The LEGO® Database

-- Johnathan Clementi –

-- Prof: Alan Labouseur –

-- Date: 12/4/2017 –

-- Assignment: Design Project LegoDB –

-- File name: legoDB_documentation --

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Executive Summary

In preparation for the 2017 Christmas season, the Lego® Group was looking for an upgrade to their database. To do this, they hired Daniel Craig, a relational database designer from London in early September of 2017. Unfortunately, Mr. Craig has gone missing, and the Lego® Group needs this database as soon as possible so they can keep track of their holiday sales. Instead, The Lego® Group has hired a student from Marist College in Poughkeepsie, NY – Mr. Johnathan Clementi. This is Mr. Clementi's documentation for his Lego DB.

Designed in PostgreSQL, a relational database management system, the database contains information pertinent to running the Lego® Group such as bricks, sets, designers, customers, and transaction information. This paper explains the implementation the database: First is an entity relation (ER) diagram which graphically explains how the database's tables are related to one another. Next is a detailed listing of each table as well as queries to retrieve information (data with context) from such tables. After this stored procedures, views, reports, and triggers to enhance usability of the database are found. Finally, known problems and future enhancements are addressed.

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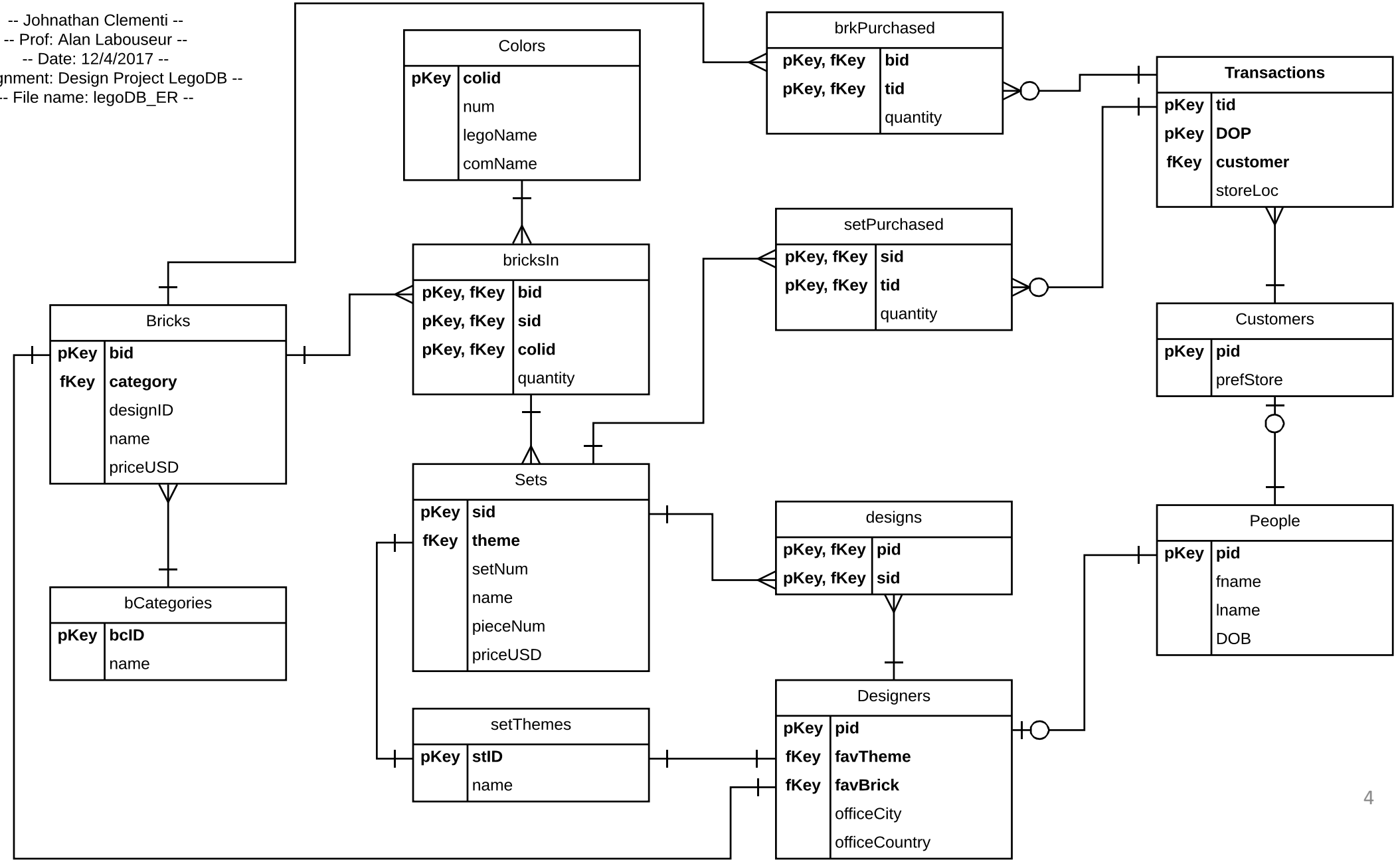
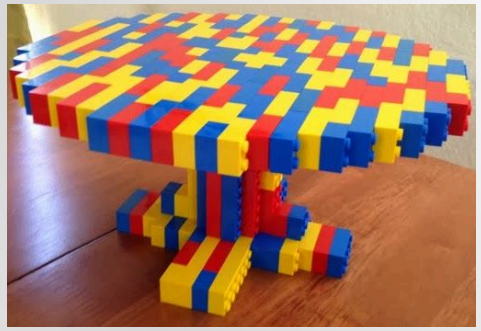


Table declarations and explanations

Brick Categories Table

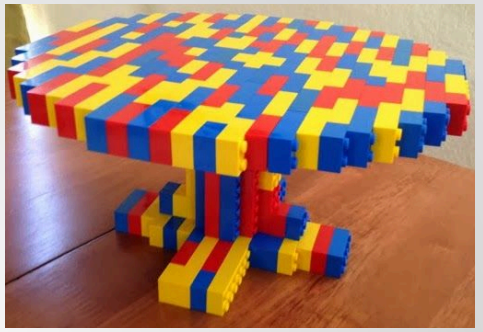
- This table contains 17 categories of Lego® bricks
- Functional Dependencies:
  - (bcID) → name

```
CREATE TABLE bCategories (
        bcID    CHAR(4) PRIMARY KEY NOT NULL,
        name    TEXT NOT NULL
);
```



	bcid character (4)	name text
1	bc01	Beams
2	bc02	Bricks
3	bc03	Bricks w/ Bows and Arc…
4	bc04	Bricks, special
5	bc05	Bricks, Technic 4.85
6	bc06	Connectors
7	bc07	Decoration Elements
8	bc08	Figure parts
9	bc09	Figure Clothing
10	bc10	Figure Heads and Masks
11	bc11	Figure Accessories
12	bc12	Frames, Windows, Wall…
13	bc13	Functional Elements
14	bc14	Plates
15	bc15	Plates, special
16	bc16	Signs, Flags, and Poles
17	bc17	Transportation

Colors Table

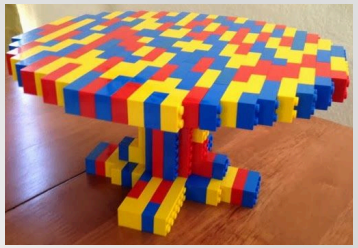


- This table contains 19 of the most common colors of Lego® bricks. Colid is an artificial key, num is a Lego® number assigned to the color, legoName is the official name given to the color by Lego® , and comName is the common name
- Functional Dependencies:
  - (colid) → num, legoName, comName

```
CREATE TABLE Colors (
        colid           CHAR(3) PRIMARY KEY NOT NULL,
        num             VARCHAR(3) NOT NULL,
        legoName        TEXT NOT NULL,
        comName         TEXT
);
```

	colid character (3)	num character varying (3)	legoname text	comname text
1	c01	1	White	White
2	c02	5	Brick Yellow	Tan
3	c03	18	Nougat	Flesh
4	c04	21	Bright Red	Red
5	c05	23	Bright Blue	Blue
6	c06	24	Bright Yell...	Yellow
7	c07	26	Black	Black
8	c08	28	Dark Green	Green
9	c09	323	Aqua	Unikitty Bl...
10	c10	326	Spring Yell...	Unikitty Gr...
11	c11	40	Transparent	[null]
12	c12	41	Transpare...	[null]

Bricks Table

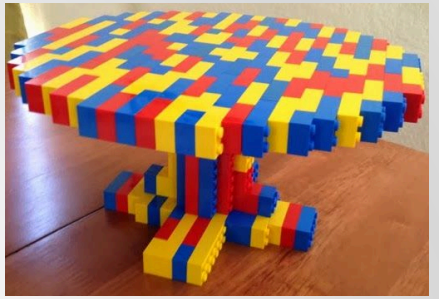


- This table contains 65 examples of Lego® bricks. Includes Lego®'s numbering system (designID), the category in which the brick belongs, the name of the brick, and the price of 1 individual brick
- (bid) → designID, category, name, priceUSD

```
CREATE TABLE Bricks (
        bid             VARCHAR(7) PRIMARY KEY NOT NULL,
        designID        VARCHAR(7) NOT NULL, -- designID is Lego's identifier for a type of brick --
        category        CHAR(4) NOT NULL REFERENCES bCategories(bcID),
        name            TEXT,
        priceUSD        NUMERIC(10,2)
);
```

	bid character va	designid character va	category character (4)	name text	priceusd numeric (10,2)
1	b001	3005	bc02	Brick 1x1	0.07
2	b002	3004	bc02	Brick 1x2	0.10
3	b003	3622	bc02	Brick 1x3	0.14
4	b004	3010	bc02	Brick 1x4	0.15
5	b005	3009	bc02	Brick 1x6	0.24

Set Themes Table



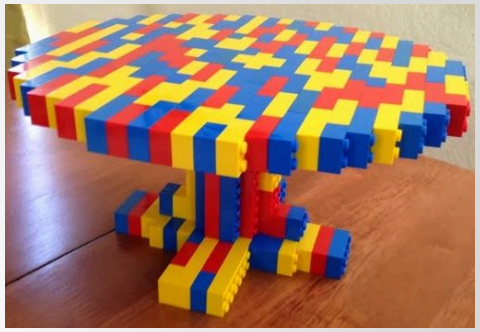
- This table contains 27 themes (currently in production) of Lego® sets. These are the themes that are currently in production.
- (stID) → name

```
CREATE TABLE SetThemes (
        stID    CHAR(4) PRIMARY KEY NOT NULL,
        name    TEXT NOT NULL
);
```

	stid character (4)	**name** text
1	st01	Architecture
2	st02	The Lego Movie
3	st03	Boost
4	st04	City
5	st05	City: Octan
6	st06	City: Vehicles
7	st07	Classic
8	st08	Creator

Sets Table

- This table contains 30 examples of Lego® sets. setNum is a Lego® assigned unique value for each of their sets.
- (sid) → setNum, theme, name, pieceNum, priceUSD

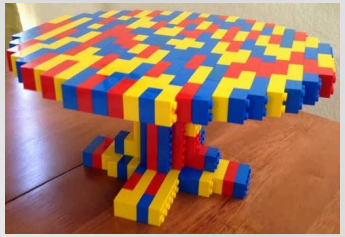


```
CREATE TABLE Sets (
        sid             CHAR(4) PRIMARY KEY NOT NULL,
        setNum          VARCHAR(7) NOT NULL, -- Lego's set identifier --
        theme           CHAR(4) NOT NULL REFERENCES setThemes(stID),
        name            TEXT NOT NULL,
        pieceNum  INT NOT NULL,
        priceUSD   NUMERIC(10,2) NOT NULL
);

SELECT s.sid, s.setNum, st.name AS setTheme, s.name, s.pieceNum, s.priceUSD
FROM Sets s INNER JOIN setThemes st on s.theme = st.stID;
```

	sid character	setnum character	settheme text	name text	piecenum integer	priceusd numeric (10,2)
1	s001	10179	Lego Star Wars	Millennium Falcon	5195	3899.99
2	s002	10221	Lego Star Wars	Super Star Destroyer	3152	969.99
3	s003	10256	Architecture	Taj Mahal	5922	4499.99
4	s004	10214	Creator	Tower Bridge	4295	239.99

People Table

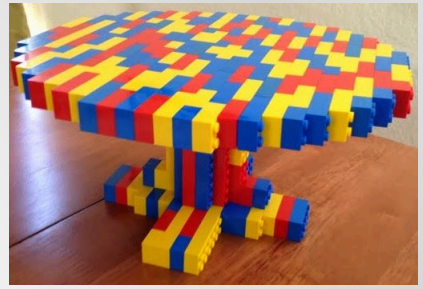


- This table contains data for people involved with Lego® in some fashion (both customers and designers)
- (pid) → fname, lname, DOB

```
CREATE TABLE People (
        pid             CHAR(4) PRIMARY KEY NOT NULL,
        fname           TEXT NOT NULL,
        lname           TEXT NOT NULL,
        DOB             DATE NOT NULL
);
```

	pid character (4)	fname text	lname text	dob date
1	p001	Johnathan	Clementi	1996-05-12
2	p002	Alan	Labouseur	1970-01-15
3	p003	Megan	Clementi	1968-11-15
4	p004	Paul	Clementi	1966-01-25
5	p005	Kathryn	Rivera	1998-11-12

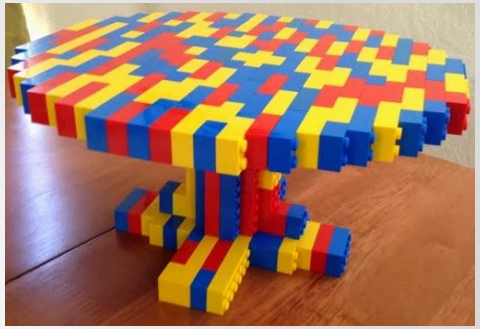
Designers Table



- This table contains 12 examples of designers of Lego® sets. A designer is a person, thus this table is a subset of the people table. FavTheme and FavBrick are foreign keys to setThemes and bricks respectively. Finally the table has information about the designer's office location.
- (pid) → favTheme, favBrick, officeCity, officeCountry

```
CREATE TABLE Designers (
        pid                 CHAR(4) NOT NULL REFERENCES People(pid),
        favTheme            CHAR(4) REFERENCES setThemes(stID),
        favBrick            CHAR(4) REFERENCES bricks(bid),
        officeCity          TEXT,
        officeCountry       TEXT,
    PRIMARY KEY(pid)
);
```

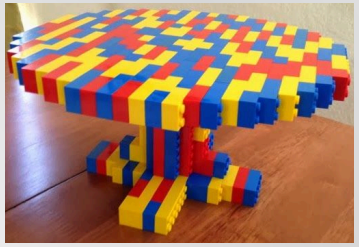
Designers Table (cont.)



```
SELECT p.fname, p.lname, st.name as favTheme, b.name as favBrick, d.officeCity, d.officeCountry
FROM Designers d INNER JOIN People p ON d.pid = p.pid
                 INNER JOIN setThemes st ON d.favTheme = st.stID
                 INNER JOIN bricks b ON d.favBrick = b.bid;
```

	fname text	lname text	favtheme text	favbrick text	officecity text	officecountry text
1	Alan	Labouseur	The Lego Movie	Plate 2x12	London	England
2	Megan	Clementi	Lego Star Wars	Brick 1x1	Prague	Czech Republic
3	Paul	Clementi	Technic	Plate 4x12	Singapore	Singapore
4	Jorgen Vig	Knudstorp	Duplo	Plate 1x2	Philadelphia	United States ...

Customers Table



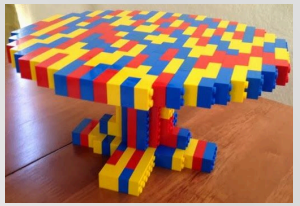
- This table contains 12 examples of customers of Lego® sets. A customer is a person, thus this table is a subset of the people table. PrefStore refers to the customer's preferred store, or the store they shop at the most.
- (pid) → prefStore

```
CREATE TABLE Customers (
        pid                 CHAR(4) NOT NULL REFERENCES People(pid),
        prefStore           TEXT NOT NULL,  -- Customer's preferred store --
    PRIMARY KEY(pid)
);
```

```
SELECT p.fname, p.lname, prefStore
FROM Customers c INNER JOIN People p on c.pid = p.pid;
```

	fname text	lname text	prefstore text
1	Johnathan	Clementi	King of Prussia
2	Megan	Clementi	San Fransisco
3	Kathryn	Rivera	New York City
4	Alex	Antaki	Shanghai
5	Matthew	Oakley	Dallas

Transactions Table



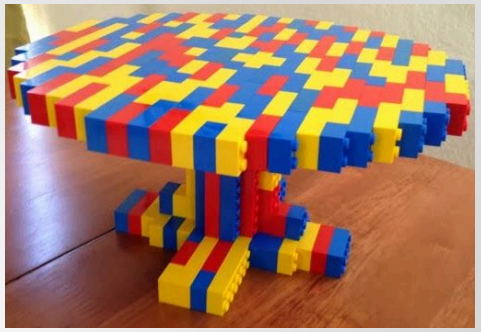
- This table contains all of the transactions to purchase Lego® bricks and sets
- (tid) → customer, storeLoc, DOP

```
CREATE TABLE transactions (
        tid             CHAR(4) PRIMARY KEY NOT NULL,
        customer   CHAR(4) NOT NULL REFERENCES customers(pid),
        storeLoc        TEXT NOT NULL,
        DOP             DATE NOT NULL -- Date of Purchase –
);
```

```
SELECT t.tid, p.fname, p.lname, t.storeLoc, t.DOP
FROM transactions t  INNER JOIN customers c on t.customer = c.pid
                     INNER JOIN people p on c.pid = p.pid;
```

	tid characte	fname text	lname text	storeloc text	dop date
1	t001	Johnathan	Clementi	King of Prussia	2017-12-01
2	t002	Megan	Clementi	San Francisco	2017-12-02
3	t003	Megan	Clementi	New York City	2017-12-03
4	t004	Kathryn	Rivera	Shanghai	2017-12-04
5	t005	Alex	Antaki	Shanghai	2017-12-01
6	t006	Matthew	Oakley	Moscow	2017-12-02

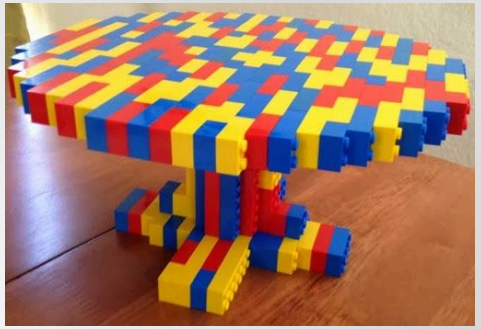
Sets Purchased Table



- This represents the Lego® sets purchased, and is therefore a subset of the transaction table. Because there can be many sets purchased in the same transaction, there must be an associative entity (the setsPurchased table) to map every intersection while maintaining uniqueness and referential integrity.
- (sid, tid) →quantity

```
CREATE TABLE setPurchased (
        sid             CHAR(4) NOT NULL REFERENCES sets(sid),
        tid             CHAR(4) NOT NULL REFERENCES transactions(tid),
        quantity        INT NOT NULL
);
```

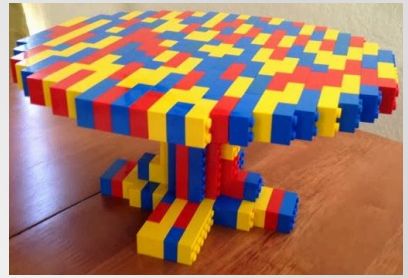
Sets Purchased Table (cont.)



```
SELECT sp.tid, s.name AS setName, p.fname, p.lname, t.storeLoc, t.DOP, sp.quantity
FROM setPurchased sp INNER JOIN sets s on sp.sid = s.sid
                     INNER JOIN transactions t on sp.tid = t.tid
                     INNER JOIN customers c on t.customer = c.pid
                     INNER JOIN people p on c.pid = p.pid;
```

	tid characte	setname text	fname text	lname text	storeloc text	dop date	quantity integer
1	t001	Millennium Falcon	Johnathan	Clementi	King of Prussia	2017-12-01	1
2	t002	Airport Rescue Vehicle	Megan	Clementi	San Francisco	2017-12-02	2
3	t006	Death Star	Matthew	Oakley	Moscow	2017-12-02	2
4	t007	Princess: Ariels Magica...	Eric	Seltzer	Singapore	2017-12-03	1

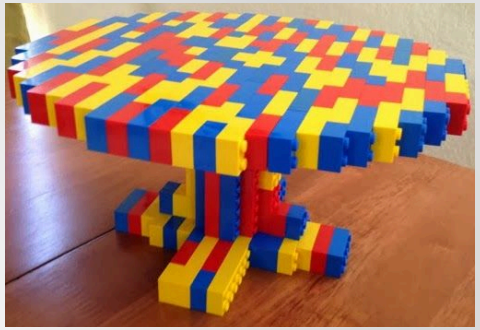
Bricks Purchased Table



- This represents the Lego® bricks purchased, and is therefore a subset of the transaction table. For the same reason that sets purchased table is an associative entity, the bricks purchased table is an associative entity.
- (bid, tid) →quantity

```
CREATE TABLE brkPurchased (
        bid             CHAR(4) NOT NULL REFERENCES bricks(bid),
        tid             CHAR(4) NOT NULL REFERENCES transactions(tid),
        quantity        INT NOT NULL
);
```

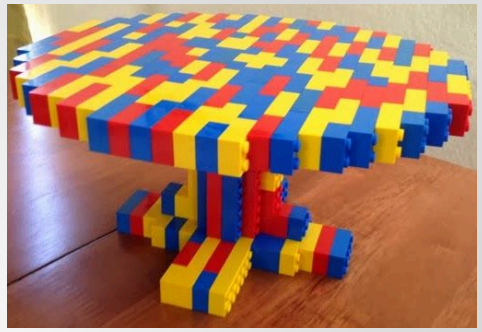
Bricks Purchased Table (cont.)



```
SELECT bkp.tid, b.name AS brickName, p.fname, p.lname, t.storeLoc, t.DOP, bkp.quantity
FROM brkPurchased bkp       INNER JOIN bricks b on bkp.bid = b.bid
                            INNER JOIN transactions t on bkp.tid = t.tid
                            INNER JOIN customers c on t.customer = c.pid
                            INNER JOIN people p on c.pid = p.pid;
```

	tid character (4)	**brickname** text	**fname** text	**lname** text	**storeloc** text	**dop** date	**quantity** integer
1	t002	FLat Tile 1x3	Megan	Clementi	San Francisco	2017-12-02	20
2	t003	Brick 2x4	Megan	Clementi	New York City	2017-12-03	185
3	t004	Brick 1x6	Kathryn	Rivera	Shanghai	2017-12-04	34
4	t005	Brick 1x8	Alex	Antaki	Shanghai	2017-12-01	95

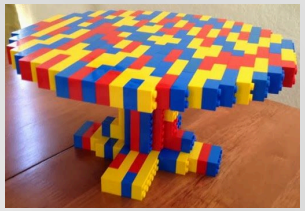
Bricks In Table



- This table is an associative entity that explains which bricks are in which sets and which color they appear in. Because the same brick can appear in the same set, but in a different color, the primary key of this table is the composite of bid, sid, and colid.
- (bid, sid, colid) → quantity

```
CREATE TABLE bricksIn (
        bid             CHAR(4) NOT NULL REFERENCES bricks(bid),
        sid             CHAR(4) NOT NULL REFERENCES sets(sid),
        colid           CHAR(4) NOT NULL REFERENCES colors(colid),
        quantity        INT NOT NULL,
    PRIMARY KEY(bid, sid, colid)
);
```

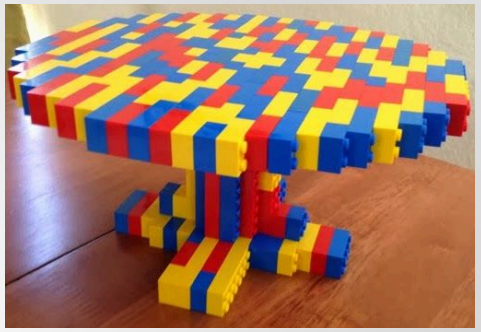
Bricks In Table (cont.)



```
SELECT s.name AS setName, b.name AS brickName, c.legoName AS Color, bi.quantity
FROM bricksIn bi INNER JOIN sets s ON bi.sid = s.sid
                 INNER JOIN bricks b ON bi.bid = b.bid
                 INNER JOIN colors c ON bi.colid = c.colid;
```

	setname text	brickname text	color text	quantity integer
1	Millennium Falcon	Brick 1x4	White	2
2	Millennium Falcon	Brick 1x6	Brick Yellow	234
3	Millennium Falcon	Brick 1x8	Nougat	13
4	Super Star Destroyer	Plate 2x16	Bright Red	52
5	Super Star Destroyer	Brick W/ B...	Bright Blue	65
6	Super Star Destroyer	Mini Leg	Bright Yellow	24
7	Taj Mahal	Plate 4x4	Black	54
8	Taj Mahal	Plate 2x2	Dark Green	4
9	Taj Mahal	Brick 1x3	Aqua	23
10	Tower Bridge	Brick 1x10	Spring Yello...	67
11	Tower Bridge	Brick 1x2x2	Transparent	73
12	Tower Bridge	Brick W/ Ar...	Transparent...	33

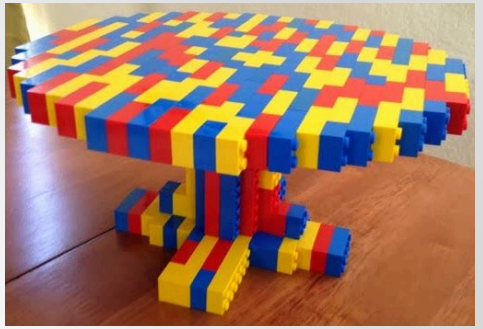
Designs Table



- This table is an associative entity that connects designers to the sets that they have designed. Because Lego® design can be a collaborative effort, thus many designers which design many sets, an associative entity is necessary.
- (pid, sid) →

```
CREATE TABLE designs (
        pid             CHAR(4) NOT NULL REFERENCES designers(pid),
        sid             CHAR(4) NOT NULL REFERENCES sets(sid),
    PRIMARY KEY(pid, sid)
);
```

Designs Table (cont.)



```
CREATE TABLE designs (
        pid             CHAR(4) NOT NULL REFERENCES designers(pid),
        sid             CHAR(4) NOT NULL REFERENCES sets(sid),
    PRIMARY KEY(pid, sid)
);
```

	fname text	lname text	setname text
1	Bob	Odenkirk	Millennium Falcon
2	Bob	Odenkirk	Super Star Destroyer
3	Bob	Odenkirk	Taj Mahal
4	Grant	Dixon	Tower Bridge
5	Alan	Labouseur	Grand Carousal
6	Alan	Labouseur	Sandcrawler

Reports, Views, Stored Procedures, and Triggers

Sets Without Bricks Report

- This query outputs a list of customers who have purchased a set(s) but have not purchased a brick(s)

```
SELECT DISTINCT p.pid, p.fname, p.lname
FROM people p INNER JOIN customers c ON p.pid = c.pid
WHERE c.pid IN (Select c1.pid
                FROM setPurchased sp INNER JOIN transactions t1 ON sp.tid = t1.tid
                                     INNER JOIN customers c1 ON t1.customer = c1.pid
                 WHERE c1.pid NOT IN (Select c2.pid
                                      FROM brkPurchased bkp INNER JOIN transactions t2 ON bkp.tid = t2.tid
                                                            INNER JOIN customers c2 ON t2.customer = c2.pid)
                )
ORDER BY p.fname ASC;
```

	pid character (4)	fname text	lname text
1	p007	Alex	Mahlm...
2	p019	Bradley	Mobek
3	p017	Eric	Seltzer
4	p025	Walter...	White

Bricks Without Sets Report

- This query outputs a list of customers who have purchased a brick(s) but have not purchased a set(s)

```
SELECT DISTINCT p.pid, p.fname, p.lname
FROM people p INNER JOIN customers c ON p.pid = c.pid
WHERE c.pid IN (Select c1.pid
                    FROM brkPurchased bkp INNER JOIN transactions t1 ON bkp.tid = t1.tid
                                                INNER JOIN customers c1 ON t1.customer = c1.pid
                     WHERE c1.pid NOT IN (Select c2.pid
                                                FROM setPurchased sp INNER JOIN transactions t2 ON sp.tid = t2.tid
                                                                            INNER JOIN customers c2 ON t2.customer = c2.pid)

                    )
ORDER BY p.fname ASC;
```

	pid character (4)	fname text	lname text
1	p005	Kathryn	Rivera

Most Selling Stores View

- This view outputs the most selling store based on number of transactions.

```
CREATE OR REPLACE VIEW mostSellingStores AS
    SELECT t.storeloc, COUNT(t.tid)
    FROM transactions t
    GROUP BY t.storeloc
    HAVING (COUNT(t.tid) >= 0)
    ORDER BY COUNT(t.tid) DESC;
```

	storeloc text	count bigint
1	King of P...	3
2	Singapore	3
3	New Yor...	3
4	Shanghai	3
5	Moscow	2
6	Sydney	2
7	San Fran...	1
8	Philadelp...	1
9	Prague	1
10	San Fran...	1

Stored Procedures – Transaction Calculations

```
-- This stored procedure will calculate the cost of a transaction for bricks

CREATE OR REPLACE FUNCTION transbrkCalc (TEXT, REFCURSOR)
RETURNS refcursor AS
$$
        Declare
                transNum TEXT := $1;
                resultSet REFCURSOR := $2;BEGIN
        OPEN resultSet FOR
                SELECT t.tid, (b.priceUSD * bkp.quantity) AS totalCostUSD
                FROM transactions t INNER JOIN brkPurchased bkp ON t.tid = bkp.tid
                                        INNER JOIN bricks b ON bkp.bid = b.bid
                WHERE t.tid LIKE transNum;
                RETURN resultSet;
        END;
$$
LANGUAGE plpgsql;

select transBrkCalc('t0%%', 'ref');
FETCH ALL FROM ref;
```

Output:

	tid character (4)	totalcostusd numeric
1	t002	2.00
2	t003	37.00
3	t004	8.16
4	t005	25.65
5	t006	3.90

Stored Procedures – Transaction Calculations

```
-- This stored procedure will calculate the cost of a transaction for bricks

CREATE OR REPLACE FUNCTION transSetCalc (TEXT, REFCURSOR)
RETURNS refcursor AS
$$
        Declare
                transNum TEXT := $1;
                resultSet REFCURSOR := $2;BEGIN
        OPEN resultSet FOR
                SELECT t.tid, (s.priceUSD * sp.quantity) AS totalCostUSD
                FROM transactions t INNER JOIN setPurchased sp ON t.tid = sp.tid
                                        INNER JOIN sets s ON sp.sid = s.sid
                WHERE t.tid LIKE transNum;
                RETURN resultSet;
        END;
$$
LANGUAGE plpgsql;

select transSetCalc('t0%%', 'ref1');
FETCH ALL FROM ref1;
```

Output:

	tid character (4)	totalcostusd numeric
1	t001	3899.99
2	t002	159.98
3	t006	928.96
4	t007	39.99
5	t008	224.97

Triggers – Out of production sets

Unfortunately, the Lego® Group has stopped producing the Taj Mahal set. For this reason, customers should not be able to purchase it. It is a new policy of the Lego® Group that if a customer tries to purchase this set, they will instead purchase a SHIELD Helicarrier. This trigger enforces that business rule.

```
CREATE OR REPLACE FUNCTION checkSet()
RETURNS TRIGGER AS
$$
BEGIN
            IF (SELECT sp.sid FROM setPurchased sp
                WHERE sp.sid = 's003') = NEW.sid
            THEN
                DELETE from setPurchased sp where sp.sid = NEW.sid;
                INSERT INTO setPurchased(tid, sid, quantity)
                                VALUES (NEW.tid, 's012', NEW.Quantity);
          END IF;
            RETURN NEW;
END;
$$
language plpgsql;
CREATE TRIGGER checkSet
AFTER INSERT ON setPurchased
FOR EACH ROW
EXECUTE PROCEDURE checkSet();
```

Triggers – Out of production sets

-- Testing checkSet trigger –
INSERT INTO transactions(tid, customer, storeLOC, DOP) VALUES ('t021','p008','Beijing','2017-12-06');
INSERT INTO setPurchased(tid, sid, quantity) VALUES ('t021', 's003', 2);

Without the trigger, this query would return the data just inserted into the setPurchased table.
SELECT * from setPurchased sp where sp.sid = 's003';

	sid character (4)	tid character (4)	quantity integer

However, if we try this query, we see that this customer has now purchased a Helicarrier (s012), instead of the Taj Mahal.
SELECT * from setPurchased sp where sp.sid = 's012';

	sid character (4)	tid character (4)	quantity integer
1	s012	t021	2

User Roles / Security

-- LegoDB administrator's can access, add, edit, and delete everything on the database.
CREATE ROLE lego_admin;
GRANT ALL ON ALL TABLES
TO lego_admin;

-- Lego designer's can access, add, edit, and delete anything to do with Lego products, but may not add or delete designers, they may only see who other designers are.
CREATE ROLE lego_designer;
GRANT ALL ON designs, setThemes, sets, bricksIn, bricks, bCategories, colors TO lego_designer;
GRANT SELECT ON designers TO lego_designer;

-- Lego customers can see which transactions have occurred, and create new transactions. They can also see which bricks, colors, sets and the different categories and themes of bricks and sets respectively.
CREATE ROLE lego_cust;
GRANT SELECT, INSERT ON transactions, brkPurchased, setPurchased TO lego_cust;
GRANT SELECT ON bricks, sets, colors, bCategories, setThemes TO lego_cust;

Known Problems / Future Enhancements

- For the purposes of this exercise, I created an artificial key for most of my tables. I know that Lego uses 'unique' identifiers for each of their bricks and sets, but I didn't want to use those to guarantee atomicity. I wonder if these identifiers could be utilized. (bricks.designID and sets.setNum
- While the color table is accessible by means of the bricksIn table, this data can only be applied to sets. A quick fix would be to add a reference clause in the brkPurchased table that allows for the addition of color data.
- New subtypes of people could be implemented – such as store managers and sales associates
- Combine the transaction stored procedures to calculate the total cost of a transaction