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# EFFECTS OF USING A CONCEPT MAPPING STRATEGY IN DATABASE DESIGN ON NOVICE STUDENTS' LEARNING PERFORMANCE

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**Abstract**. This paper presents the results obtained when concept map is used as a first step of data modeling. The sample of this study consists of 50 first-year university students. These students were assigned into two groups: an experimental group and a control group. Only the experimental group used the concept map as a first step of data modeling. We have studied entity-relationship diagrams made by students of the two groups during the achievement test to detect and analyze conceptual modeling errors. Student's scores were also analyzed to see if there was a significant difference between the two groups. The results of the study revealed that there is a statistically significant difference between the mean scores of the experimental group and those of the control group in favor of experimental group.

***Keywords**:* concept map, database, conceptual data modeling, entity-relationship diagram

## 1 Introduction

The concept map described by Novak in 1972, is a useful graphical tool for organizing and representing knowledge (Novak and Cañas, 2008). It is based on Ausubel's Assimilation theory (Ausubel, 1968) and Novak's theory of learning (Novak and Gowin, 1984), which state that we learn better when the integration of new concepts into our cognitive structure occurs by linking new knowledge to concepts already acquired. The concept map is useful for linking new knowledge to existing knowledge. This allows it to be used in different teaching contexts. Following the example of Gómez-Gauchía & McFadyen (2011) we used it in our teaching as a first step of data modeling with novice students to check how it could help them in the data modeling process. It seems relevant to us to use the concept map as a tool that can deepen the understanding of the problem to model and reduce the difficulties of transposition of the domain description from natural language to the conceptual database schema.

## 2 Concept Mapping Strategy

### *2.1 Principles*

The principles used to develop the concept map are based on those proposed by Sien & Carrington (2007), McFadyen (2008) and Farza (2018). The figure below represents the key-concepts of a concept map:

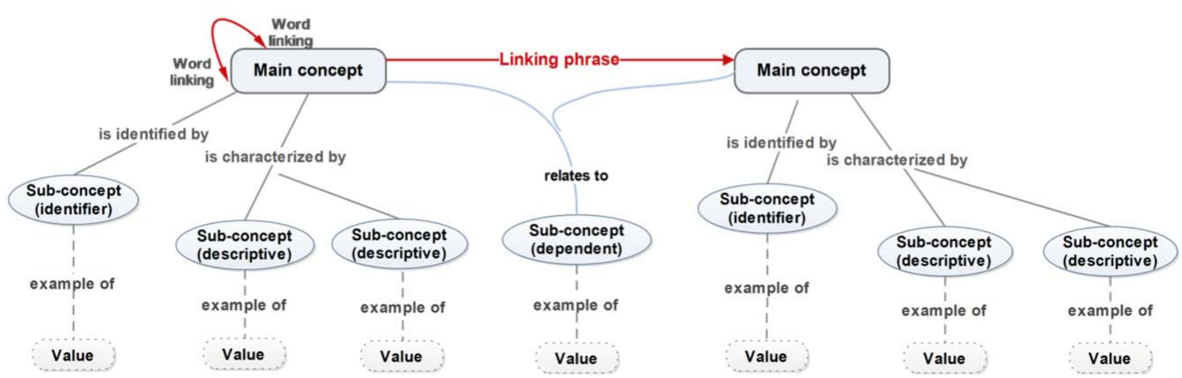


**Figure 1**. The key-concepts of the concept map (Farza, 2018)

- The nodes on the map designate two categories of concepts: main concept and sub-concept.
- A main concept represents a set of objects of real world to be modeled that have common characteristics.
- An instance (or value) corresponds to a value taken by the sub-concept. An instance of a main concept is constituted of all of the values of its sub-concepts (one value per sub-concept),

- The sub-concepts can be classified into descriptive sub-concept, identifier sub-concept and dependent sub-concept. Descriptive sub-concept and identifier sub-concept are used to describe main concepts.
- The identifier sub-concept specifies the main concept. It uniquely identifies each instance of the main concept.
- A dependent sub-concept is used to define a characteristic related to two main concepts.
- The linking phrase represents the meaning of the link between two main concepts (arrow line), a main concept and itself (bidirectional arrow arc to and from the same main concept), a main concept and a sub-concept (line) or between a sub-concept and an instance (or value) of this sub-concept (dashed line).

### 2.2 *Example of a Concept Map*

The figure 2 shows an example of a concept map designed for a simple *order management* database about *customers* and their *orders* for a company. A customer may place one or more orders. An order is placed by only one customer. Each order may include one or more products. A product may appear in one or more orders or in no order. A *product* can be *stored* in many *warehouses* and a *warehouse* can contain many *products.* A product can be composed of several products. A product can enter itself into the composition of other products.

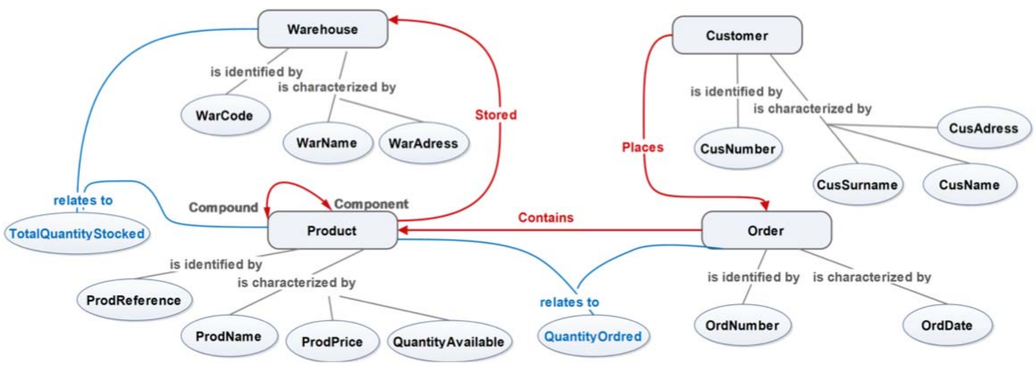


**Figure 2**. Example of a concept map

### 2.3 *Transposition of the Concept Map*

The Entity-Relationship model is one of the most commonly used conceptual data model in an introductory database course. Various graphical notations may be used for conceptual data modeling (e.g. Chen, Bachman).

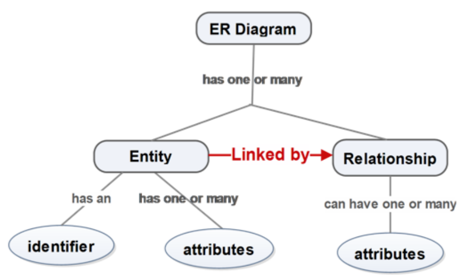


**Figure 3**. Concept map of ER Concepts

To elaborate a conceptual database schema, we usually use the Entity-Association or Entity-Relationship (ER) formalism from Merise Method, a French methodology initially developed by Tardieu. The ER design is based on three main concepts: the entity, the association or the relationship and the attribute or propriety (Figure 3). An entity has a unique identifier and one or more attributes. A relationship in Merise is a semantic link between one or more entities.

Figure 4 shows the transposition of a concept map to an ER diagram:

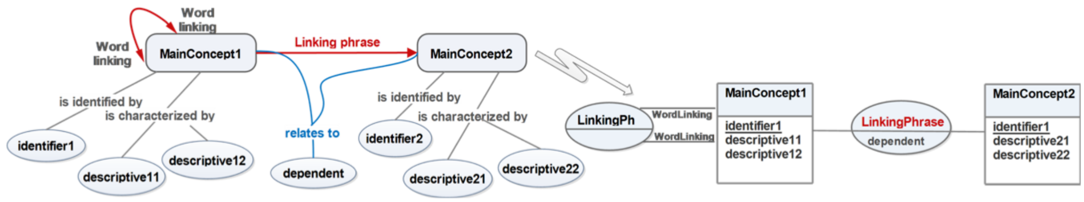


**Figure 4**. Concept Map converted to Entity-Relationship Diagram (without indication of the cardinality)

The next figures are an example of Entity-Relationship diagram related to the concept map of figure 2:

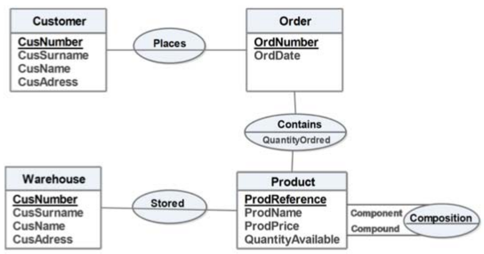


**Figure 5a**. Example of ER diagram without cardinality

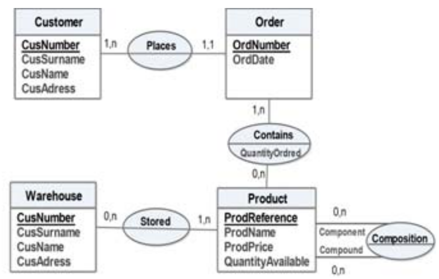


**Figure 5b**. Example of ER diagram with cardinality

## 3 Purpose of the Study

Our purpose is to investigate the effects of using concept map as a first step of data modeling in improving novice student's ability in database design (Farza, 2018). The main research questions are the following:

- Does the use of a concept map as a first step in data modeling help students to learn conceptual data modeling easier than the traditional method of learning?
- What are the errors produced by students when drawing ER diagram? Can concept map significantly reduce errors?
- Is there a significant difference between the student's scores in the experimental group and those in the control group?

## 4 Method

The sample of the study consisted of 50 first-year university students randomly assigned into two groups: an experimental group (22 students) and a control group (28 students). All students in both groups were not familiar with database design and never heard about concept map. They followed exactly the same course with the same teacher. The concept map was used as a first step of data modeling by the experimental group.

In this research a pre-test was conducted to evaluate students' computer science prior knowledge. A one way ANOVA showed that there was no significant difference between the pre-test scores of experimental group and control group. At the end of the course students took an identical post-test at the same time, they were asked to draw an ER diagram that satisfies the given requirements. The experimental group created a concept map and translated it into an ER diagram. Then we have analyzed the diagrams made by all the students of the two groups in order to determine conceptual modeling errors.

A survey was also distributed to the experimental group at the end of the course to determine student's satisfaction with the concept map activity. For each question the students were asked to choose as a response one of the following proposals: "Strongly agree", "Slightly agree", "Slightly disagree" and "Strongly disagree".

## 5 Results

As a result of the study, we found that the experimental group performed better than the control group on post-test. The average score of experimental group (4.69), in which the concept map strategy is applied, was higher than that of the control group (3.87). A one way ANOVA showed that there is a statistically significant difference between the post-test scores of the experimental and the control groups ($F = 5.456$, $p = 0.02 < 0.05$) (Farza, 2018). The success rate in the experimental group is seemingly caused by the use of the concept mapping strategy in terms of enabling learner to better understand database requirements.

We also compared the errors made on the ER diagram produced by students of the two groups. The Figure 6 shows the percentage of the four error categories in the ER diagrams in the post-test evaluation made by both groups.

This experiment shows that the cardinality errors are the most errors made by the experimental group. This type of error is due to a misunderstanding of the management rules (which are not represented in the concept map). For the control group, the percentage of attributes related errors and also the relationship related errors are higher than in the experimental group. The lower percentage for the latter group can be explained by the use of the concept map as a first step of conceptual data modeling. This may allow students to actively think about the requirements of the problem to be modeled and better understand these requirements before moving to a more complex representation (Farza, 2018).

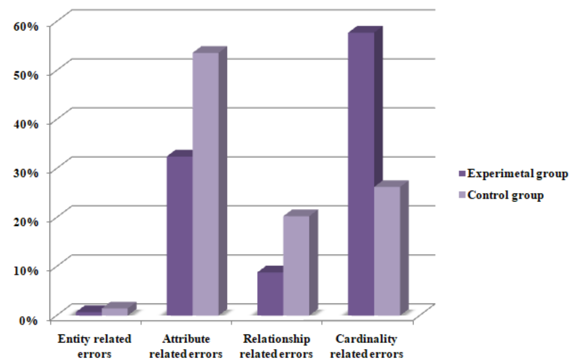


**Figure 6**. Percentage of errors made by students of both groups

When reviewing students' answers to the questionnaire in where students have to indicate whether they considered concept map to be useful for their learning, we found that most students believe that the concept mapping strategy in database design contributes to help them understand database requirements, makes their design easier and increases their ability to create an Entity-Relationship diagram.

The results, presented in figure 7 show that the majority of the students agree slightly or strongly that the concept map create facilities on the learning of the conceptual modeling, allow them a better understanding of the database requirements and help them in the elaboration of the ER diagram. They also agree that the translation between the concept map and the ER diagram was easy and fast. However about 50% of the participants agree slightly or strongly that they prefer elaborate the entity-relationship diagram without using the concept map because the concept map takes a long time to establish.

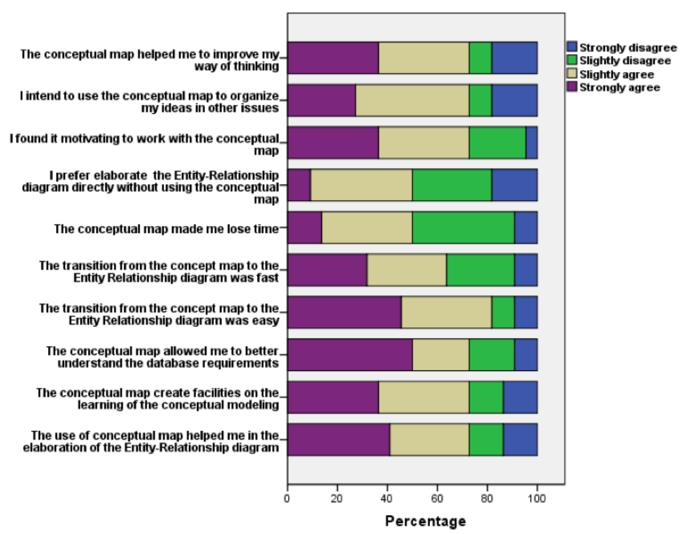


**Figure 7**. Student's perceived usefulness of concept mapping

## 6 Conclusion

This paper presents an experimental of applying the concept map as a first step in database modeling with first-year university students. The results of this study suggest that, for novice learners, the concept map strategy in conceptual data modeling is more efficient than the traditional approach because it simplifies modeling tasks. It helps to minimize the data modeling complexity and to improve novice's student's performance in database design.

A second experiment was conducted during this year where we took into account the management rules during the elaboration of the concept map to mitigate cardinality related errors. This study in progress may provide more information's about conceptual modeling errors.

## References


Ausubel, D. P. (1968). *Educational Psychology: A Cognitive View*. New York : Holt, Rinehart and Winston.

Farza, L. (2018). La carte conceptuelle comme outil favorisant l'apprentissage de la modélisation des bases de données. *Revue internationale de pédagogie de l'enseignement supérieur*, 34 (1).

Gómez-Gauchía, H., & McFadyen, R. (2011). Conceptual Mapping as a First Step in Data Modeling. *Applied Concept Mapping: Capturing, Analyzing, and Organizing Knowledge, 277-292*. CRC Press.

McFadyen, R. (2008). Designing Databases with Concept Maps. In A.J. Cañas, P. Reiska, M.K. Åhlberg & J.D. Novak (eds.), *Concept Mapping: Connecting Educators* (Vol. 3, pp. 144-147): *Proceedings* of the Third International Conference on Concept Mapping. Tallinn, Estonia & Helsinki, Finland, 22-25 September.

Novak, J. D., & Cañas, A. J. (2008). *The Theory Underlying Concept Maps and How to Construct Them*. Technical Report IHMC CmapTools 2006-01, Florida: Institute for Human and Machine Cognition.

Novak, J. D., & Gowin, D. B. (1984). *Learning How to Learn*. New York: Cambridge University Press.

Sien, V.Y., & Carrington, D. (2007). A concepts-first approach to object-oriented modeling. In Sahni, S. (éd.), *Advances in Computer Science and Technology* (pp. 108-113): Proceedings of the Third IASTED International Conference on Advances in Computer Science and Technology. Phuket, Thailand, 2-4 April.