Visual Learning Tool for Teaching Entity Relationship Mapping Rules

Lu Zhang, Mudasser F. Wyne, Alireza Farahani, Bhaskar Sinha, Mohammad Amin

School of Engineering and Computing, National University, San Diego, CA

Abstract

Based on the authors' experience in teaching the subject of conceptual modeling, many students are unable to master the mapping process for converting an Entity Relationship Diagram (ERD) into its corresponding set of relations. This perhaps is surprising to many since the steps and mechanism for converting an ERD into relational tables are not overwhelmingly complicated and are quite mechanical. Further exploration discovers that the traditional way of describing and teaching the mapping process involves "too much math", as characterized by struggling students, therefore forging a mental barrier for students to learn the mapping concepts appropriately and effectively. This paper describes a new approach to teach the mapping process and rules that "un-math" the math bias associated with the traditional approach. The majority of us are visual learners. Therefore, the proposed approach is visual-based and uses task maps, visual clues, and animations to "un-math" the complexity perceived by students. Specifically, task maps are used to provide an overall roadmap and context of the mapping process while visual clues are embedded into both the task maps and mapping rules to eliminate seemingly complex mathematical notations. Eventually, 3D animations will be utilized to enhance students' learning by turning abstractions into animated environment and in particular to show the movement of primary keys based on the cardinalities of involved relationships. Assessment activities will also be carried out in the future to determine the effectiveness of the new approach.

1. Introduction

Relational database was first proposed by EF Codd in early 1970s. He laid out the foundation of database based on relational theories or set theories. Database is generally considered as a multidisciplinary subject, therefore it is also at times termed as database engineering, because of direct application of computer science and relational mathematics that enables us to solve real world problems. Since database is part of any digital activity that we perform in our daily life thus database remains among the most sought-after and popular subjects taken by students studying in engineering, science, business and technology disciplines. Many, both technical and non-technical, programs (graduate and undergraduate) at times require at least one database course. Usually, such a course introduces the conceptual model of database design (Entity Relationship Model), implementation model (Relational Model) and administration. Teaching a database course to students from different disciplines in one class is always a challenging task, and at the same time, however it can be most rewarding if we are able to explain the transformation process of conceptual model to implementation model in an appropriate manner.

Based on the authors' experience in teaching the Database design subject in general and conceptual modeling topic in specific, many students have difficulty in mastering the mapping process for converting an Entity Relationship Diagram (ERD) into its corresponding relational schema. Specifically, students seem to have trouble comprehend the overall picture and context of the mapping process and rules. They also have difficulties discerning the arrangement of primary keys based on the cardinalities of relationships; including decision as to when it is necessary to create new relations during the mapping process. This perhaps is surprising to many since the steps and mechanism for converting an ERD into relational model are not overwhelmingly complicated and are quite simple and mechanical. There are also some tools available to perform the mapping. Further exploration discovers that the traditional way of describing and teaching the mapping process involves "mathematical approach", as characterized by some struggling students, therefore forging a mental barrier for struggling students to learn the mapping concepts appropriately and effectively.

This paper describes a new approach to teach the mapping process and rules that is not to be perceived by struggling students as "mathematical approach", the bias associated with the traditional approach. Since the majority of us are visual learners, so the proposed approach is visual-based and uses task maps, visual clues, and animations to avoid the complexity of traditional approach as perceived by students. Specifically, task maps are used to provide an overall roadmap and context of the mapping process while visual clues are embedded into both task maps and mapping rules to eliminate seemingly complex mathematical notations. Our objective is to eventually utilize 3D animations to enhance students' learning, by turning abstractions into animated environment and in particular to show the establishment of primary keys based on the cardinalities of involved relationship types. We also plan to analyze the effectiveness of the new approach by performing assessment activities.

The conventional approach of teaching the mapping process for converting an Entity Relationship Diagram into its corresponding set of relations is reviewed first. Its potential obstacles hindering students in mastering the mapping process is then discussed. In the later section we present the task map outlining the overall mapping process will be proposed. the section that follows is dedicated to incorporate visual clues into both the task map presented in the previous section as well as the mapping rules to eliminate, if necessary, intimidating mathematical notations. Plans for developing animations for each mapping rule is then described. Finally, further research directions will be identified.

2. Conventional Approach for Teaching the Mapping Process

In this section, the conventional approach of teaching the mapping process for converting an Entity Relationship Diagram into its corresponding set of relations is reviewed. For discussions delivered in this paper, the following assumptions are made with respect to Entity Relationship Diagram:

- The basic Chen's ERD notation is used throughout this paper.
- Derived attributes are prohibited.

- Many-to-many relationships should be used in lieu of associative or intersection entities since associative or intersection entities are not necessary.
- ISA relationships are used instead of supertype and subtype relationships to simply the discussion of the mapping rules.

There are a number of schemes presented in the literature[1,2,3] for converting an Entity Relationship Diagram into its corresponding set of relations. In light of the assumptions made at the beginning of this section, the mapping process is summarized into the following eight rules. The rules are organized as follows: (1) one rule for mapping non-weak (i.e., regular or strong) entities, (2) one rule for mapping weak entities, (3) four rules for converting binary relationships (one for each type of binary relationships, i.e., ISA, one-to-one, one-to-many, and many-to-many), and (4) one rule for mapping n-ary relationships with n >= 3. Here are the eight rules:

- Rule #1: For each non-weak entity *E*, create a relation/table *R*. The name of the relation *R* is the same as the name of the entity *E*. Further, the attributes of the relation is the set of simple attributes associated with the entity plus all the simple component attributes associated with their composite attributes of *E*.

- Rule #2: For each multi-valued attribute *A* of an entity *E*, create a relation/table *R* whose attributes are composed of the attribute corresponding to *A* and the primary key of *E*.

- Rules #3: For each entity *A* which is related to another entity *B* via an "ISA" relationship (i.e., *A* "ISA" *B*), include in the relation corresponding to *A* the primary key of *B*.

- Rule #4: For each binary *one-to-one* relationship *R* between entities *A* and *B* with their corresponding relations *S* and *T*, include in *S*, the primary key of *B*. Further, if the relationship *R* has attributes, include them in *S*. Alternatively, choose *T* in the role of *S*.

- Rule #5: For each binary *one-to-many* relationship *R* between entities *A (1-side)* and *B (n-side)* with their corresponding relations *S* and *T*, include in *T*, the primary key of *A*. Further, if the relationship *R* has attributes, include them in *T*.

- Rule #6: For each binary *many-to-many* relationship *R* between entities *A* and *B* with their corresponding relations *S* and *T*, create a new relation *Q* with the same name as the relationship *R* and include in *Q*, the primary key of *A* and *B*. Further, if the relationship *R* has attributes, include them in *Q*.

- Rule #7: For each *n*-ary (*n*>=3) relationship *R*, create a new relation *Q* and include in *Q* the primary keys of all the entities involved in *R*. Further, if the relationship *R* has attributes, include them in *Q*.

- Rule #8: For each weak entity *E*, create a relation *R* whose schema consists of all the attributes of the entity *E* plus the partial key attributes of weak entity *E*'s owner entity or entities. *E*'s owner entities are those entities connected to entity *E* via identifying relationships (double-diamonds).

  Note that the above rule takes care of mapping identifying relationships. Therefore, no further mapping of identifying relationships is necessary.

When mapping relationships involving a weak entity *E*, the key for *E* to be used in the mapping is the combination of all the partial key attributes of *E* and the key attributes of weak entity *E*'s identifying entity or entities.

As one can tell, the above rules are axiomatic and therefore are perceived by some students as mathematical in nature. Consequently, students, especially those who are afraid of math, form a mental barrier preventing them from learning the mapping process properly and effectively. Another difficulty with the above rules is that it is quite hard to relate the entities with their corresponding relations. It is even harder to envision what the resulting relations should look like.

3. The New Approach

Based on the teaching experience of the authors the new approach for teaching the mapping process is evolved. This approach entails three components, the first component is a task map providing an overall roadmap and context of the mapping process while the second component is a set of programs animating each of the eight mapping rules. The third component is to incorporate visual clues into the concept as well as the eight mapping rules. In the following sections we explain our approach by first explaining all the tasks that are part of the process, then showing how we envision these tasks using animation and finally presenting the visual clues for each rule.

3.1 **Task maps**

The first component of the proposed new approach is a task map, based on the notion of concept maps, providing an overall roadmap and context of the mapping process. A concept map is a graphical tool and is typically used to organize ideas and knowledge by connecting related concepts with arrows. The notion of task maps used in this paper organizes related tasks instead via arrows and is adopted to present an overall plan for the mapping process. Hence, it should be introduced before the mapping rules are explained. As depicted in Figure 1 below, the task map offers students a clear "divide-and-conquer" plan for converting an Entity Relationship Diagram to its corresponding relational database schema. Specifically, the task map divides the process into two tasks, namely "map entities & attributes" and "map relationships". The task of "Map entities & attributes" in turn is accomplished by mapping non-weak entities and attributes, mapping weak entities and attributes, and mapping multi-valued attributes. On the other hand, "map relationships" is achieved by mapping binary relationships and mapping n-ary relationships. Finally, "map binary relationships" is carried out based on the four different types of binary relationships. The task map also helps student remember the mapping concepts better. Note that the concept introduced here is to be read from top to bottom by following the arrows. Tasks on the leaf level correspond to the eight mapping rules discussed in Section 2. However, it does not imply concurrency with respect to tasks of the same level, nor does it assume an order. For example, "Map Binary Relationships" and "Map n-ary (n>=3) Relationships" appear on the same level on the task map. It does not signify that these two tasks have to be performed at the same. Nor does it assume that "Map Binary Relationship" has to be done before "Map n-ary (n>=3) Relationships" or vice versa.

3.2 Animations

The second component of the proposed new approach is composed of a set of 3D animation programs for each of the eight rules discussed. The idea is to demonstrate the mapping rules in an animated environment to show the creation of relations and highlight the movement of primary keys based on the cardinalities of involved relationships. Figure 2 is a very basic sketch illustrating the mapping of a one-to-many relationship type. Note that the actual animation programs are much more effective in serving the intended purpose than the sketch provided. There actual development is the subject of future work.

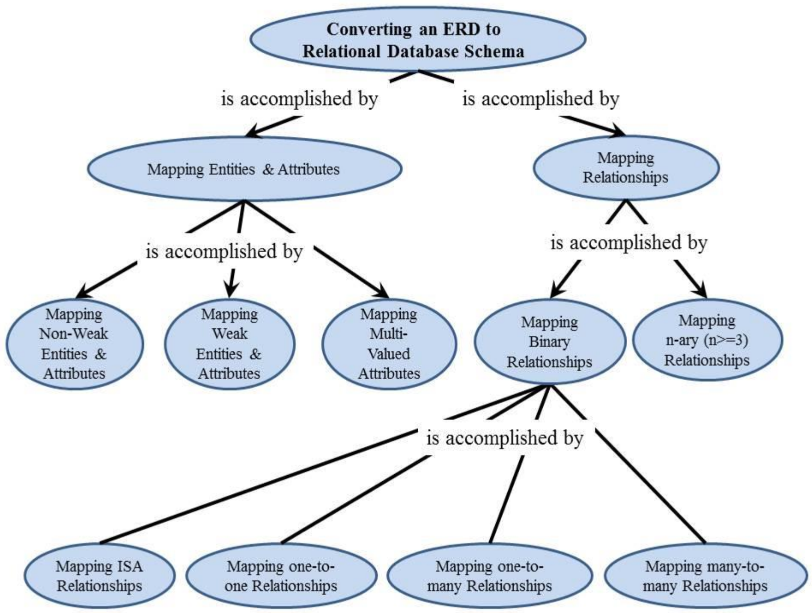


Figure 1 – Task map outlining the Mapping Process

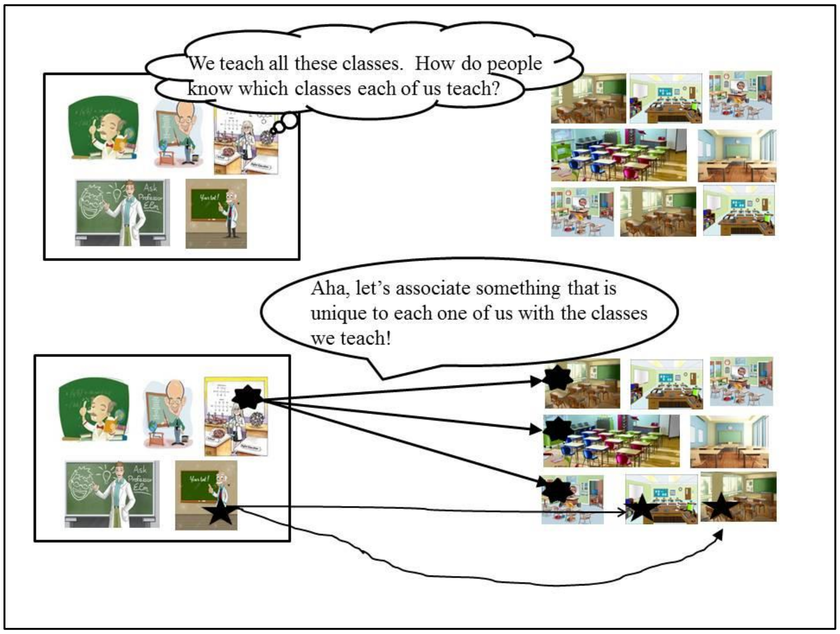


Figure 2 – Animation Sketch

3.3 Visual Clues

Most people are visual learners. Research shows that graphic and visual objects help students comprehend complex ideas and subjects. Further, they improve student retaining concepts taught in the classrooms[4]. The second component of the proposed new approach involves incorporating visual clues into the task map as well as the eight mapping rules. The goal is to "un-math" the mathematical complexity embedded in the eight mapping rules as perceived by students by replacing mathematical notations with visual objects whenever possible. The task map with visual clues is illustrated in Figure 2 below. This task map should be used instead of the initial one presented in the previous section.

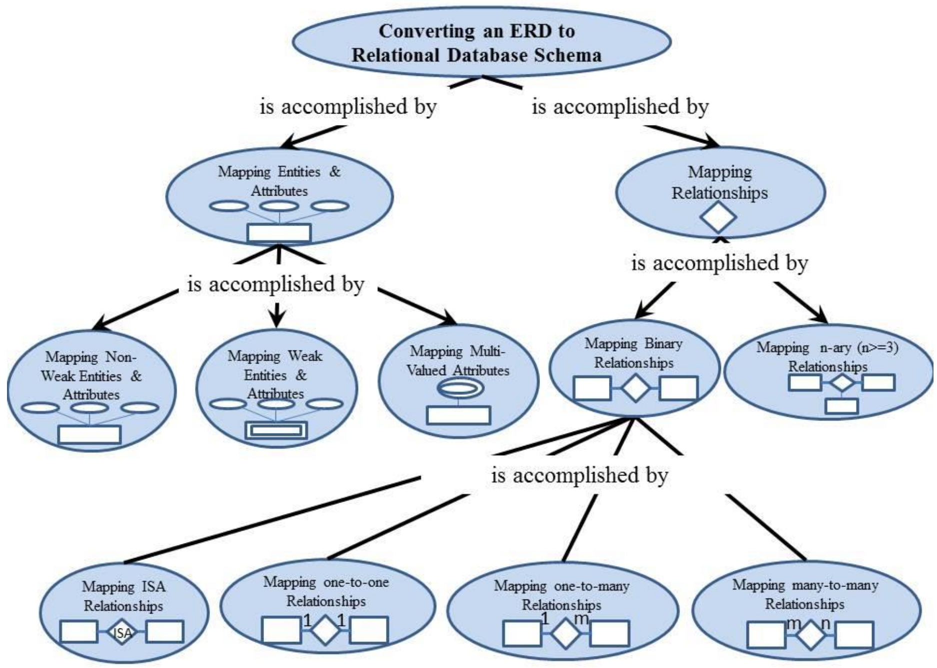
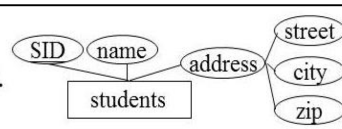


Figure 3 – Task map with Visual Clue

The eight rules with visual clues are presented in Figures 4 through 10. Take rule #1 as shown in Figure 3 as an example, first of all, the mathematical notation has been removed from the rule. Instead, actual examples of an entity and its corresponding relation are included in the rule as visual clues. As a result, students are able to the entity with its corresponding relation. Furthermore, the visual clues serve as a specific example for the rule as well.

For each non-weak entity (e.g.



), create a database relation/table. The name of the relation is the same as the name of the entity. Further, the attributes of the relation is the same as the set of attributes associated with the entity (i.e.,

students

SID	name	street	city	zip

).

Figure 4 – Rule #1

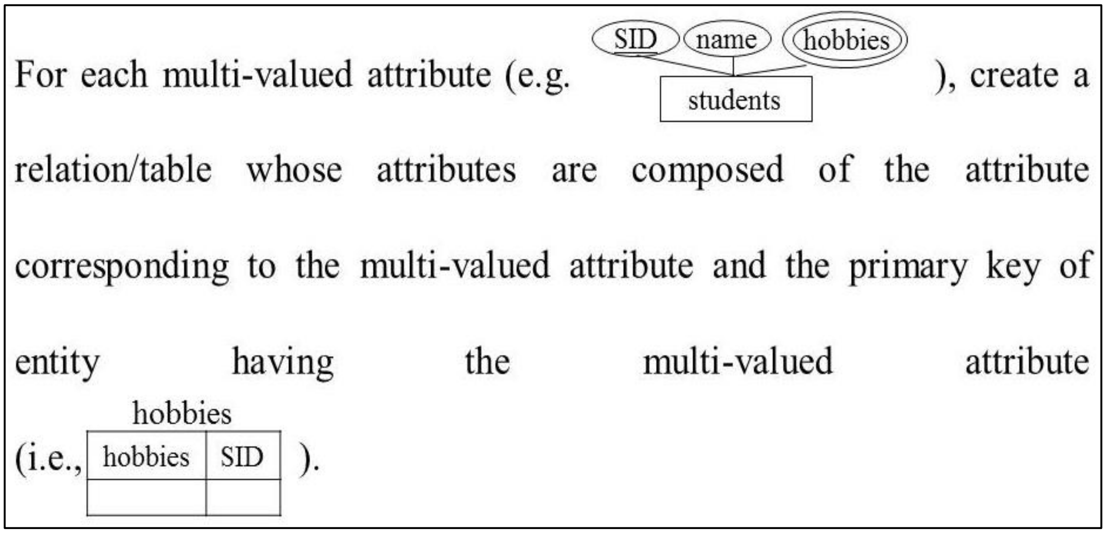


Figure 5 – Rule #2

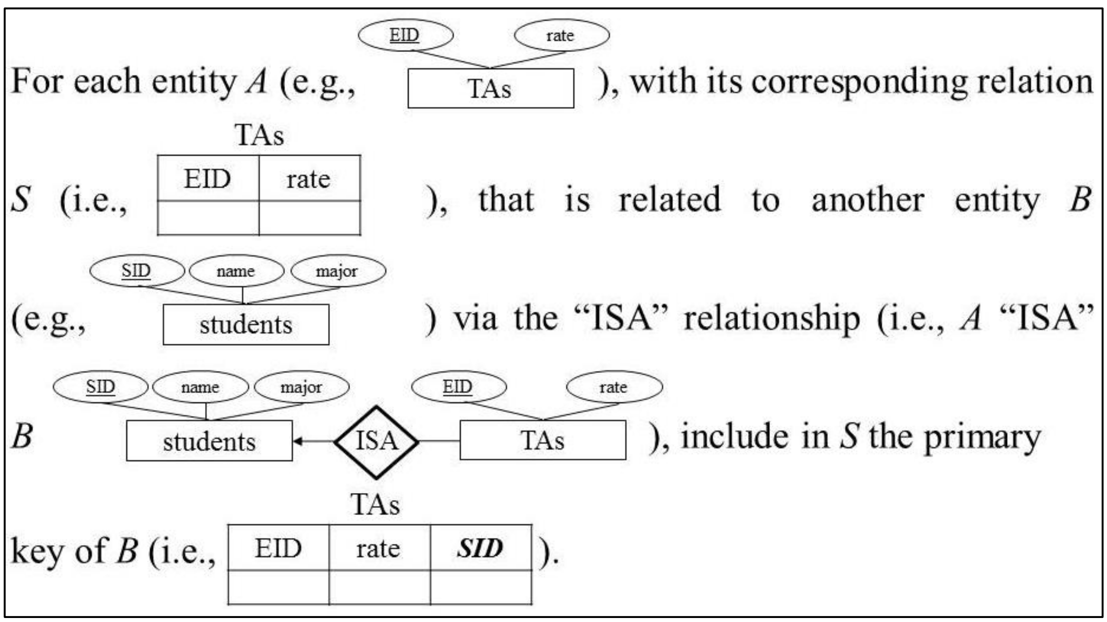


Figure 6 – Rule #3

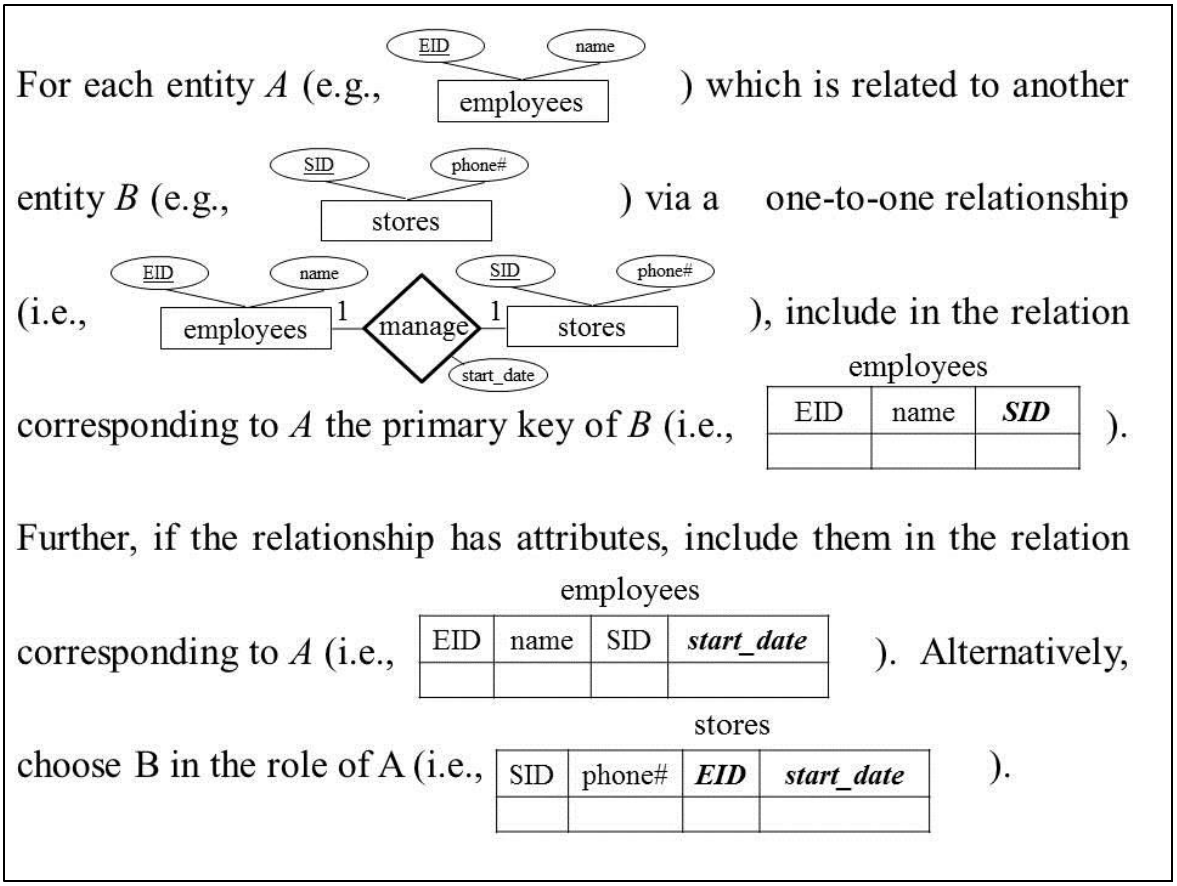


Figure 7 – Rule #4

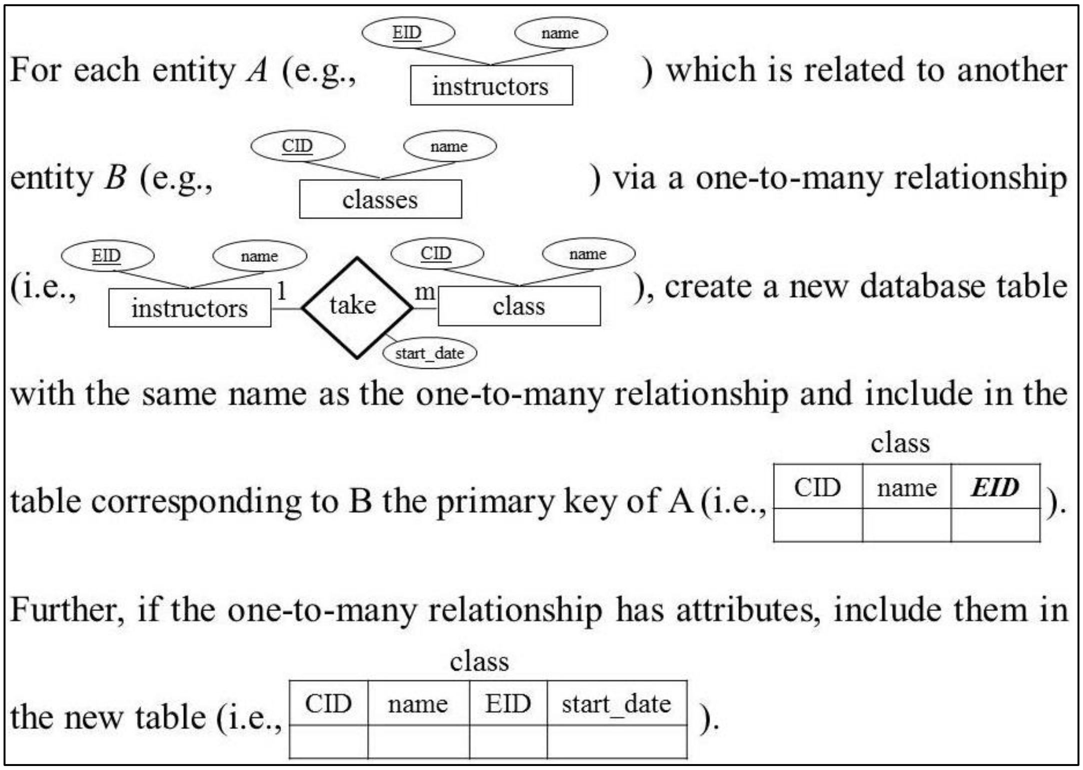


Figure 8 – Rule #5

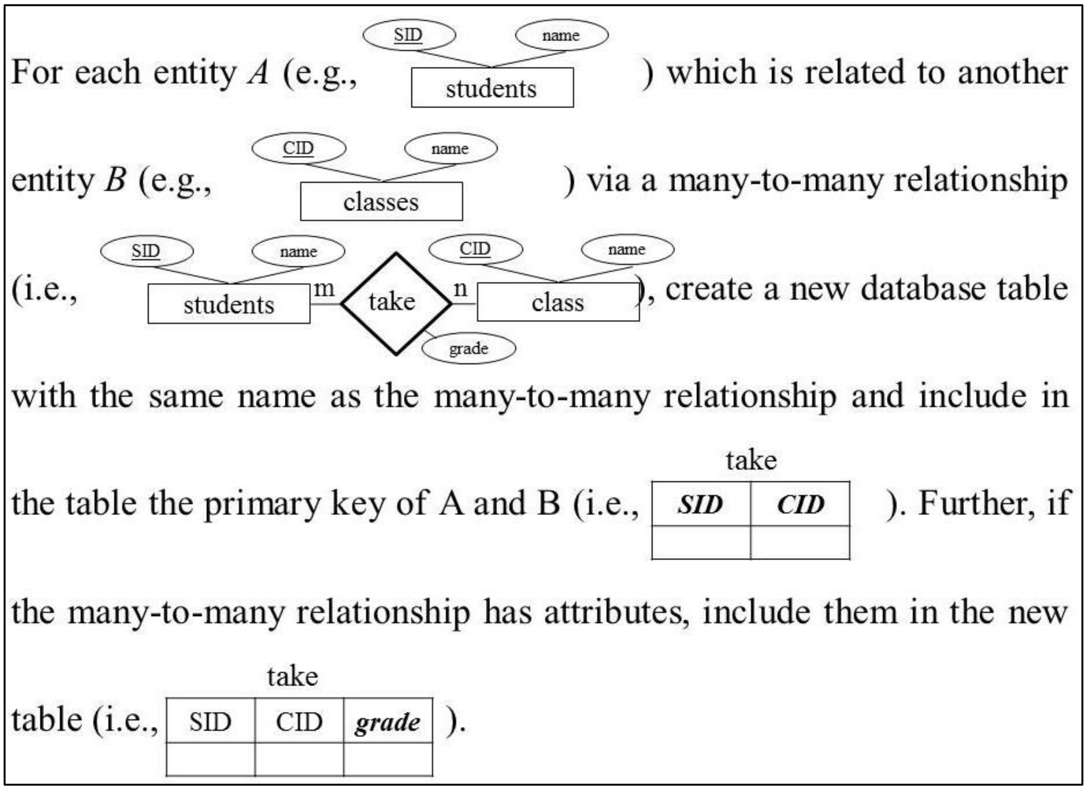


Figure 9 – Rule #6

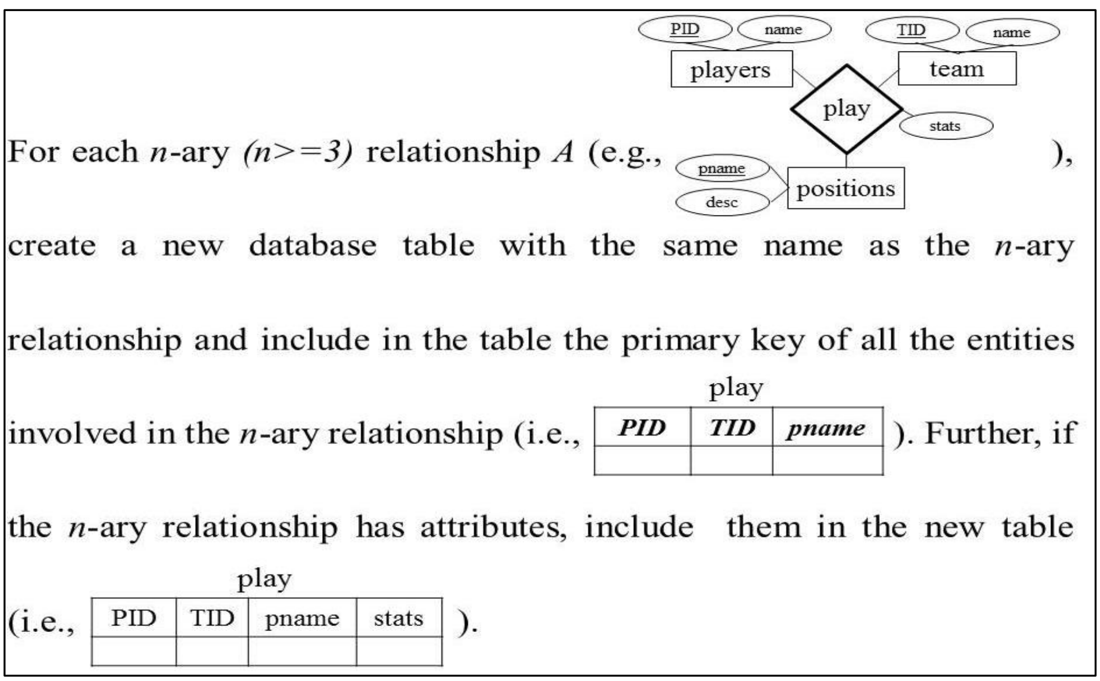
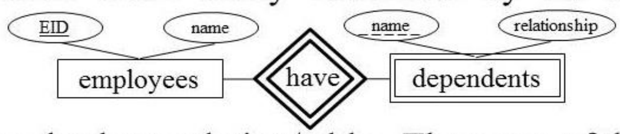


Figure 10 – Rule #7

For each weak entity identified by its owner entity or entities (e.g.



), create a database relation/table. The name of the relation is the same as the name of the weak entity. Further, the attributes of the relation is composed of the set of attributes associated with the weak entity plus key attributes of the weak entity's owner entity or entities (e.g., dependents

EID	name	relationship

).

Figure 11 – Rule #8

1. Conclusion and Future Work

In this paper, a new approach for teaching the mapping process for converting an Entity Relationship Diagram into its corresponding set of relations is introduced. The new approach improves upon the conventional teaching method by incorporating task maps, visual clues, and 3D animations as well as removing unnecessary mathematical notations.

What's presented in this paper is just the beginning. As noted earlier, further research activities include the actual development of 3D animation programs by using Alice. Further, exercises will be developed and classroom activities will be carried out to assess the effectiveness of this new approach. Specifically, classes will be divided into two groups and one group is taught the mapping process by following the conventional approach while the other group with the new approach. Afterwards, the students will be given the same assessment exercise to gauge the effectiveness of the new approach.

Bibliography

1. Garcia-Molina, H., Ullman, J., & Widom, J. (2014), *Database Systems: The Complete Book*, PEARSON EDUCATION, ISBN-13: 9780131873254
2. Coronel, C., Morris, S., & Rob, P. (2012), *Database Systems: Design, Implementation, and Management,* Cengage Learning, ISBN-13: 9781111969608
3. Elmasri, R., & Navathe, S. (2011), *Fundamentals of Database Systems,* Addison-Wesley, ISBN-13: 9780136086209
4. Mona Westhaver, M. (2011), *Webspiration Classroom From Bloom's Perspective*, url: http://www.inspiration.com/blog/2011/03/webspiration-classroom-from-blooms-perspective/