)	**3**	1,43 (n = 30)	(0,86)	**3**

Tab. 3: Mean test scores, standard deviations and empirical rank orders (low prior economic knowledge)

KAT = Knowledge Acquisition Test
FRT = Free Recall Test
R^{exp} = Expected rank order (according to hypotheses)
R^{emp} = Empirical rank order (according to data)

1) Note that KAT 1 and KAT 2 could take values between 0 and 9.
2) Note that FRT could take values between 0 and 5.

5 Discussion and suggestions for future research

With respect to secondary level economics and business education, the study on the whole does not show that concept mapping generally enhances students' cognitive achievements: The data only partly reflect the expected effects. However, the results seem to reveal an important relationship between the specific modalities of concept mapping on the one hand and learning outcomes as well as prior knowledge on the other. Thus, a more refined perspective on the operating conditions of concept mapping within our field of application might be needed. On the basis of the data, at least three directions for such refinements seem to be evident:

1. Firstly, the results yield the presumption that students who can be considered as high-achievers in terms of prior economic knowledge seem to profit most from an individually concept mapping task. In contrast, collaboration seems to be particularly helpful in supporting students with low pre-test scores. From these findings, which again confirm the substantial influence of prior domain knowledge on learning with concept maps (e.g. Chularut & DeBacker, 2004), it can be recommended to differentiate concept mapping assignments with respect to learner characteristics. As the results of van Boxtel (2007) suggest, further investigations within this strand of refinement might include studies that contrast the concept mapping task with a task that involves generation of analogues drawings since these drawings seem to be easier for low-level learners to construct.
2. Secondly, the results indicate that concept mapping in secondary level economics and business education seems to be of specific use for promoting long-term retention of central text ideas, whereas no such effect with respect to detailed text recognition could have been found. In accordance with researchers of learner-generated graphical representation in other domains (e.g. Lee & Nelson, 2005; Van Meter et al. 2006), we therefore deem it necessary to differentiate the effectiveness of concept mapping tasks with respect to intended learning outcomes. Following this line of argumentation, we plan to extent the quite simple outcome measures and to prospectively include more complex outcome variables such as problem-solving and strategy learning.
3. Thirdly, along with De Simone, Schmid and McEwen (2001) we feel that in order to gain a deeper understanding of the 'driving forces' and the specific benefits of concept mapping within our domain, we need to study in more depth the learning processes that are associated with the various treatment conditions.

Apart from the need for a more sophisticated account of learning with concept maps within secondary level economics and business education, analyses of the learner-generated graphics as well as informal conversation with the participants give rise to the assumption that many students are still not sufficiently accustomed and/or inclined to generate graphical representations. Thus, additional long-term training efforts as well as efforts to ensure an authentic and motivating instructional embedding of the concept mapping task are needed. We hope to achieve both these aims by extending the experimental studies by means of a design-based research approach.

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