Database Design - Section 2

Instructor Guide
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**Database Design - Section 2**

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Lesson Preparation

This lesson begins the actual data-modeling content. Before jumping into definitions of attributes and entities, we first want students to understand the concept of modeling and to recognize models -- conceptual vs. physical. This lesson provides reasons for creating a data model in the first place, as opposed to just going ahead and building a database.

You may want to ask students, “Have you ever had trouble finding a document in a filing cabinet or folder that someone else organized? The files may have been organized to meet their needs, but not your own.”

Data modeling attempts to capture the needs of the business users so that the resulting database is one that everyone can use easily.

What to Watch For

No additional teaching information for this page.

Connections

None at this point -- this is the first chapter that actually talks about data modeling.
In this lesson, you will learn to:

- Identify and examine data
- List reasons for the significance of data
- List reasons for tracking/labeling data
- Measure the importance of describing information requirements
- Distinguish between a conceptual model and the physical implementation
- List five reasons for building a conceptual data model
- List examples of conceptual models and physical models
Why Learn It?

Ask: "If you were the manager of a fast-food restaurant, why would you want to collect information about how to make the customer lines at the food counter go faster?"

Discuss who benefits from this.

Answers include:

The faster you can serve people, the greater the profits are for your store!

What would be the profits of [USE THE NAME OF A POPULAR RESTAURANT IN YOUR AREA] if they could only serve one customer per hour?

Businesses benefit, as well as the customer. You would not return to a restaurant that could serve only one person per hour, would you?
Tell Me / Show Me

Play the animation and then ask the class:

- What is the problem in this animation?
- What could have been done to make this easier?
- Who should do things differently, the chef or the customer?

Feel free to replay and pause the animation if it helps the class discussion.

**Key responses would include:**

The chef should have asked more questions before preparing the sandwiches because he is the one who needs to do all of the work!

The woman should have a better-defined order.
Tell Me / Show Me

Tell Me / Show Me

What the person had in mind was the "conceptual model," and what the chef created was the "physical model" of the sandwich tray.

It would have helped if the conceptual model was understood by both from the beginning.

Can you think of other examples where describing what you want (conceptual) is important in getting what you want (physical)?

Tell Me / Show Me

You can explain the graphics if necessary:

In the first one, the boy is thinking of getting a nice sports car but is given a practical car instead.

In the second one, the girl is expecting a big bouquet of flowers but gets something considerably smaller.
Tell Me / Show Me

This animation is similar to the one at the beginning of the lesson, but this time, the customer specifies what she wants from the start.

The chef is able to execute the order perfectly. No time is wasted and everyone is happy.

You may want to ask students how could the same result be achieved?

Answer: The chef could have questioned the customer until he knew exactly what she wanted. If there was an employee manual specifying how to take an order, there would have been a complete order given to the chef by an “order taker.”
Try It / Solve It

The objective of the dream-house activity is for students to demonstrate precise communication as a means to facilitate discussion and prevent mistakes and misunderstandings.

Form student groups of two and explain the directions to the class: Working in pairs, one student describes his/her "dream house" while the other student attempts to draw it. The pairs can discuss specific details, but the student describing the house is not allowed to see what is being drawn until after time is called.

Assessment:

Collect student drawings and tape to the board/wall.
Ask volunteer student pairs to describe the discrepancies between what they thought was being described and what was actually drawn.
Solicit student ideas on how they would improve the communication process if they were to do the same activity again.

Possible answers may include: Describe shapes and colors. Describe relative sizes (bigger than a hut, smaller than a hotel, etc.) Be specific (2 doors, 3 stories, 5 windows, etc.). Make comparisons to known things (similar to Mary’s house, like a castle, etc.).
Other ways to test for understanding: Make sure that the students understand the difference between a conceptual and a physical data model by presenting examples and asking them to identify them as conceptual or physical:

- Blueprint of a house versus a house
- Sketch of an outfit/dress/suit versus the real thing
- Recipe for a cake versus the cake itself

If you can show actual samples of the above (house plans, draw a dress/suit on the board, print out a recipe), that would drive home the point even better. Feel free to supplement with other examples that are more familiar or accessible to you.
Lesson 2 - Entities and Instances

Lesson Preparation
No further lesson preparation information.

What to Watch For
Other ways to test understanding:
Give additional examples of entities (SHOPPING MALL, MOVIE STAR, SHOE) and ask them to name instances of each.
This will help you determine if they can distinguish between the two.

Connections
Recall the Dream House activity in Lesson 1. Identify the entities versus the instances there.
Some examples of entities and instances (Note that this is not an exhaustive list.):

<table>
<thead>
<tr>
<th>Entity</th>
<th>Instance</th>
</tr>
</thead>
<tbody>
<tr>
<td>DOOR</td>
<td>Front (location) or French (type)</td>
</tr>
<tr>
<td>WINDOW</td>
<td>Bedroom (location) or Bay (type)</td>
</tr>
<tr>
<td>TREE</td>
<td>Maple</td>
</tr>
<tr>
<td>PAINT COLOR</td>
<td>Blue</td>
</tr>
<tr>
<td>ROOM</td>
<td>Living</td>
</tr>
</tbody>
</table>
What Will I Learn?

In this lesson, you will learn to:

- Define and give an example of an entity
- Distinguish between an entity and an instance of an entity
- Identify three aspects of a business about which data must be known when given a brief description of a business
Why Learn It?

Ask students what kind of information they need to know or work with in each of these jobs:

- IT programmer/consultant
- Bank manager
- Restaurant cashier
- Artist
- Parent
Pass magazine ads around the class and/or look at commercial websites. Some suggestions are:

- nike.com - sports equipment
- weyl.nl - beef industry
- en-tranz.com - entertainment
- carmax.com - used cars
- hallmark.com - greeting cards
- sephora.com - beauty products
- telstra.com - communication
- changan.com.cn - automobiles

Ask students to identify the “main thing” about the ads or sites. They will usually come up with a list of entities and instances. Define entities and distinguish them from instances with examples. For example, if you use the Nike website/business with your class, make sure that they see the difference between the entity FOOTWEAR and the instance of the entity as Nike Shoe (or other shoe style).
Tell Me / Show Me

An entity is:

- "Something" of significance to the business about which data must be known
- A name for the things that you can list
- Usually a noun

Examples: objects, events

Entities have instances.
A Dalmatian, a Siamese cat, a cow, and a pig are instances of ANIMAL.
A convertible, a sedan, and a station wagon are instances of CAR.
There are many entities.
Some entities have many instances; some have only a few.
Entities can be:
- Tangible, like PERSON or PRODUCT
- Nontangible, like SKILL LEVEL
- An event, like CONCERT
Try It / Solve It

Activity: The Student Entity

Consider the entity STUDENT.

You are all students in a class. However, each one of you is a unique instance of that entity.

Your teacher will lead you through an exercise to demonstrate this.

Try It / Solve It

Activity: The Student Entity

It is useful to engage the students physically at this point -- so this activity will have them stand and sit. The activity is designed to help them distinguish between entities and attributes. In this case, the entity STUDENT and an instance of STUDENT (e.g., Julie Miller).

Say, “STUDENTS please stand up.” Have everyone sit down and then say, “Julie Miller (or some specific student in your class), please stand up.”

Then explain that while they are all students, Julie Miller is a specific instance of STUDENT.

Have students write on a 3 x 5 note card the answers to the questions below, or fill out a preprinted sheet of paper with the following information:

- Month of birthday
- Color of shirt/blouse
- Shoe color
- Color of backpack/school bag
- Glasses/no glasses
- Year in school
• Eye color
• Has a pet cat/dog/bird
• Right/left-handed
• Number of brothers and sisters

Note: The specific traits can be varied as long as there are six or more different traits. You need at least six traits to uniquely identify a student.

Collect the card/paper from each student. Ask all students to stand up. Randomly select one student’s card/paper. Ask a question for each trait that the students recorded. You are trying to eliminate other students until you are left with only the student whose card you have. This student is your INSTANCE. For example:

1. Will all those students who were born before or after (the month listed on the selected card) please sit down?
2. Will all those students who are not wearing shoes of color (the color on selected card) please sit down?
3. Will all those students who (wear/not wear) glasses please sit down?
4. Will all those students who do not have eye color (eye color on selected card) please sit down?
5. Will all those students who are (left/right)-handed please sit down?
6. Will all those students who have fewer or more siblings than (number of brothers and sisters) please sit down?

Make sure students can distinguish between entities and instances. Ask them how you can distinguish one student from another. You can ask them to provide answers now (name, gender, hair color, etc.), but tell them that these are attributes and will be discussed further later.

Ask students which traits would make good attributes to identify someone:

• Does the month of your birthday ever change?
• Does your shoe color change?
• What other traits could be added if shoe color and glasses are eliminated?

This will also be a good introduction to the discussion of attributes (sex, hair color, birth date) in the next lesson on attributes as well.
Try It / Solve It

Activity: The Haircutters

Think about the last time you went to get a haircut, permanent, manicure, or after service from a barbershop/hair salon.

Discuss the business of a barbershop/hair salon. Can you name the entities that are the “main things” about this business? Can you name instances of each entity?

Customer – Vishal Gupta

Services – color, cut, permanent wave, manicure, shampoo

Employees/technicians – stylist, shampoo person, cashier, receptionist

Products – shampoo, color, styling gel, lotion

Tools – hair dryer, scissors

Note: In naming entities, the class may also be including attributes. If they do this, correct them, and identify them as attributes, and tell them that we will discuss the difference more in the next lesson.
Lesson Preparation

In this lesson, we will start discussing the data model for a DJ (disc jockey) business. This is an example business scenario and model that will recur throughout the content. This consistent topic will help the students to learn data-modeling concepts. No diagram will be shown in this lesson; we just want the students to start thinking about the business.

What to Watch For

Make sure they can distinguish between entities and attributes. Is the attribute single-valued? If not, then it’s an entity. (Use example of CLASS and STUDENT, where there are many students in one class.)
Connections

Go back to entities identified in the Haircutters activity and identify attributes. Which are mandatory and which are optional?

Some entities identified could be STYLIST, CUSTOMER, SERVICE. Attributes could be the following:

- **STYLIST**
  - name (mandatory)
  - specialty (optional)
  - salary (mandatory)

- **CUSTOMER**
  - name (mandatory)
  - phone number (mandatory)

- **SERVICE**
  - code or name (mandatory)
  - description (mandatory)
  - price (mandatory)

Again, the mandatory or optional nature of attributes is determined by the business rules. The class may argue for answers different from what is given here.
What Will I Learn?

Ask students what another word for attribute is. This will help students define the term for other students who may not be familiar with this term.

Next, ask students if they can identify some attributes of a dog/cat/elephant? The idea is to clarify the term "attribute" before proceeding.

Alternatively, you can start the discussion by saying, “I am going to give you three attributes of something and see if you can guess it. Large, gray, African.” Answer: elephant.
Why Learn It?

There are two main concepts in this lesson: attributes and unique identifiers. Reasons are given for learning both.
Why Learn It?

It is important to learn about unique identifiers because they distinguish one instance of an entity from another.

For example:

- In a restaurant, you need to sort out the different orders.
- When classifying your CD collection, you need to be able to locate a particular CD.
- When building several sales reports for a department, you must pick out the correct sales report from a list of reports.
Tell Me / Show Me

An attribute is a piece of information that in some way describes an entity. An attribute is a property of the entity, a small detail about the entity.

Entities Have Attributes
For now, tell students to assume that all entities have at least one attribute. Later, we will discover exceptions to this assumption. Usually, there are many attributes for an entity, but again, we are interested only in those attributes that are of importance to the business.
Tell Me / Show Me

Attributes:

Point out that the only attributes they need to model are those that the business cares to track. So for example, you may want to track shoe size as an attribute of customer if you are a shoe store, but maybe not if you are a grocery store. It all depends on the business requirements.

Every attribute has a data type. For example, the attribute “name” would be of a data type like character string, the attribute “salary” would have a number data type, and the attribute “photograph” would likely be of an image data type.

Attribute Is Single-Valued

An attribute for an entity must be single-valued. In more precise terms, an entity instance can have only one value for that attribute at any point in time. This is the most important characteristic of an attribute. The attribute value, however, may change over time.

For example: The entity CAR may have attributes “model” and “color.” There can be only one value for these (for example, "beetle" and "green") at one time. Although model stays constant over the lifetime of the car, color could change.
Volatile Attributes
Some attributes are volatile (unstable). An example is the attribute age. Always look for nonvolatile, stable attributes. If there is a choice, use the nonvolatile one. For example, use the attribute birth date instead of age.

Mandatory vs. Optional Attributes
Explain that depending on the business, some attributes must have a value (mandatory), whereas for others the value is optional.
For example, email address could be a mandatory attribute for EMPLOYEE if you are modeling an email application. It could be optional for a CUSTOMER if you are modeling an online catalog.
Tell Me / Show Me

Have students talk about their favorite DJs and what makes them so good. DJs have to know a lot about music. Talk about the SONG entity, which is the collection of songs and soundtracks. Ask class to give attributes that describe it and values for each attribute.

Possible answers would be title (here they could name their favorite songs), composer, date released/composed, duration, and artist (this one is potentially multivalued, as several artists could perform the same song. Provide the business assumption that each artist’s version is considered a different performance of that song, and we will define it as a different instance in the SONG entity. After all, when you request a song, you often also have a specific artist’s version in mind).

Then point out attributes that are mandatory (such as a title) and some that are optional (such as the date it was released). Explain that release date is a better attribute than age because it is less volatile.

Note: The DJ Business scenario is introduced in its entirety in the next lesson.
Tell Me / Show Me

When picking a unique identifier for SONG, have students recall the Student Entity activity from the previous lesson. What combination of traits finally resulted in just one student? Then ask if there is a simpler way to find a specific student -- perhaps a student number or ID? (Most schools assign one to each student.)

**Ask the class if title would be sufficient to uniquely identify a SONG.**

**Answer:** No, because there are cases of songs with the same title.

Would a combination of attributes work? Probably. (Example: title and composer and artist.) Could you decide to just assign a unique ID to each SONG, similar to Student number? Yes.
Try It / Solve It

**Assessment:**

In order to guide students in the direction of the given solution, you may want to provide business contexts for each concept, such as:

- Vehicle (a car-rental agency)
- Diet Coke (a restaurant)
- Price (a department store)
- Customer number (an online catalog)
- Green (a botanical garden)
- Cookie (a restaurant)

Please note that the solution given here is one of many possibilities. If students give different answers, encourage class discussion about their responses. For example: Vehicle is most likely an entity in a car-rental business. You can have a list of vehicles (an entity is something you can make a list of items for). Each item on the list would be an instance of the entity (such as convertible, sports utility, sedan, coupe). Vehicle would probably not be an attribute because there would be many values for a vehicle (remind them that attributes are single-valued). Could
vehicle be an instance? It’s unlikely in a car-rental agency that rents only vehicles. However, one could argue that in a more general rental business that offers other items besides vehicle (tools, other equipment), then vehicle could be an instance of an entity called RENTAL ITEM. Alternative answers may be considered acceptable, if the student can argue successfully and provide a business context or rule for it.
Try It / Solve It

Activity: Song

The goal of this practice is to recognize attributes for an entity.

On the left side of the illustration are three entities that play a role in the business: SONG, EVENT, and CUSTOMER. On the right is a choice of attributes.

Match the attribute to the entity or entities it describes.

<table>
<thead>
<tr>
<th>SONG</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Description</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>EVENT</th>
<th>Venue</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Type</td>
</tr>
<tr>
<td></td>
<td>Description</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CUSTOMER</th>
<th>First name</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Last name</td>
</tr>
<tr>
<td></td>
<td>Phone number</td>
</tr>
<tr>
<td></td>
<td>Email address</td>
</tr>
</tbody>
</table>
Assessment:
Entity: STUDENT
Attributes: student ID, first name, last name, address
UID: student ID

Entity: MOVIE
Attributes: title, date released, producer, director
UID: a combination of title and date released, or an artificial UID such as movie ID

Entity: LOCKER
Attributes: size, location, number
UID: number
Lesson Preparation

No further lesson preparation information.

What to Watch For

Make sure that information is stored only once -- the same attribute should not be repeated in another entity if it is describing the same information. For example: price can be an attribute of FOOD ITEM, but total price of an ORDER can be derived so it should not be an attribute there.

Assess for understanding by asking students if entities change depending on the type of database, computer, or programming language used. Answer: No. This is what is meant when we say that data modeling is “implementation-free.”
Connections

Reiterate that the ERD is a tool for discussion, especially when designing a system. It gives you and the customer something to react to, validate, and correct. Ask students to think back to the Dream House activity. When the student who wanted the dream house saw the picture that the other student had drawn, the student knew that the other person either (a) got it right! or (b) got it wrong. That’s how an ERD works.

Other examples that help illustrate this point: getting a haircut based on a picture in a magazine (have you ever forgotten the picture?); having a dress made from a picture in a magazine (what if you could only explain it?); describing a gift you want to your parents who’ve never seen this item. Pictures help!
What Will I Learn?

In this lesson, you will learn to:

- List the four goals of entity relationship modeling
- Identify an entity relationship diagram (ERD)
- List the major types of databases
- Define the meaning of "implementation-free" as it relates to data models and database design implementation
Remind students that they need to know what an ERD looks like -- they will be drawing ERDs in the next section and throughout the course. This is where students become architects and draw their clients’ "dream" models.
Database Types: Hierarchical, Relational, Network

This picture shows us that an ER model captures business information that can be used as a basis for any database. The ER model tells us something about the business, not about the implementation. Having said that, in practice, the majority of the ER models lead to relational database implementations.
Tell Me / Show Me

Discussion points using the school-record example:

Where does the school store student information? How is it stored?
Who is responsible for updating changes to student information?
What information indicates that a student is eligible for graduation?
Have you ever updated information only to be asked to do it again?
What happens to student data when the school gets new database computers?
How do you locate your information among all the other student records?
How do your grades not get confused with another student with the same last name?
Tell Me / Show Me

You will be showing the ER model to the class as an example of a complete data model. This will contain supertypes/subtypes, arcs, barred relationships, and other data-modeling techniques that you have not taught yet. Just explain that by the end of the course, they will know what it all means. For now, focus on the entity names in softboxes and on the attributes inside the softbox, which are mandatory (*) and which are optional (o). Point out the relationships. These are coming up in the next lesson.

Drawing conventions will be discussed in another lesson, so you may not want to use the terms “softbox” when going over the ERD. You may not even want to go over the drawing conventions for mandatory and optional attributes (* vs. o), but it is all right if some students deduce this from your demonstration.
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Activity: The Restaurant

Read the business scenario of a fast food restaurant below:

We are a small fast food business. Our menu features food items that can be ordered by a customer. A customer places an order at the counter and indicates what food items he/she would like on that order.

Lately we've noticed that we have some regular customers, so we started asking them for information - such as name and address, so we can mail them coupons when we have specials.
Try It / Solve It

Activity: The Restaurant

The restaurant ERD and business scenario is a partial version of the progressive project, Global Fast Foods, which they will be building throughout the course. This is not a definitive solution for this activity. Other students may want an entity called MENU, with food item as an attribute. Be careful with this one: although MENU could be a valid entity, food item as an attribute would be repeating; there would be many different food items on a menu. Therefore, even with MENU as an entity, you would still need FOOD ITEM as another entity. Attributes of menu could be name, hours served, etc.

Ask students why they would choose to make an attribute mandatory or optional. This makes them start thinking about business rules.
UID for ORDER could be number, UID for FOOD ITEM could be name (or ID), and UID for CUSTOMER could be name and address together or ID.
Tell Me / Show Me

This is an exercise that asks students to identify and analyze information contained on a printed report. Throughout the course, they will be looking at “source documents” such as reports, receipts, notes, etc., and creating data models from them. At this point, we want the students to start asking the right questions, given a source document.

Assessment:

What is this table about?
It is about food items purchased in a lunch room, most likely in a school.
What data was collected? How often is it collected?
The table shows the count of types of food items (hamburger/taco, pizza, soup/salad) purchased per day, broken out by faculty sales and student sales. It seems that the data is collected weekly.

What information does this table provide?
The table gives us information about which items are the most popular.
**How do you think these data are used?**

It could be used to plan inventory for food and to assign duties in the kitchen and at the serving counter.

Generate at least one conclusion based on the data provided.

Hamburgers and tacos are the most popular food; soup and salad are the least popular.

Generate at least one question that you could ask about the data provided.

Do students and teachers prefer the same food? How do the total counts for students and teachers break down in terms of type of food purchased?
Lesson 5 - The Missing Link

Lesson Materials

Picture from a Magazine
This should tell a story, but allow you to hold back a piece of the story. For example, if you choose a scene of a busy street with a man getting splashed by a car driving by, you can hold onto the piece with part of the man on it. Ultimately, any image will work, but it’s more fun if it’s a mystery for the students.

Take the 8 1/2 x 11 image and cut it into 16 equal pieces. Divide the class into three groups/teams. (Note: if the class is larger than 20, you may want to break them into four groups and have the fourth work as observers. If that is the case, then have the observers follow the "Observe" directions listed below.) Depending on your time limitations, you also may want to have them decide on a group name for themselves.

Mix up the pieces of the puzzle and randomly distribute five pieces to each group. This leaves one piece left over. The instructor should hide this piece in pocket or on desk.

Draw the relationships that represent the ERD.

Scissors
This activity is a small-group communication exercise to be completed in class.
Lesson Preparation

Explain the rules of engagement:

- Do not allow any other team to see the pieces you have.
- Attempt to identify the missing piece of the picture.

These rules are simple, yet profound. They serve to create a situation where students work collaboratively together to "analyze" their problem, develop a "strategy" for their solution and "design" a method for implementing that solution.

**Observe:** The students will first attempt to lay out the pieces they have in front of them and try to fit them together. Once they realize there are gaps, they'll begin attempting to communicate with the other groups. Note the experiential learning process taking place. Identify and record the how the class discovers the "missing link." Also, note any metaphors (see Assessment) that may be unique to this classroom.

Define specific roles for each group member. This keeps students from just running around the room quickly trying to get “the answer.” Specifically, each group should have only one member that can talk to anyone else in the room. This person comes back to his/her group and shares information found.

**Completion:** Once the students have decided upon the missing piece and given an accurate verbal description, have them come together in a central location and put the pieces of the 8 1/2 x 11 image together. This is the first time that students will see other group’s pieces. The instructor will add the final, missing piece.

**What to Watch For**

Discuss metaphors that the game represents, such as:

Data - original five pieces in front of them.

Information - when data is connected. How was data grouped? Were any entities identified (these would be things in the picture)?

Relationships - words describing each piece or the location in the "big picture."

**Connections**

No connections for this lesson.
What Will I Learn?

In this lesson, you will learn to:

- Complete the image and identify the "missing link" of the puzzle
- Identify areas of the "missing link" exercise that are similar to entity relationship modeling
- Evaluate the communication process used and assess the strengths and weaknesses
Why Learn It?

This lesson provides a frame of reference for concepts such as “strategy,” “analysis,” and “design.”

Point out that the data modeler is a detective of sorts. Sometimes clients don’t even know what is missing from their description of what they want them to build. Asking the right questions, working with others, and teasing out important information for the task is crucial to the success of the project.
Tell Me / Show Me

Working in groups, you will all participate in the Missing Link activity.

Your teacher will distribute the materials and give you directions on how to complete it.
Assessment

Debrief the activity. Share with the students your observations (or the observing group). Examine how the students developed their strategy for providing a solution. Discuss the communication process and how vital this role is in transforming business requirements into an operational database. Did the students create their own method for solving the problem? How is this similar to analyzing business needs?
Try It / Solve It

Section 2
Lesson 5 - The Missing Link

Try It / Solve It

Extension Activity: Reactions to Missing Link

Write your reactions to the activity in your journal. Was it interesting? Worthwhile? How did the activity support the idea of data modeling and database design?