Lab 4 Explanations For SQL Server

This explanation document illustrates how to correctly execute each SQL construct step-by-step for Lab 4, and explains important theoretical and practical details. Before completing a step, read its explanation here first.

Use this explanations document only if you are using SQL Server. If you are using Oracle or Postgres, explanations for those DBMS' are available in a different document in the assignments section of the course.

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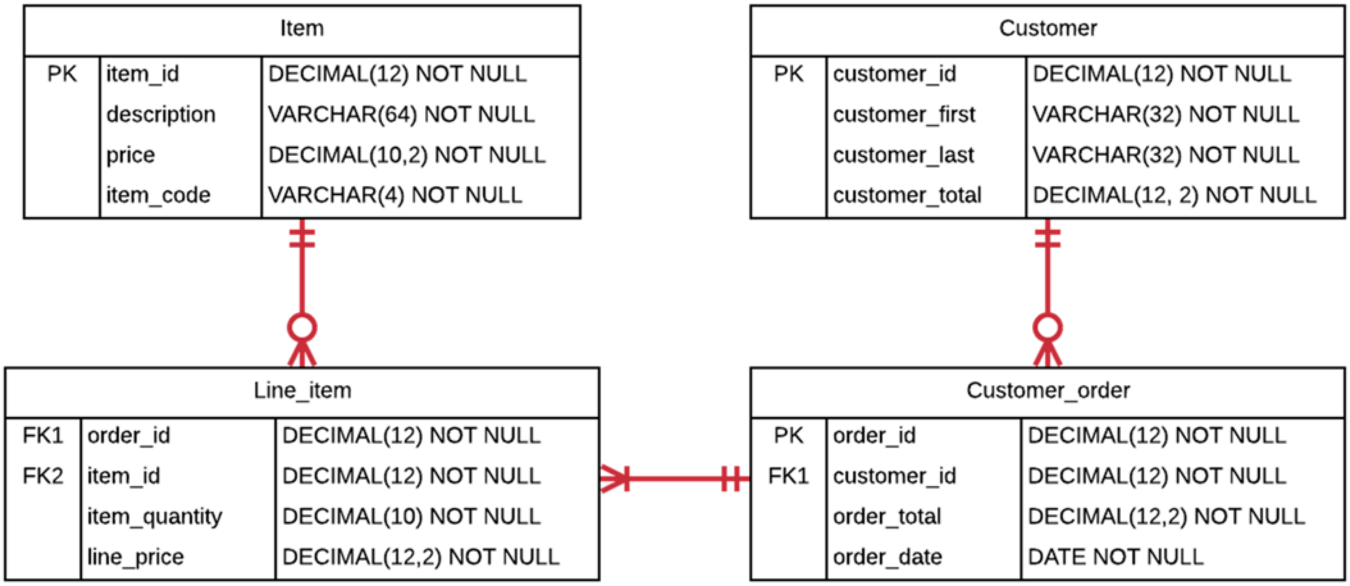
Section One – Stored Procedures

Step 1 – Create Table Structure

To help demonstrate how to complete the commands in this section, we work with simplified customer order schema which tracks customers and their orders of items. The schema itself is illustrated below.



Item

PK	item_id	DECIMAL(12) NOT NULL
	description	VARCHAR(64) NOT NULL
	price	DECIMAL(10,2) NOT NULL
	item_code	VARCHAR(4) NOT NULL

Customer

PK	customer_id	DECIMAL(12) NOT NULL
	customer_first	VARCHAR(32) NOT NULL
	customer_last	VARCHAR(32) NOT NULL
	customer_total	DECIMAL(12, 2) NOT NULL

Line_item

FK1	order_id	DECIMAL(12) NOT NULL
FK2	item_id	DECIMAL(12) NOT NULL
	item_quantity	DECIMAL(10) NOT NULL
	line_price	DECIMAL(12,2) NOT NULL

Customer_order

PK	order_id	DECIMAL(12) NOT NULL
FK1	customer_id	DECIMAL(12) NOT NULL
	order_total	DECIMAL(12,2) NOT NULL
	order_date	DATE NOT NULL

The Item table contains items that can be purchased, with a primary key, a description of the item, a price, and an item_code which is an identifier by which the item can be referenced. The Customer table contains basic information on customers such as their first and last name, and a total balance which they owe. The Customer_order table contains basic information about an order itself, including a reference to the customer who placed the order, the sum total for the order, and the date the order was placed. The Line_item table contains information on individual lines in the order, including a reference to the item that was purchased, the quantity that was purchased, and the total amount for that line (for example, if an item costs $10 and 2 of them were purchased, the total amount for the line would be $20).

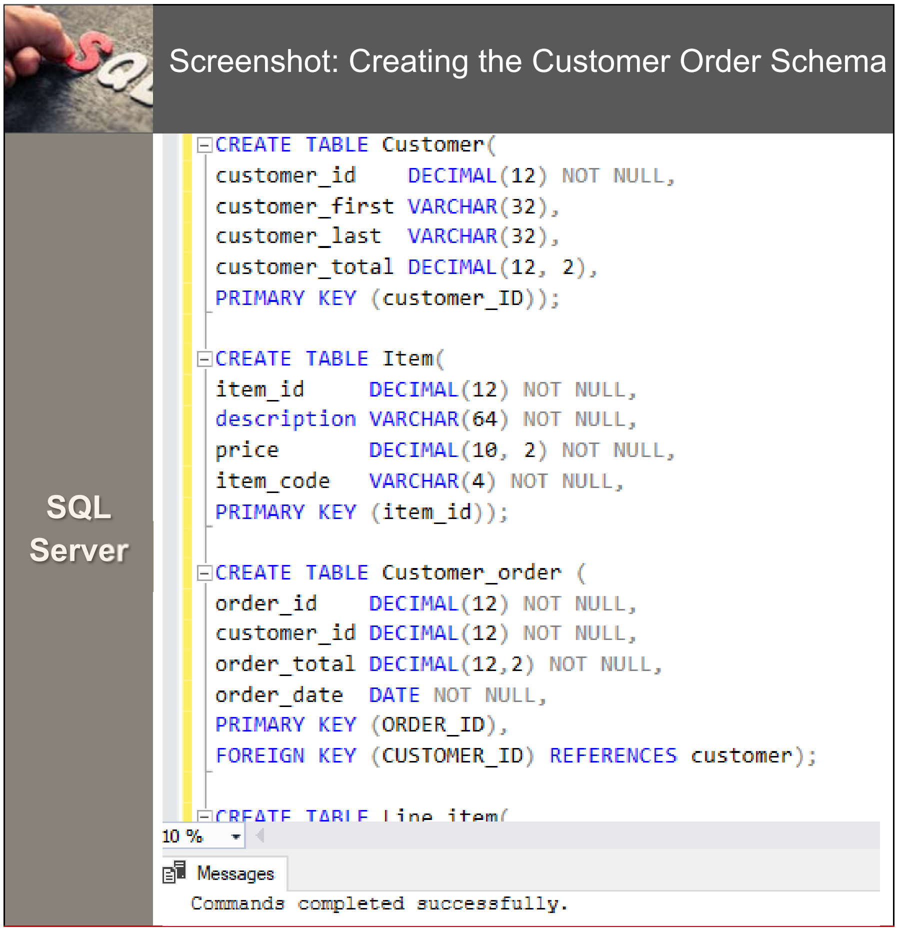
We create the customer odder schema illustrated above in its entirety, including all primary and foreign key constraints, with the SQL below.

Here's the code we use for creating the schema.

Code: Creating Customer Order Schema

```
CREATE TABLE Customer(
customer_id    DECIMAL(12) NOT NULL,
customer_first VARCHAR(32),
customer_last  VARCHAR(32),
customer_total DECIMAL(12, 2),
PRIMARY KEY (customer_ID));

CREATE TABLE Item(
item_id     DECIMAL(12) NOT NULL,
description  VARCHAR(64) NOT NULL,
price       DECIMAL(10, 2) NOT NULL,
item_code   VARCHAR(4) NOT NULL,
PRIMARY KEY (item_id));

CREATE TABLE Customer_order (
order_id    DECIMAL(12) NOT NULL,
customer_id DECIMAL(12) NOT NULL,
order_total DECIMAL(12,2) NOT NULL,
order_date  DATE NOT NULL,
PRIMARY KEY (ORDER_ID),
FOREIGN KEY (CUSTOMER_ID) REFERENCES customer);

CREATE TABLE Line_item(
order_id      DECIMAL(12) NOT NULL,
item_id       DECIMAL(12) NOT NULL,
item_quantity DECIMAL(10) NOT NULL,
line_price    DECIMAL(12,2) NOT NULL,
PRIMARY KEY (ORDER_ID, ITEM_ID),
FOREIGN KEY (ORDER_ID) REFERENCES customer_order,
FOREIGN KEY (ITEM_ID) REFERENCES item);
```

Below are screenshots of creating the schema.


Screenshot: Creating the Customer Order Schema

```
CREATE TABLE Customer(
customer_id    DECIMAL(12) NOT NULL,
customer_first VARCHAR(32),
customer_last  VARCHAR(32),
customer_total DECIMAL(12, 2),
PRIMARY KEY (customer_ID));

CREATE TABLE Item(
item_id     DECIMAL(12) NOT NULL,
description VARCHAR(64) NOT NULL,
price       DECIMAL(10, 2) NOT NULL,
item_code   VARCHAR(4) NOT NULL,
PRIMARY KEY (item_id));

CREATE TABLE Customer_order (
order_id    DECIMAL(12) NOT NULL,
customer_id DECIMAL(12) NOT NULL,
order_total DECIMAL(12,2) NOT NULL,
order_date  DATE NOT NULL,
PRIMARY KEY (ORDER_ID),
FOREIGN KEY (CUSTOMER_ID) REFERENCES customer);

CREATE TABLE Line_item(
```

```
Commands completed successfully.
```

Our next step is to create a sequence for each table. A *sequence* is a database object capable of generating unique primary key values, and is the preferred mechanism for doing so. Sequences generate unique whole numbers, starting with the first, and incrementing to the next number each time a new value is needed. The database guarantees a sequence will not generate the same number twice, thus making the values unique and suitable for primary keys.

Why use a sequence when we can hardcode values like 1 and 2 in our insert statements? There are many reasons. First, inserts often happen over many years as applications live on and on, so it is impractical to hardcode every value. Additionally, real-world databases oftentimes have millions of rows in some of the more used tables. Again, it is not practical to hardcode millions of values in such instances. We are looking for automation, so we do not want a human being to be asked for the primary and foreign key values every time an application needs to insert more rows. In short, dynamically generating primary key values is critical to modern database operation, and sequences are the preferred means of doing so.

There are a few advanced options with sequences which are available but not typically used for primary key configurations. Many sequences are configured to start at 1, and increment upward by 1 each time a new value is needed; however, the starting value and incrementing value can be changed if needed (such as starting at 10 and incrementing by 10, for example). Sequences can be set to cycle, which means once they reach their maximum value, they reset back to the minimum value again. This means once a cycle occurs, the sequence will be regenerating numbers already generated, making them non-unique. Typically for primary keys, the sequence is not configured to cycle. Instead, we make sure the primary key is large enough to hold all values, current and future.

The SQL syntax for creating a basic sequence is straightforward:

CREATE SEQUENCE <sequencename> START WITH 1

Because we need one sequence per table, a convention I recommend for sequence names is to name it like this:

tablename_seq

For example, if we had a Person table and that table needed a sequence, we would name the sequence “person_seq”.

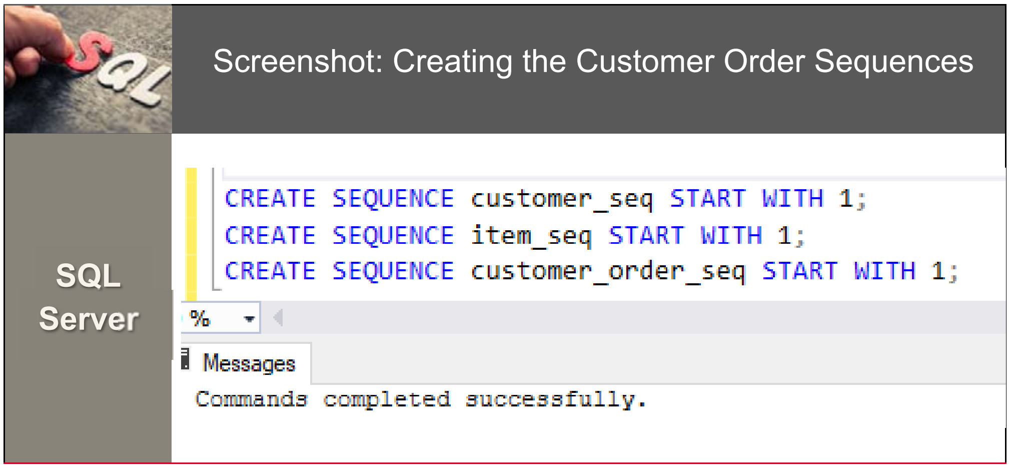
Below are the sequences I create for the customer order schema.

Code: Creating Customer Order Sequences

```
CREATE SEQUENCE customer_seq START WITH 1;
CREATE SEQUENCE item_seq START WITH 1;
CREATE SEQUENCE customer_order_seq START WITH 1;
```

The three sequences are for the Customer, Item, and Customer_order tables, respectively. Line_item does not need a sequence, because it uses a composite primary key consisting of other tables’ keys. That is, we do not need to generate unique values for the Line_item table since it does not use a synthetic primary key of its own.

Creating them looks as follows.



Screenshot: Creating the Customer Order Sequences

```
CREATE SEQUENCE customer_seq START WITH 1;
CREATE SEQUENCE item_seq START WITH 1;
CREATE SEQUENCE customer_order_seq START WITH 1;
```

```
Commands completed successfully.
```

As you can see, creating sequences for tables is straightforward.

Step 2 – Populate Tables

You can interact with a sequence in one of two ways – obtaining the next value of the sequence, and obtaining the current value. Obtaining the next value generates the next unique number. The next value is typically requested when a new primary key value is needed for a table. Sequences are safe to use concurrently. This means even if hundreds or thousands of transactions are running simultaneously that use the same sequence, the sequence generates unique numbers for them all. Obtaining the current value does not generate the next unique number, but instead returns the last number requested. The current value is typically used when a primary key value has already been obtained, and that same value is needed again so it can be inserted into a different table as a foreign key.

When sequences are involved, the order of inserts becomes quite important. The reason is, if we use a sequence to insert a new row, and then a referencing table must have a foreign key to that row. We would want to use the sequence’s current value to create the foreign key, so wouldn’t want to change the value.

For example, in the customer order schema, Customer_order references Customer. So rather than inserting all customers followed by all customer orders, we would insert one customer, followed by all of that customer’s orders. Then we would insert the second customer, followed by the second customer’s orders, and so on. This way we can make use of the sequence’s *current value* to insert the foreign keys. Let’s look at an example of inserting the first customer and order.

Code: Inserting First Customer and Order

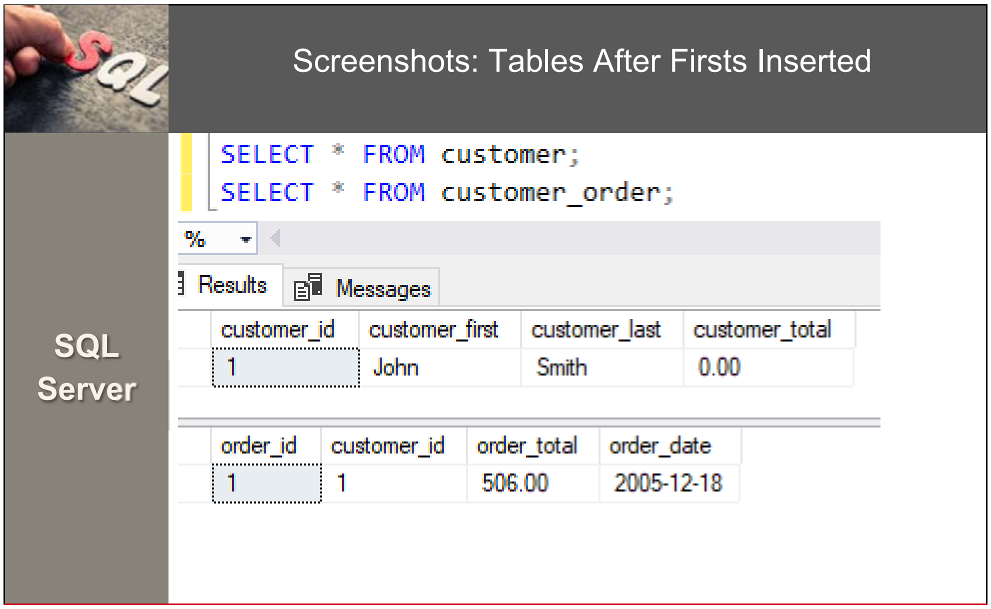
```
--Insert first customer and order.
DECLARE @current_customer_seq INT = NEXT VALUE FOR customer_seq;
INSERT INTO customer VALUES(@current_customer_seq,'John','Smith',0);
DECLARE @current_customer_order_seq INT = NEXT VALUE FOR customer_order_seq;
INSERT INTO customer_order VALUES(@current_customer_order_seq,@current_customer_seq,
506,CAST('18-DEC-2005' AS DATE));
```

Since this is the first time we are using a sequence in this lab, let’s examine this code closely. The first line declares a variable to hold the next value generated by *customer_seq*. A *variable* is a location where a value may be stored and later retrieved by name. The value of the variable is set using the *NEXT VALUE FOR* keywords on *customer_seq*. Those keywords tell the database to retrieve the next unique value from the sequence, which is “1” since the sequence was just created. The second line inserts John Smith as a customer, using that the variable’s unique value as the primary key, in lieu of hardcoding a primary key value (such as “1” or “2”).

The second insert follows the pattern of the first to create the first order for John Smith. Another variable, *@current_customer_order_seq* is used to retrieve the first unique value for from customer_order_seq, then later used as the primary key for the customer_order. Again, this is in lieu of hardcoding a value. The unique value will also be “1” since that sequence was also just created. The foreign key referencing back to Customer is set using the *@current_customer_seq* variable.

The use of the foreign key shows why it is important to only insert one customer at-a-time. We need to retrieve the next unique value for the *@current_customer_seq* variable, then use it to create the new customer as well as all of that customer’s orders. The insert to create the customer can use the variable for the customer’s primary key. The insert to create the orders can also use the variable as the foreign key value referencing back to customer. If we had inserted all customers first instead of just one, then we'd need some other means of looking up the foreign key values when inserting the orders.

Let's examine the two tables after the inserts above have been executed.



Screenshots: Tables After Firsts Inserted

```
SELECT * FROM customer;
SELECT * FROM customer_order;
```

customer_id	customer_first	customer_last	customer_total
1	John	Smith	0.00

order_id	customer_id	order_total	order_date
1	1	506.00	2005-12-18

Because we had just created the sequence and it starts at 1, John Smith's customer_id value was generated as 1 when using *NEXT VALUE FOR customer_seq*. Similarly, the first order has a primary key value of 1 for the same reason. And, the order successfully references back to John Smith's primary key value of 1, by using the *@current_customer_seq* variable for the foreign key value. So, we have seen an example where, with careful ordering of our inserts and judicious use of a variable, we can use sequences for our inserts, instead of hardcoding values.

Before proceeding further, we need to think about how we are going to insert line items and items. Line items reference back to the orders they belong to, in addition to the item they are representing. While we may be able to use a variable to reference back to the order, we can't do the same for the item foreign key, because many different line items may reference the same item. That is, different customers may purchase the same item, so we can't possibly order everything in a way such that using a variable is sufficient.

We need another method, which is a *subquery lookup*. In short, in lieu of hardcoding an item's primary key value, we'll look it up with a small subquery instead. Continuing on after inserting our first customer and order, we'll go ahead and insert all items with the following code.

Code: Inserting All Items

```
INSERT INTO item VALUES(NEXT VALUE FOR item_seq,'Plate',10, 'P001');
INSERT INTO item VALUES(NEXT VALUE FOR item_seq,'Bowl',11, 'B002');
INSERT INTO item VALUES(NEXT VALUE FOR item_seq,'Knife',5, 'K003');
INSERT INTO item VALUES(NEXT VALUE FOR item_seq,'Fork',5, 'F004');
INSERT INTO item VALUES(NEXT VALUE FOR item_seq,'Spoon',5, 'S005');
INSERT INTO item VALUES(NEXT VALUE FOR item_seq,'Cup',12, 'C006');
```

We insert all items, generating unique primary keys with *NEXT VALUE FOR item_seq*. We don't save each item's primary key in a variable (in a real-world database there could be hundreds or thousands). Rather, we'll look them up as needed. With those inserted, we can now create the line items for the first customer's first order, shown below.

Code: Inserting Line Items for First Order

```
--Create the line items for the first order.
INSERT INTO line_item
VALUES(@current_customer_order_seq,(SELECT item_id FROM item WHERE description='Plate'),10,100);
INSERT INTO line_item
VALUES(@current_customer_order_seq,(SELECT item_id FROM item WHERE description='Spoon'),2,10);
INSERT INTO line_item
VALUES(@current_customer_order_seq,(SELECT item_id FROM item WHERE description='Bowl'),36,396);
```

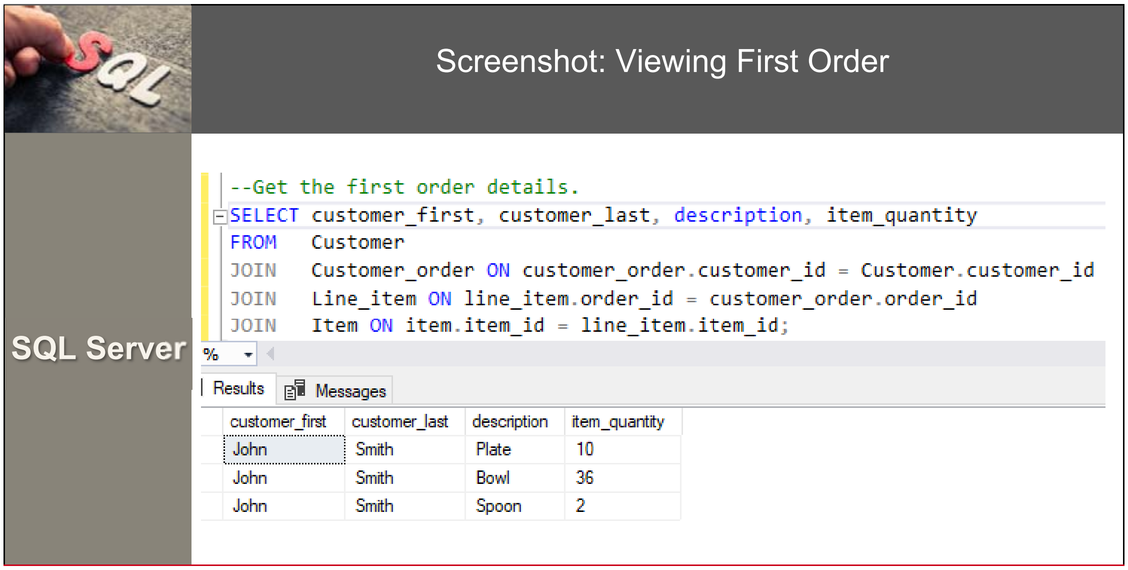
Let's review these inserts. For the foreign key to customer_order, we use the previously declared variable *@current_customer_order_seq* to refer to the first inserted customer order. We are already familiar with using the variable, so this part of the insert is just another example of doing so.

For retrieving the primary key of each item, however, we use the subquery `(SELECT item_id FROM item WHERE description=<item_description>)`. Although subqueries in general are the topic of a future lab, for this lab it is enough to know that instead of hardcoding a single value, we can substitute a query that retrieves exactly one value in its place. In this case, each subquery retrieves one item id corresponding to the item that matches the description in the subquery's WHERE clause. For example, the first insert retrieves the item_id for "Plate", meaning that the first line will reference "Plate" in the Item table. The second line item is for spoons, and the third line item is for bowls.

With the first order completely inserted, we can now use the query shown below to view the items in the order.

Code: Viewing First Order

```
--Get the first order details.
SELECT customer_first, customer_last, description, item_quantity
FROM   Customer
JOIN   Customer_order ON customer_order.customer_id = Customer.customer_id
JOIN   Line_item ON line_item.order_id = customer_order.order_id
JOIN   Item ON item.item_id = line_item.item_id;
```



```
--Get the first order details.
SELECT customer_first, customer_last, description, item_quantity
FROM   Customer
JOIN   Customer_order ON customer_order.customer_id = Customer.customer_id
JOIN   Line_item ON line_item.order_id = customer_order.order_id
JOIN   Item ON item.item_id = line_item.item_id;
```

customer_first	customer_last	description	item_quantity
John	Smith	Plate	10
John	Smith	Bowl	36
John	Smith	Spoon	2

The query results show us that the first order is for a plate, bowl, and spoon, with varying quantities of each.

Below are the remainder of the inserts. These use both methods. Note that we are redeclaring the variables again because this is executing in its own code block. That is, if we had inserted the first customer's order along with the rest of the customers all in one block, we would have declared the variable once and used it throughout. In this case, we separated the first block above for illustrative purposes, so we could explain how it works, and now we are executing a second block for the rest. So it's necessary to redeclare the variables again. In your code, you just need to declare the variables once and use them throughout, since you will not be separating the initial inserts from the others.

Code: Inserting Remainder of Customer Data

```
--Insert the rest of the orders and customers.
DECLARE @current_customer_seq INT = 1;
DECLARE @current_customer_order_seq INT;
--John's remaining orders.
SET @current_customer_order_seq = NEXT VALUE FOR customer_order_seq;
INSERT INTO customer_order
VALUES(@current_customer_order_seq,@current_customer_seq,1000,CAST('17-DEC-2005' AS DATE));
INSERT INTO line_item
VALUES(@current_customer_order_seq,(SELECT item_id FROM item WHERE description='Plate'),95,950);
INSERT INTO line_item
VALUES(@current_customer_order_seq,(SELECT item_id FROM item WHERE description='Knife'),10,50);
SET @current_customer_order_seq = NEXT VALUE FOR customer_order_seq;
INSERT INTO customer_order
VALUES(@current_customer_order_seq,@current_customer_seq,10,CAST('19-DEC-2005' AS DATE));
INSERT INTO line_item
VALUES(@current_customer_order_seq,(SELECT item_id FROM item WHERE description='Fork'),3,15);
--Mary's orders.
SET @current_customer_seq = NEXT VALUE FOR customer_seq;
INSERT INTO customer VALUES(@current_customer_seq,'Mary','Berman',0);
SET @current_customer_order_seq = NEXT VALUE FOR customer_order_seq;
INSERT INTO customer_order
VALUES(@current_customer_order_seq,@current_customer_seq,1584,CAST('18-DEC-2005' AS DATE));
INSERT INTO line_item
VALUES(@current_customer_order_seq,(SELECT item_id FROM item WHERE description='Fork'),3,15);
--Elizabeth's orders.
SET @current_customer_seq = NEXT VALUE FOR customer_seq;
INSERT INTO customer VALUES(@current_customer_seq,'Elizabeth','Johnson',0);
SET @current_customer_order_seq = NEXT VALUE FOR customer_order_seq;
INSERT INTO customer_order
VALUES(@current_customer_order_seq,@current_customer_seq,15,CAST('19-DEC-2005' AS DATE));
INSERT INTO line_item
VALUES(@current_customer_order_seq,(SELECT item_id FROM item WHERE description='Cup'),132,1584);
SET @current_customer_order_seq = NEXT VALUE FOR customer_order_seq;
INSERT INTO customer_order
VALUES(@current_customer_order_seq,@current_customer_seq,15,CAST('20-DEC-2005' AS DATE));
INSERT INTO line_item
VALUES(@current_customer_order_seq,(SELECT item_id FROM item WHERE description='Fork'),3,15);
--Peter's orders.
SET @current_customer_seq = NEXT VALUE FOR customer_seq;
INSERT INTO customer VALUES(@current_customer_seq,'Peter','Quiqley',0);
SET @current_customer_order_seq = NEXT VALUE FOR customer_order_seq;
INSERT INTO customer_order
VALUES(@current_customer_order_seq,@current_customer_seq,100,CAST('17-DEC-2005' AS DATE));
INSERT INTO line_item
VALUES(@current_customer_order_seq,(SELECT item_id FROM item WHERE description='Spoon'),5,25);
INSERT INTO line_item
VALUES(@current_customer_order_seq,(SELECT item_id FROM item WHERE description='Bowl'),2,10);
SET @current_customer_order_seq = NEXT VALUE FOR customer_order_seq;
INSERT INTO customer_order
VALUES(@current_customer_order_seq,@current_customer_seq,40,CAST('18-DEC-2005' AS DATE));
INSERT INTO line_item
VALUES(@current_customer_order_seq,(SELECT item_id FROM item WHERE description='Knife'),3,15);
```

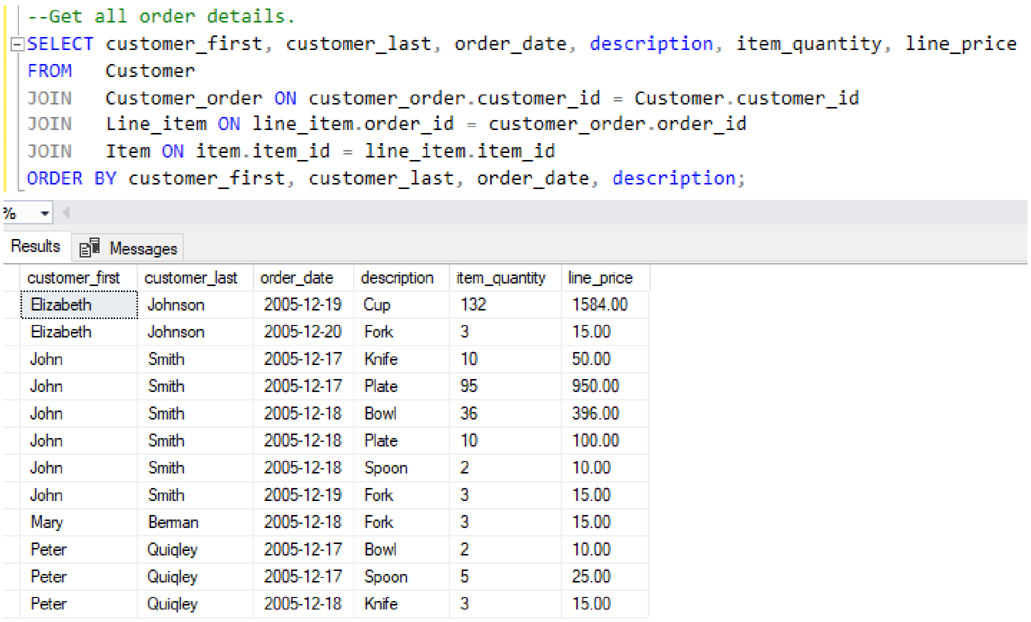
Below the code and screenshot captures the important order information, showing all orders.

Code: Viewing All Orders

```
--Get all order details.
SELECT customer_first, customer_last, order_date, description, item_quantity,
line_price
FROM   Customer
JOIN   Customer_order ON customer_order.customer_id = Customer.customer_id
JOIN   Line_item ON line_item.order_id = customer_order.order_id
JOIN   Item ON item.item_id = line_item.item_id
ORDER BY customer_first, customer_last, order_date, description;
```

Screenshot: Viewing All Orders

SQL Server



```
--Get all order details.
SELECT customer_first, customer_last, order_date, description, item_quantity, line_price
FROM   Customer
JOIN   Customer_order ON customer_order.customer_id = Customer.customer_id
JOIN   Line_item ON line_item.order_id = customer_order.order_id
JOIN   Item ON item.item_id = line_item.item_id
ORDER BY customer_first, customer_last, order_date, description;
```

customer_first	customer_last	order_date	description	item_quantity	line_price
Elizabeth	Johnson	2005-12-19	Cup	132	1584.00
Elizabeth	Johnson	2005-12-20	Fork	3	15.00
John	Smith	2005-12-17	Knife	10	50.00
John	Smith	2005-12-17	Plate	95	950.00
John	Smith	2005-12-18	Bowl	36	396.00
John	Smith	2005-12-18	Plate	10	100.00
John	Smith	2005-12-18	Spoon	2	10.00
John	Smith	2005-12-19	Fork	3	15.00
Mary	Berman	2005-12-18	Fork	3	15.00
Peter	Quigley	2005-12-17	Bowl	2	10.00
Peter	Quigley	2005-12-17	Spoon	5	25.00
Peter	Quigley	2005-12-18	Knife	3	15.00

In summary, you have seen two methods that use sequences to retrieve the correct foreign key values. The first method is using a variable to store the value so it can be used later when the foreign key values are needed. This method works when we can control the order of inserts, and we insert the referencing values immediately after the referenced values (such as inserting a customer's orders immediately after inserting the customer). The second method is using a subquery lookup. With the second method, there is less concern about the order of inserts and referencing values don't need to be inserted immediately after referenced values. Instead, the foreign key value can be retrieved with a subquery.

Armed with both of these methods, you can now complete this step.

Step 3 – Create Hardcoded Procedure

To demonstrate something similar, we'll create a stored procedure named "add_customer_harry" that has no parameters and adds a customer named Harry Joker to the customer order schema. Below is code for this procedure.

Code: Creating add_customer_harry Procedure

```
CREATE OR ALTER PROCEDURE ADD_CUSTOMER_HARRY
AS
BEGIN
  INSERT INTO CUSTOMER (CUSTOMER_ID,CUSTOMER_FIRST,CUSTOMER_LAST,CUSTOMER_TOTAL)
  VALUES(NEXT VALUE FOR customer_seq, 'Harry', 'Joker', 0);
END;
```

Let us go through code line by line and discuss the meaning.

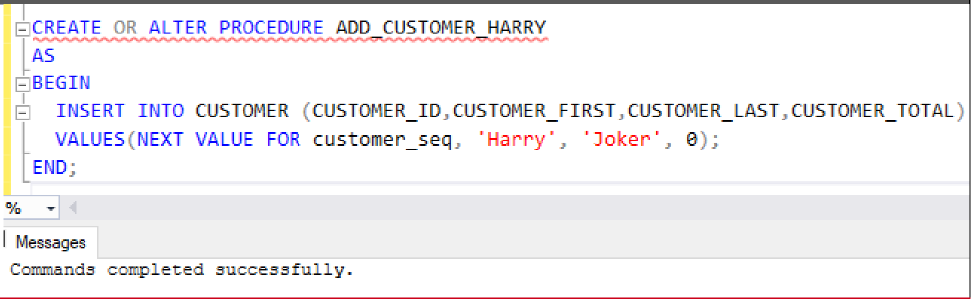
Line 1: CREATE OR ALTER PROCEDURE ADD_CUSTOMER_HARRY	
	The **CREATE OR ALTER PROCEDURE** phrase indicates to SQL Server that a stored procedure is to be created if it does not exist, or altered to the new code if it already exists. All of the words in this phrase are SQL *keywords*, meaning that they are words predefined in the SQL language to have a specific meaning. We must use keywords exactly as they are defined by the language in order to tell the language what we want to do. The **ADD_CUSTOMER_HARRY** word is the name of the stored procedure. This name is an *identifier*, which means that the language allows us to define our own name. SQL Server does restrict the length of identifiers to be no longer than 128 characters, and has some character restrictions, for example, that identifiers should not contain the "%" character. Within these restrictions we can specify any name we like. Of course, it is best to name a stored procedure reasonably based upon the function it performs. For this procedure, I chose the name **ADD_CUSTOMER_HARRY** because the logic of the procedure inserts a customer named "Harry" into the Customer table. SQL Server relaxes many of its restrictions on an identifier if the identifier is quoted or enclosed in brackets; however, it is best not to use an identifier that must be quoted each time it is used, so we stay within the regular identifier guidelines.
Line 2: AS	
	AS is a SQL keyword that is required by the language to define a stored procedure, but otherwise has no significant meaning. SQL is defined to be natural for English speakers, so the full phrase **CREATE PROCEDURE ADD_CUSTOMER_HARRY AS** leads an English speaker to naturally think that the definition of the stored procedure follows the **AS** keyword.
Line 3: BEGIN	
	This word is optional when creating stored procedures in SQL Server. Its use helps in the readability of the stored procedure, so that one can determine at a glance where the content of the stored procedure begins. If the **BEGIN** word is used, it must be coupled with the **END** keyword described below.

<table>
<tr><td colspan="2"><code>Lines 4-5:
INSERT INTO CUSTOMER
(customer_id,customer_first,customer_last,customer_total)
   VALUES(NEXT VALUE FOR customer_seq, ’Harry’, ’Joker’, 0);</code></td></tr>
<tr><td></td><td>You might think this command looks familiar, because it does! It is just a standard SQL statement. Wait a minute. The procedural language and the SQL language are two different languages, right? So why is this SQL statement inside of a stored procedure that uses the procedural language? Simple! Because certain SQL commands can be embedded inside of the procedural language in the right context. In this case, I have embedded an insert statement that inserts a new customer “Harry” into the Customer table, using <i>customer_seq</i> to generate the unique primary key value. This way, when you execute this stored procedure, the stored procedure will insert the new customer on your behalf, without the need for you to type the SQL command yourself.</td></tr>
<tr><td colspan="2"><code>Line 6: END;</code></td></tr>
<tr><td></td><td>The <b>END</b> keyword is optional and is only required if the <b>BEGIN</b> keyword is used. This word helps in the readability of the stored procedure, so that one can determine at a glance where the content of the stored procedure ends. Likewise, the semicolon after the <b>END</b> keyword is optional.</td></tr>
</table>

Now to be clear, the above code, when executed, creates the stored procedure so that it’s available for use. Below is a screenshot of creating this stored procedure.

Screenshot: Creating add_customer_harry Procedure

SQL Server



```
CREATE OR ALTER PROCEDURE ADD_CUSTOMER_HARRY
AS
BEGIN
  INSERT INTO CUSTOMER (CUSTOMER_ID,CUSTOMER_FIRST,CUSTOMER_LAST,CUSTOMER_TOTAL)
  VALUES(NEXT VALUE FOR customer_seq, 'Harry', 'Joker', 0);
END;
```

```
Commands completed successfully.
```

Notice that the output indicates that the procedure was compiled. This is a technical way for the DBMS to state that the procedure has been processed and is available for use.

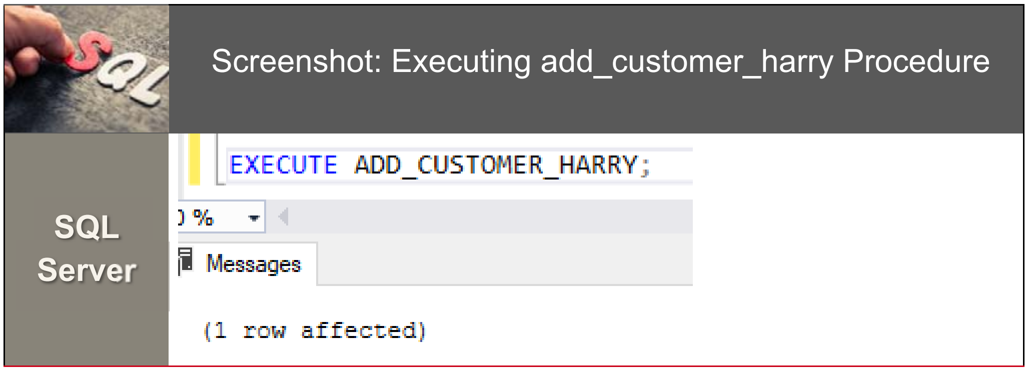
Now that we have created the stored procedure, we need to execute it for its code to take effect. First, let’s look at the code to do so.

Code: Executing add_customer_harry Procedure

```
EXECUTE ADD_CUSTOMER_HARRY;
```

The **EXECUTE** keyword can be used to execute many different kinds of objects in SQL Server, and in this context we use to execute the stored procedure we have created. We used the name of our stored procedure, **ADD_CUSTOMER_HARRY**, to specify which stored procedure to execute.

Below is a screenshot of executing this code.

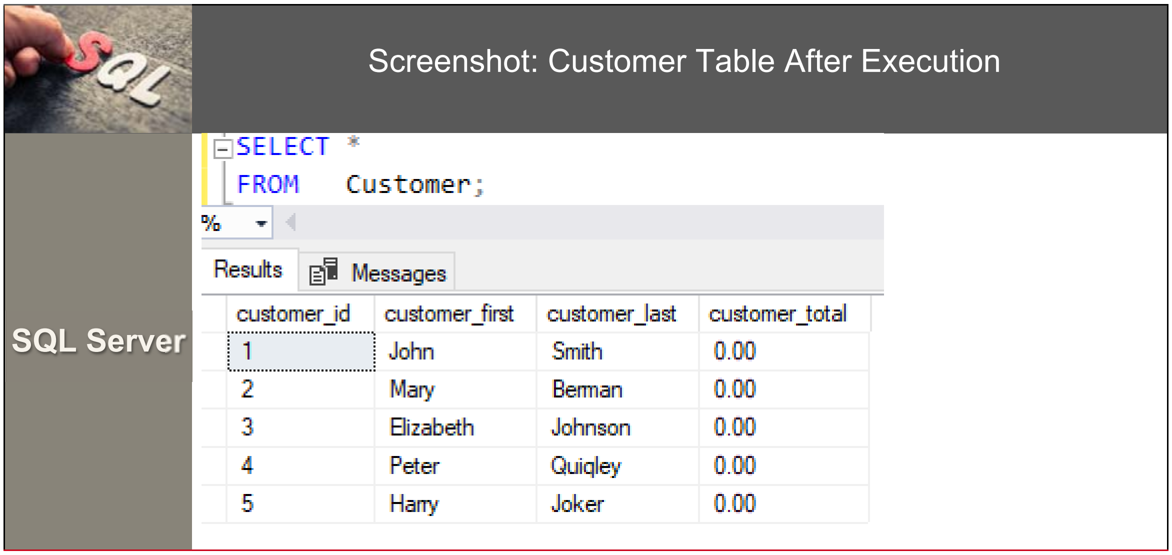


Screenshot: Executing add_customer_harry Procedure

```
EXECUTE ADD_CUSTOMER_HARRY;
```

```
(1 row affected)
```

The output states “1 row(s) affected)” to indicate that the stored procedure has executed (by inserting 1 row). We can now select all rows from the Customer table to make sure that our stored procedure inserted a row as we would expect.



Screenshot: Customer Table After Execution

```
SELECT *
FROM   Customer;
```

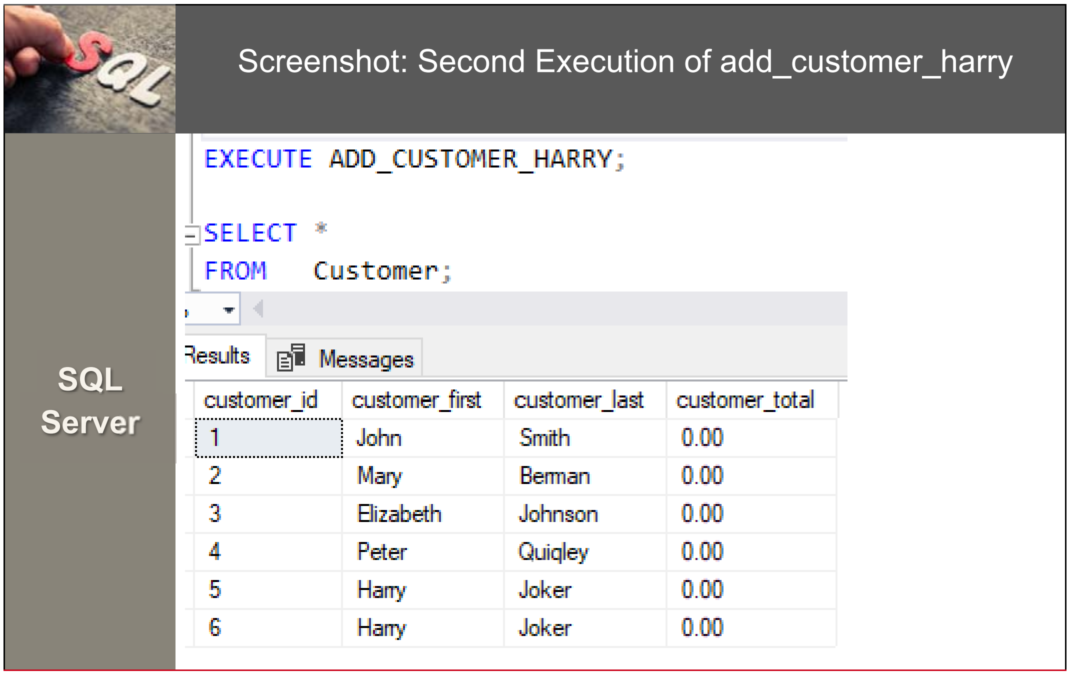
customer_id	customer_first	customer_last	customer_total
1	John	Smith	0.00
2	Mary	Berman	0.00
3	Elizabeth	Johnson	0.00
4	Peter	Quiqley	0.00
5	Harry	Joker	0.00

Sure enough, we see that the customer “Harry Joker” is listed in the table as the last row listed. We have now successfully created and executed a stored procedure!

You can now create similar code to complete this step.

Step 4 – Create Reusable Procedure

Before we create a reusable procedure, let us look at what happens if we attempt to execute the add_customer_harry procedure a second time. Inside the procedure, we placed the literal value “Harry” for the customer_first column, the literal value “Joker” for the customer_last column, and the literal value “0” for the customer_total column. This placement is termed “hardcoding” by computer programmers, a term which means that a value is embedded directly into the source of a program, instead of obtaining the value dynamically. Executing it a second time would result in inserting the same person again, just with a different primary key. This is illustrated below.



Screenshot: Second Execution of add_customer_harry

```
EXECUTE ADD_CUSTOMER_HARRY;

SELECT *
FROM   Customer;
```

customer_id	customer_first	customer_last	customer_total
1	John	Smith	0.00
2	Mary	Berman	0.00
3	Elizabeth	Johnson	0.00
4	Peter	Quigley	0.00
5	Harry	Joker	0.00
6	Harry	Joker	0.00

Notice that Harry Joker has been inserted a second time with the next primary key value. This obviously causes many issues, anomalies resulting from data redundancy perhaps being the most significant. Which record should Harry’s orders be tied to? Will there be orders tied to both records? What if Harry has a name change? Should we delete one of these records, and if so, which one? These are valid questions!

The root problem is that the stored procedure is not reusable. Every time it is invoked, it will add Harry Joker and only Harry Joker. The stored procedure is only useful for one execution, which essentially defeats the point of creating the logic in a stored procedure. One significant purpose of a stored procedure is to encapsulate logic so it can be invoked again and again by name. This stored procedure has not achieved that purpose.

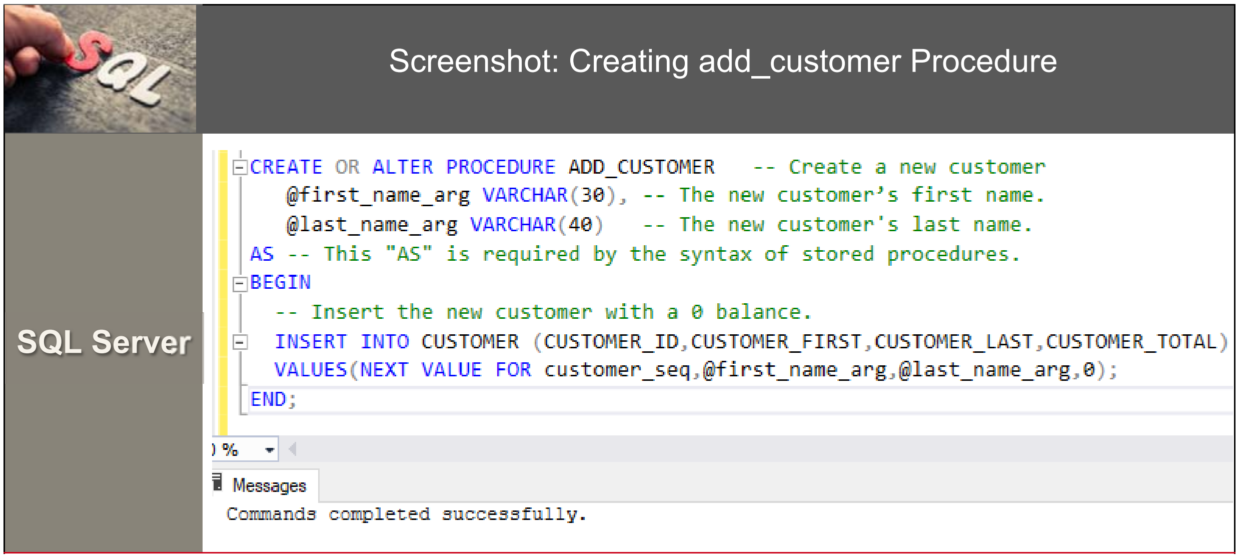
It is best to make our stored procedures reusable, so that they can be executed wherever the logic contained in them is needed. The fact that our ADD_CUSTOMER_HARRY stored procedure cannot meaningfully be executed multiple times makes it less valuable as a resource. To achieve reusability, instead of hardcoding literal values in a procedure, we use placeholders which instruct the DBMS to use whatever value is given to the stored procedure when it is executed. These placeholders are termed *parameters*. At a minimum, a parameter has a name, which is an identifier by which it is referred, and a datatype, which determines the set of legal values that can be assigned to the parameter.

For example, instead of hardcoding the value “Harry” for the *first_name* column, we can define a *first_name_arg* parameter with a datatype of “VARCHAR”. The parameter the particular value can be specified when the stored procedure is executed. Below is an ADD_CUSTOMER stored procedure that makes use of parameters and is therefore reusable, allowing us to add any customer rather than just one specific customer. Comments next to the parameters help explain their purpose.

Code: Creating add_customer Procedure

```
CREATE OR ALTER PROCEDURE ADD_CUSTOMER   -- Create a new customer
   @first_name_arg VARCHAR(30), -- The new customer’s first name.
   @last_name_arg VARCHAR(40)   -- The new customer's last name.
AS -- This "AS" is required by the syntax of stored procedures.
BEGIN
  -- Insert the new customer with a 0 balance.
  INSERT INTO CUSTOMER (CUSTOMER_ID,CUSTOMER_FIRST,CUSTOMER_LAST,CUSTOMER_TOTAL)
  VALUES(NEXT VALUE FOR customer_seq,@first_name_arg,@last_name_arg,0);
END;
```

Notice that instead of hardcoding particular values in the insert statement, the parameter names are referenced instead, particularly in the **`VALUES(NEXT VALUE FOR customer_seq, @first_name_arg, @last_name_arg,0)`** part of the insert statement. *@first_name_arg* and *@last_name_arg* parameters are used in place of hardcoded “Harry” and “Joker” values. Essentially, this is instructing the SQL engine to insert whatever values are passed into the stored procedure when it is executed. Creating the stored procedure looks as follows.



Screenshot: Creating add_customer Procedure

```
CREATE OR ALTER PROCEDURE ADD_CUSTOMER   -- Create a new customer
   @first_name_arg VARCHAR(30), -- The new customer’s first name.
   @last_name_arg VARCHAR(40)   -- The new customer's last name.
AS -- This "AS" is required by the syntax of stored procedures.
BEGIN
  -- Insert the new customer with a 0 balance.
  INSERT INTO CUSTOMER (CUSTOMER_ID,CUSTOMER_FIRST,CUSTOMER_LAST,CUSTOMER_TOTAL)
  VALUES(NEXT VALUE FOR customer_seq,@first_name_arg,@last_name_arg,0);
END;
```

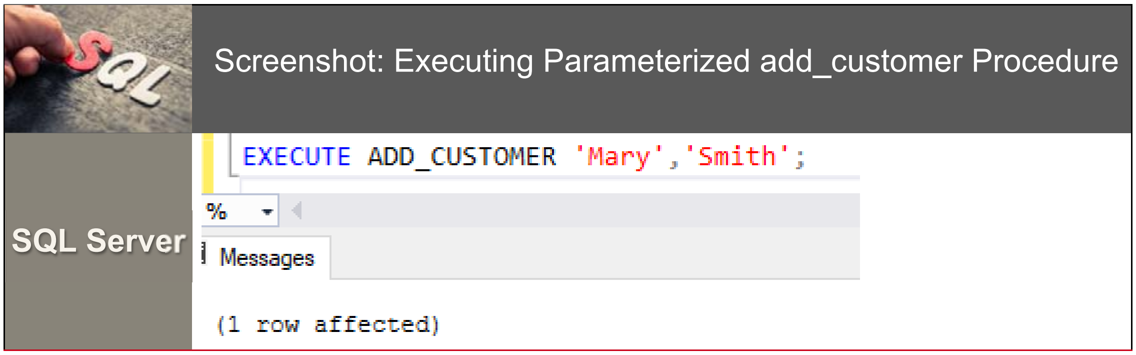
```
Commands completed successfully.
```

When the stored procedure is executed, the parameter values are specified by the executor. Example code for executing this stored procedure is below. Notice that the parameters are specified within parentheses, and separated by a comma.

Code: Executing add_customer Procedure

```
EXECUTE ADD_CUSTOMER 'Mary','Smith';
```

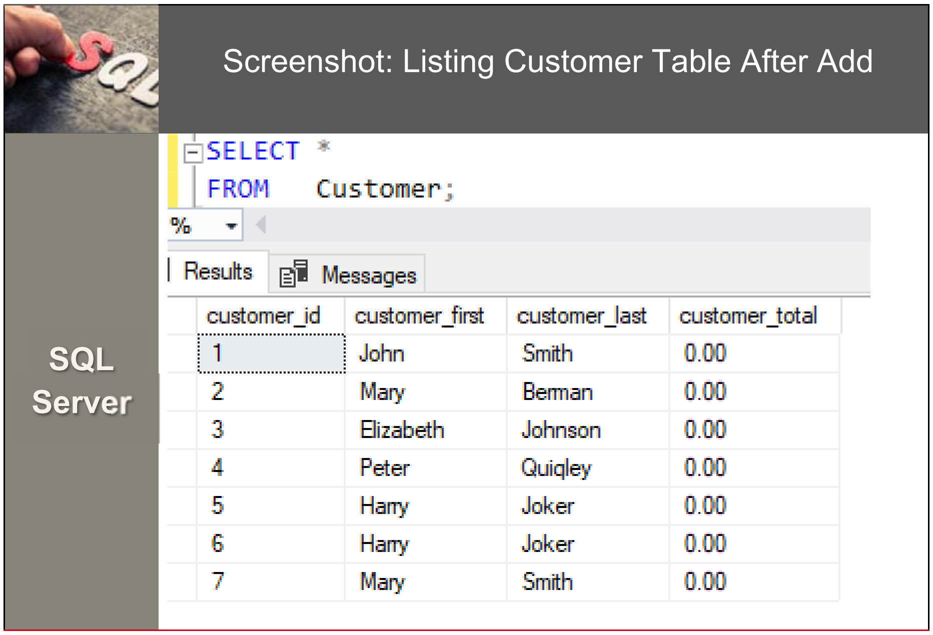
Notice that *‘Mary’, ‘Smith’* part of the stored procedure call which specifies what parameters to use. The order in which the parameters appear matters, as this ordering is correlated with the ordering the parameters are declared in the stored procedure. Since “Mary” comes first, it’s matched to *@first_name_arg*, and “Smith” is matched to *@last_name_arg*. Using this approach, you need to know the order in which the parameters are declared in the stored procedure in order to execute the stored procedure. Executing the stored procedure gives us the same confirmation we saw with the prior execution of the “add_customer_harry” procedure, as shown below.


Screenshot: Executing Parameterized add_customer Procedure

```
EXECUTE ADD_CUSTOMER 'Mary','Smith';
```

```
(1 row affected)
```

Just to make sure Mary Smith made it in, we’ll list out our Customer table again, illustrated below.


Screenshot: Listing Customer Table After Add

```
SELECT *
FROM   Customer;
```

customer_id	customer_first	customer_last	customer_total
1	John	Smith	0.00
2	Mary	Berman	0.00
3	Elizabeth	Johnson	0.00
4	Peter	Quigley	0.00
5	Harry	Joker	0.00
6	Harry	Joker	0.00
7	Mary	Smith	0.00

Notice that Mary Smith is now listed in the table. More importantly, we could add many more customers using this stored procedure just by changing the parameter values given to the stored procedure!

Hopefully this gives you an idea of the usefulness of parameterized stored procedures. You can code the logic once, then execute the stored procedure whenever you need it. For example, the logic we put into this procedure is:

- to use customer_seq to generate a unique primary key value for the new customer.
- to use the parameters given for the first and last name.
- to initialize the new customer’s balance to 0.

We could do the above manually again and again each time we insert a new customer. But doing so is error prone and less convenient. Of course, the logic above is fairly simple so only saves us minimal work; however, you will end up putting much more logic than this into more complex procedures, including parameter validations. You can now use a similar approach to address this step.

Step 5 – Create Deriving Procedure

You learned in the prior step how to create reusable stored procedures by using parameters, so using a variable is the new skill for this step. The basic concepts of variables are not too complex. A variable is a named placeholder that can store a value, and can later be referenced by name to retrieve the stored value.

Let's take an example from the customer order schema we have been using throughout this section. What if, instead of hardcoding the item code for an item, we wanted the database to assign it a unique value? What we could do is, create a variable, calculate the item code and store it in the variable, then reference the variable when inserting into the item table. Let's first illustrate this in pseudo-code so that you understand the concepts.

Pseudocode for Basic Variable Use

```
1: Declare variable v_item_code as a character string
2: Calculate a unique value and store it in the v_item_code variable
3: Insert whatever value is in the v_item_code variable into the item
table
```

In line 1 in the pseudocode, the v_item_code variable is declared. A *variable declaration* identifies the existence, name, and datatype of the variable. In programmatic SQL (and also in many programming languages), a variable cannot be used unless it is first declared. Its name identifies how the variable will be later referenced, and its datatype indicates what kind of value it can store (such as character string, number, date, etc …)

In line 2 in the pseudocode, the variable is assigned a value. A *variable assignment* places a value into the variable. Referencing the variable later will use the value assigned.

In line 3, the variable is used by referencing it by name. A *variable reference* uses whatever value is in the variable. Of course, the references to the variable are what makes a variable useful, since simply declaring one and assigning a value to it would not be useful alone.

Now that you understand the pseudocode, let's look at the stored procedure code then analyze the lines.

Code: Creating add_item Procedure

```
CREATE PROCEDURE ADD_ITEM
   @p_description VARCHAR(64), -- The item's description
   @p_price DECIMAL(10,2)      -- The item's price
AS
BEGIN
  DECLARE @v_item_code VARCHAR(4); --Declare a variable to hold an item_code value.

  --Calculate the item_code value and put it into the variable.
  SET @v_item_code = CONCAT(SUBSTRING(@p_description,1,1), FLOOR(RAND()*1000));

  --Insert a row with the combined values of the parameters and the variable.
   INSERT INTO ITEM (item_id, description, price, item_code)
   VALUES(NEXT VALUE FOR item_seq, @p_description, @p_price, @v_item_code);
END;
```

First, you'll notice that the procedure is named "add_item" since it allows for adding an item to the database. Next, you'll notice that two of the four values needed in the Item table – description and price – all have corresponding parameters. The executor will decide what these values are whenever the stored procedure is invoked (you have already witnessed this strategy in the prior step).

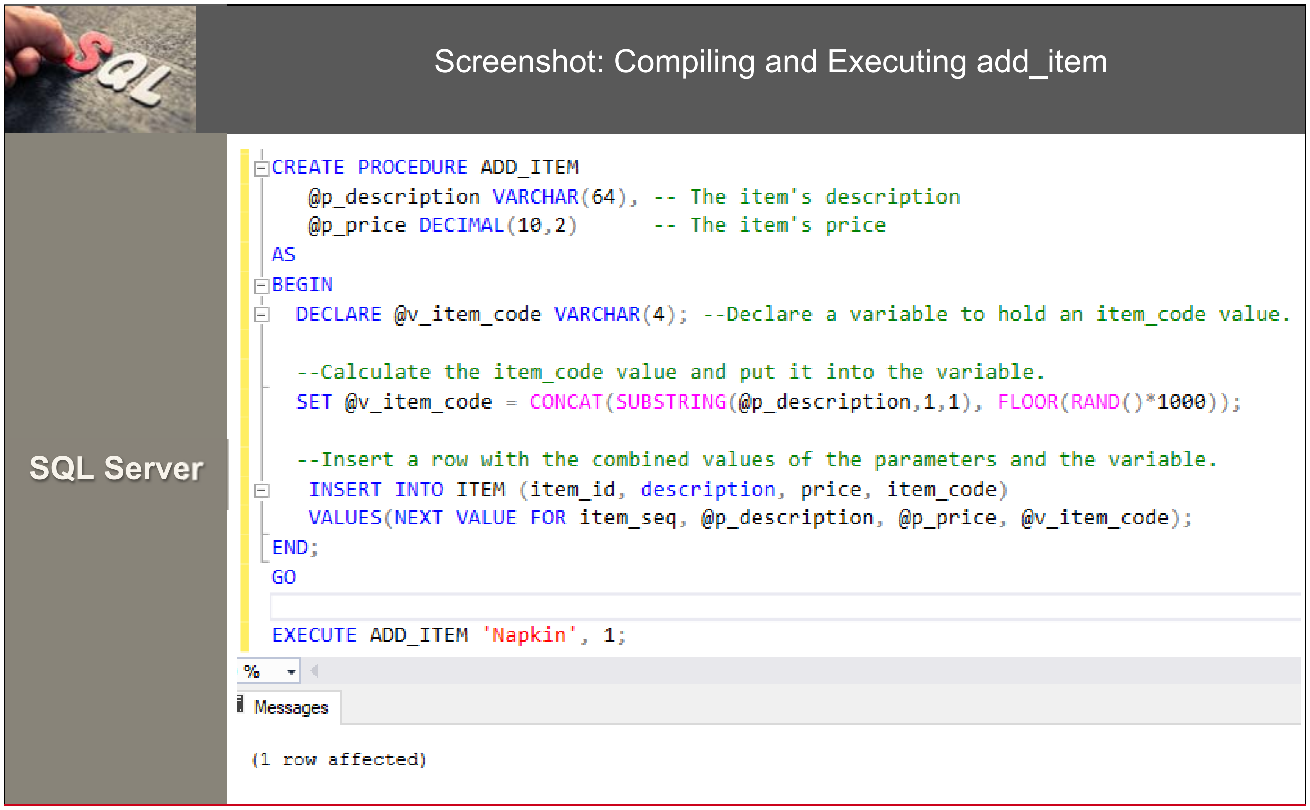
Notice the `DECLARE @v_item_code VARCHAR(4);` code. This line is the variable declaration, where we indicate the variable exists (by the existence of the declaration), give the variable its name (v_item_code), and its datatype (VARCHAR(4)). We give it that datatype since that is the same datatype as found in the table. This variable declaration sets up the variable so it can be assigned values and its values can be retrieved.

Next, you'll notice the `SET @v_item_code = CONCAT(SUBSTRING(@p_description,1,1), FLOOR(RAND()*1000));` line. There are several pieces of code here you may not recognize, but don't let that keep you from understanding the basic fact that this is the line that sets the value for the variable. What we are setting it to is the first character of the description, followed by a random 3-digit number. For example, if the item description is "Napkin", then the item code would start with "N" since that is the first letter, followed by a random 3-digit number. If the database randomly selects 867 for example, then the item code would be "N867".

The SUBSTRING function in SQL Server returns a portion of a character string. The `SUBSTRING(@p_description, 1, 1)` code indicates to start at the first character (the first 1 argument), and to grab 1 character from there (the second 1 argument), thereby retrieving the first character. The RAND() function obtains a random number between 0 and 1, so we multiply it times 1000 to get a number between 0 and 999. The FLOOR function chops off the decimal point and leaves the nearest whole number. The CONCAT() function concatenates two or more values together as a string. When the results of these functions are combined through concatenation, it results in a 4-character item code as described above.

Last, you'll notice the insert line, which inserts the values into the Item table, with a reference to "v_item_code" for the item_code value. Referencing the variable instructs the SQL engine to pull the value stored in the variable.

Let's try out compiling and executing the stored procedure to add a "napkin" item.



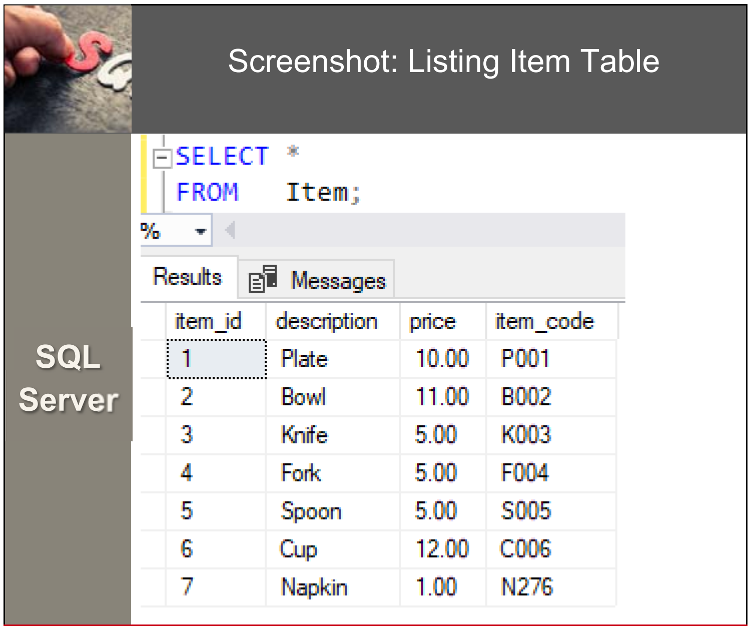
Screenshot: Compiling and Executing add_item

```
CREATE PROCEDURE ADD_ITEM
    @p_description VARCHAR(64), -- The item's description
    @p_price DECIMAL(10,2)      -- The item's price
AS
BEGIN
  DECLARE @v_item_code VARCHAR(4); --Declare a variable to hold an item_code value.

  --Calculate the item_code value and put it into the variable.
  SET @v_item_code = CONCAT(SUBSTRING(@p_description,1,1), FLOOR(RAND()*1000));

  --Insert a row with the combined values of the parameters and the variable.
   INSERT INTO ITEM (item_id, description, price, item_code)
   VALUES(NEXT VALUE FOR item_seq, @p_description, @p_price, @v_item_code);
END;
GO

EXECUTE ADD_ITEM 'Napkin', 1;
```

Messages

```
(1 row affected)
```

Notice that it was necessary to put the GO keyword after the stored procedure definition, so that we could combine DDL (data definition language) with DML (data manipulation language). We otherwise execute the add_item stored procedure just as we executed the add_customer procedure in the prior step. Let's look at the item table now to see if our item was added.



Screenshot: Listing Item Table

```
SELECT *
FROM   Item;
```

Results | Messages

item_id	description	price	item_code
1	Plate	10.00	P001
2	Bowl	11.00	B002
3	Knife	5.00	K003
4	Fork	5.00	F004
5	Spoon	5.00	S005
6	Cup	12.00	C006
7	Napkin	1.00	N276

Sure enough, the Napkin item was added, and the item_code value was automatically calculated rather than being passed in as a parameter by the executor. We achieved something new!

There is one more important concept you need to understand about variables to make effective use of them. *Variable scope* is the region in which a variable is accessible. In the examples in this step, we declare the variable within the stored procedure, which means that the variable is only accessible within that same stored procedure. Another stored procedure, or the SQL engine itself, cannot access the variable. When the procedure is invoked, the variable becomes accessible by code in the procedure. Unless a value is given in its declaration, the variable is initialized to null, and another line of code can explicitly set its value to something else.

What about multiple executions of the same procedure? Does the variable's value remain across executions? The simple answer is no. Every time the procedure is invoked, the variable's value is initialized and available only to that particular execution. Different executions of the stored procedure have access to different values of the variable. That is, even though it appears multiple executions are accessing the same variable since it carries the same and declaration, *each execution has its own copy of the variable* so that each execution can use the variable independent of another execution.

Hopefully the examples in this step help illustrate one purpose of using variables. A variable provides a place to store values, which can be calculated by using expressions, and then the variable can later be referenced to retrieve its value.

You now have enough knowledge to create the stored procedure for this step.

Step 6 – Create Lookup Procedure

What you're being asked to do is certainly becoming more complex, but don't worry, you already have most of the skills you need. You already know how to create parameterized stored procedures, and declare and use variables. The one skill you have not learned yet is setting the value of a variable based upon the results of a query. Since your procedure will be given a username and not a person_id, you will need to look this up by executing a query. There is a way to do this and store it into a variable.

We'll demonstrate how to do this by creating an "add_line_item" stored procedure that supports adding line items to the database. Rather than the executor specifying the item_id, the stored procedure will take the item_code as a parameter, then lookup the item_id. The other parameters will be specified as usual. Such a procedure can look like this.

Code: ADD_LINE_ITEM procedure

```
CREATE PROCEDURE ADD_LINE_ITEM
  @p_item_code VARCHAR(4), -- The code of the item.
  @p_order_id DECIMAL(12), -- The ID of the order for the line item.
  @p_quantity DECIMAL(10)  -- The quantity of the item.
AS
BEGIN
  DECLARE @v_item_id DECIMAL(12); --Declare a variable to hold the ID of the item code.
  DECLARE @v_line_price DECIMAL(12,2); --Declare a variable to calculate line price.

  --Get the item_id based upon the item_code, as well as the line total.
  SELECT @v_item_id=item_id, @v_line_price=price*@p_quantity
  FROM   Item
  WHERE  item_code = @p_item_code;

  --Insert the new line item.
  INSERT INTO LINE_ITEM(item_id, order_id, item_quantity, line_price)
  VALUES(@v_item_id, @p_order_id, @p_quantity, @v_line_price);
END;
```

There are four columns in the line_item table – item_id, order_id, item_quantity, and line_price. Order_id and item_quantity are specified explicitly as parameters, so the executor decides what values to pass in explicitly. However, the other two are not specified explicitly, but are looked up by using the item_code. Notice that there are two variables declared, v_item_id and v_line_price; these will be used to store these values. It's this select statement that is interesting for this step.

```
SELECT @v_item_id=item_id, @v_line_price=price*@p_quantity
FROM   Item
WHERE  item_code = @p_item_code;
```

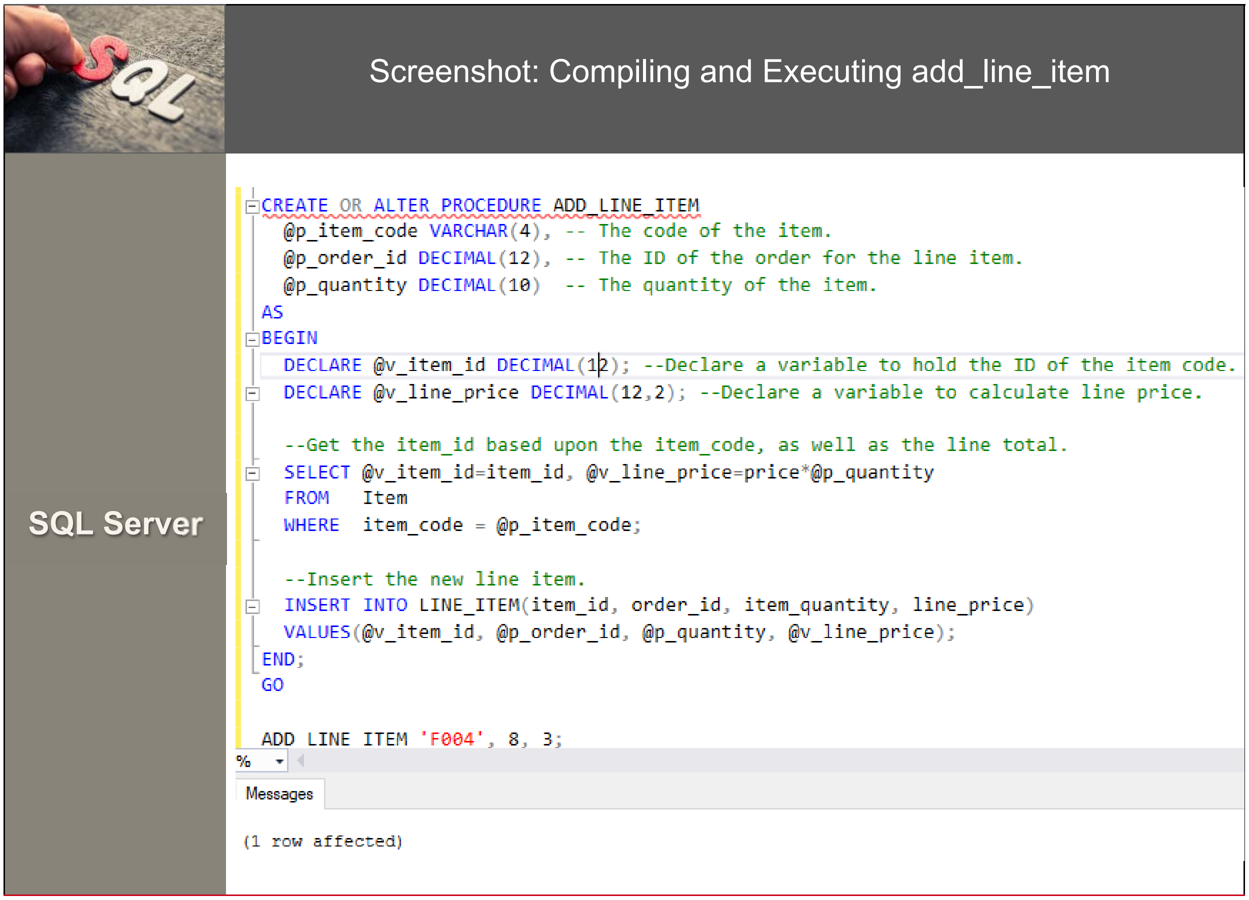
The standard SELECT, FROM, WHERE clauses combined are retrieving the item corresponding to the item code passed in as a parameter, and pulling back the item_id column, and calculating what the line price would be by multiplying the price times the quantity specified. You might have guessed that the syntax we have not dealt with before, the `@v_item_id=` and the `@v_line_price=`, provide a way to assign the column's value into a variable. @v_item_id is set to the item_id column value, and @v_line_price is set to the expression of price * @p_quantity.

Do you see the power of this syntax? You can use it to lookup values in other tables, store them in variables, then later use those variables as needed. In our case, we are using the syntax to determine what the item_id and line_price values should be, then using those variables in our insert statement.

Next, let's use our stored procedure to add a line item for an order, where three "fork" items are added. As a reminder, the "fork" item has these values:

item_id	description	price	item_code
4	Fork	5	F004

It's item_code is "F004", its price is $5, and its ID is 4. Here is a screenshot of the code used to add three fork items to an order (order with id 8).

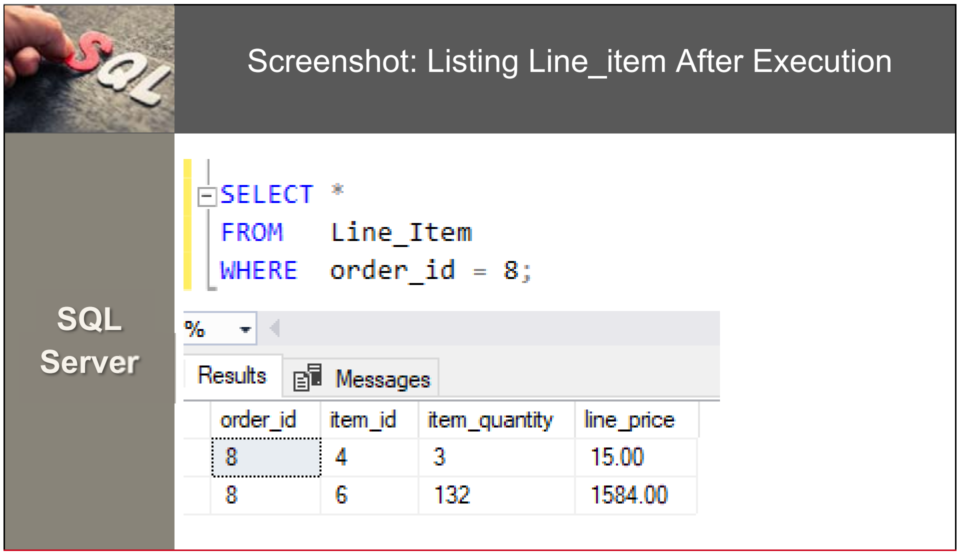


Screenshot: Compiling and Executing add_line_item

```
CREATE OR ALTER PROCEDURE ADD_LINE_ITEM
  @p_item_code VARCHAR(4), -- The code of the item.
  @p_order_id DECIMAL(12), -- The ID of the order for the line item.
  @p_quantity DECIMAL(10)  -- The quantity of the item.
AS
BEGIN
  DECLARE @v_item_id DECIMAL(12); --Declare a variable to hold the ID of the item code.
  DECLARE @v_line_price DECIMAL(12,2); --Declare a variable to calculate line price.

  --Get the item_id based upon the item_code, as well as the line total.
  SELECT @v_item_id=item_id, @v_line_price=price*@p_quantity
  FROM   Item
  WHERE  item_code = @p_item_code;

  --Insert the new line item.
  INSERT INTO LINE_ITEM(item_id, order_id, item_quantity, line_price)
  VALUES(@v_item_id, @p_order_id, @p_quantity, @v_line_price);
END;
GO

ADD_LINE_ITEM 'F004', 8, 3;
```

```
(1 row affected)
```

The ADD_LINE_ITEM procedure was invoked, referencing the "F004" item code, order id 8, and a quantity of 3. Now let's see if our results made it into the table by selecting all line items for order 8.



Screenshot: Listing Line_item After Execution

SQL Server

```
SELECT *
FROM   Line_Item
WHERE  order_id = 8;
```

order_id	item_id	item_quantity	line_price
8	4	3	15.00
8	6	132	1584.00

Notice that the first line is the one we just inserted using the procedure! Order with ID 8 now has an additional line item for forks (with ID 4), quantity 3, and a price of $15 (since $5 * 3 = $15).

We are able to use this procedure to automatically calculate the line price, and to retrieve the correct item, all with its item code. Do you see now the power of lookups and storing the values in? It gives a new dimension to your stored procedures, as your procedures can now take parameters, lookup values in various tables, and use them as needed. You’re on your way to becoming an expert!

Now you can use a similar strategy to create your procedure.

Step 7 – Single Table Validation Trigger

To demonstrate how to do this, we will create a trigger that prevents the customer balance from being negative. This validation only needs information from the table being modified and so qualifies as an intra-table validation. Below is the code for such a trigger.

Code: No Negative Balance Validation Trigger

```
CREATE TRIGGER no_neg_bal_trg
ON Customer AFTER INSERT,UPDATE
AS
BEGIN
  DECLARE @CUSTOMER_TOTAL DECIMAL;
  SET @CUSTOMER_TOTAL=(SELECT INSERTED.customer_total FROM INSERTED);

  IF @CUSTOMER_TOTAL < 0
  BEGIN
    ROLLBACK;
    RAISERROR('Customer balance cannot be negative',14,1);
   END;
END;
```

Since we have not yet reviewed triggers, let's examine this line by line.

Line 1: CREATE TRIGGER no_neg_bal_trg

The **CREATE TRIGGER** phrase indicates that a trigger is to be created. The **no_neg_bal_trg** word is the name of the trigger, an identifier of our own choosing. We put "trg" at the end of the identifier as a convention, so it's recognizable as the name of a trigger. The rest of the name helps describe what the trigger does, which is validate that there is no negative balance.

Line 2: ON Customer AFTER INSERT,UPDATE

ON Customer ties to trigger to the Customer table, that is, indicates that the aforementioned actions (update and insert) will fire this trigger only if they happen on the Customer table. Triggers are inexorably linked to one table by definition. If the table is dropped, the trigger is also automatically dropped.

AFTER is a SQL keyword that instructs the trigger is to be executed after the insert or update occurs in the database (but still within the same transaction). **INSERT,UPDATE** indicates that the trigger is to be fired when either an insert or an update statement happens on the table. If we had omitted "INSERT" for example, then the trigger would only fire when an update occurs. We want to block all negative balances so we have the trigger fire on both updates and inserts.

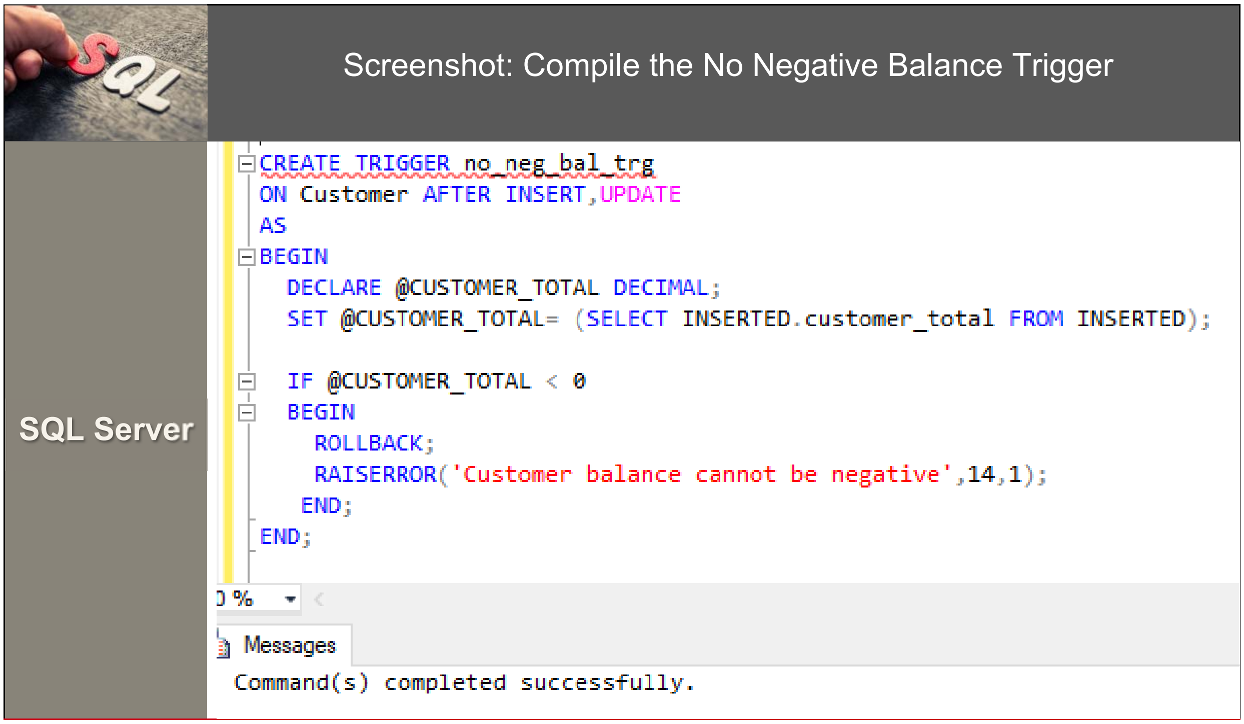
Line 3: AS

This is just part of the syntax of creating the trigger (similar to stored procedures).

Line 4: BEGIN

	Just as with stored procedures, code for triggers needs to be defined within a BEGIN/END block. The BEGIN keyword opens the block for the trigger.
Line 5: DECLARE @CUSTOMER_TOTAL DECIMAL;	
	This declares a variable that will be used to store the total just updated or inserted.
Line 6: SET @CUSTOMER_TOTAL=(SELECT INSERTED.customer_total FROM INSERTED);	
	This sets the customer_total variable to the total just inserted or updated. INSERTED is a pseudo-table only available in triggers which has all of the same columns as the table the trigger is attached to (in this case, Customer), and has all of the updated rows (since inserts and updates can affect more than one row in SQL Server). By accessing INSERTED.customer_total, we are accessing the total column after it was updated or inserted. Notice that we used the SET keyword to set the value of the customer_total variable, with a nested query. This is just an alternative method for setting the variable. We could have also used the "@customer_total=" syntax within the query itself.
Line 7: IF @CUSTOMER_TOTAL < 0	
	The **IF** keyword tells SQL Server that the block following is only to be executed of the Boolean expression evaluates to true. If statements allow us to conditionally execute code. For this trigger, we only want to reject SQL statements that attempt to create a negative balance, so we use an if statement. The **@CUSTOMER_TOTAL < 0** component is the Boolean expression that the if statement will evaluate, which evaluates to true only when the new customer_total value is less than 0 (negative).
Line 8: BEGIN	
	This begins the block for the if statement. Any code within this block is conditionally executed based upon the Boolean expression.
Line 9: ROLLBACK;	
	This is a transaction control statement that rolls back the in-progress transaction. Even though the trigger is firing after the update has been made, the trigger is still executing within the same transaction as the insert or update statement that caused the trigger to fire. Since we don't want the insert or update to make it into the database, we must rollback the transaction.
Line 10: END;	
	This ends the IF block. Code outside the IF block is not conditional, and code within the IF block is conditional.
Line 11: END;	
	This ends the block for the trigger itself.

First, we compile the trigger as illustrated in the screenshot below.

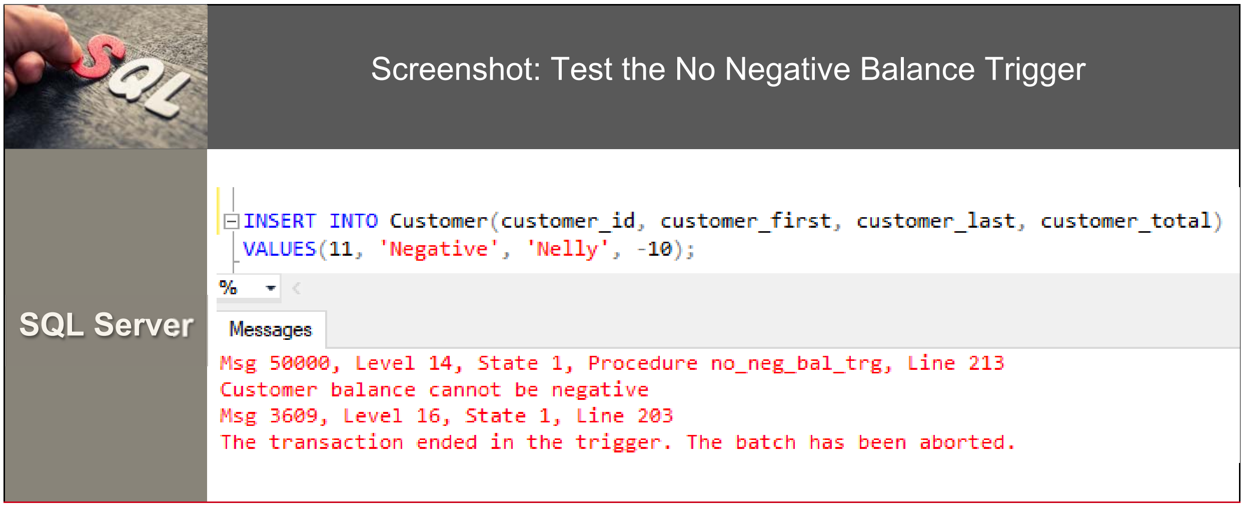


Screenshot: Compile the No Negative Balance Trigger

```
CREATE TRIGGER no_neg_bal_trg
ON Customer AFTER INSERT,UPDATE
AS
BEGIN
  DECLARE @CUSTOMER_TOTAL DECIMAL;
  SET @CUSTOMER_TOTAL= (SELECT INSERTED.customer_total FROM INSERTED);

  IF @CUSTOMER_TOTAL < 0
  BEGIN
    ROLLBACK;
    RAISERROR('Customer balance cannot be negative',14,1);
   END;
END;
```

```
Command(s) completed successfully.
```

As soon as the trigger is compiled successfully, it is active in the database and will execute when the triggering event happens from that point forward (until, of course, the trigger is disabled or dropped). If we attempt to insert a customer with a negative balance, the trigger will fire and reject it, shown below.



Screenshot: Test the No Negative Balance Trigger

```
INSERT INTO Customer(customer_id, customer_first, customer_last, customer_total)
VALUES(11, 'Negative', 'Nelly', -10);
```

```
Msg 50000, Level 14, State 1, Procedure no_neg_bal_trg, Line 213
Customer balance cannot be negative
Msg 3609, Level 16, State 1, Line 203
The transaction ended in the trigger. The batch has been aborted.
```

Notice that the insert was immediately rejected by the trigger, and the message is "Customer balance cannot be negative." We cannot execute the trigger directly, but we can see the effects of the trigger when we execute a triggering statement such as an insert.

You can use similar logic to create your validation trigger.

Step 8 – Cross-Table Validation Trigger

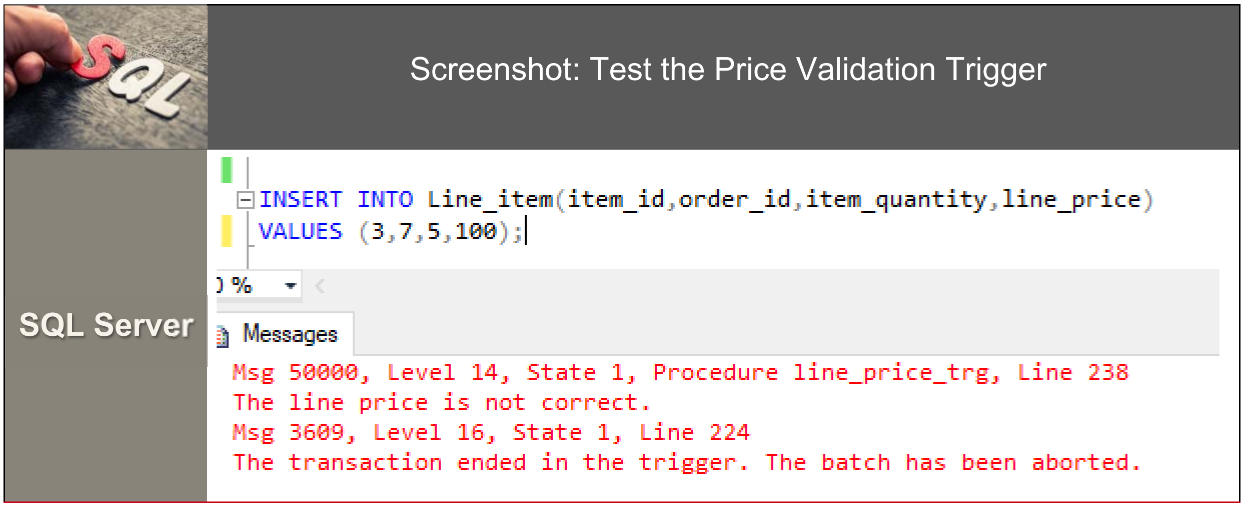
To demonstrate cross-table validation, imagine we want to validate the fact that the line price for a line item actually equals the quantity times the item price. The quantity is stored in the Line_item table while the item price is stored in the Item table. We can setup a trigger on the Line_item table to perform this validation using constructs we've already used in prior steps in this lab. Here is the code for such a trigger.

Code: Correct Line Price Validation Trigger

```
CREATE TRIGGER line_price_trg
ON Line_item AFTER INSERT,UPDATE
AS
BEGIN
  DECLARE @v_actual_line_price DECIMAL(12,2);
  DECLARE @v_correct_line_price DECIMAL(12,2);
  SELECT @v_actual_line_price=INSERTED.line_price,
         @v_correct_line_price=INSERTED.item_quantity * Item.price
  FROM   Item
  JOIN   INSERTED ON INSERTED.item_id = Item.item_id;

  IF @v_actual_line_price <> @v_correct_line_price
  BEGIN
    ROLLBACK;
    RAISERROR('The line price is not correct.',14,1);
   END;
END;
```

You've seen all of the constructs here individually, but the integration of them needs more explanation. Two variables are declared, one to store the actual line price being inserted or updated, and the other to store the correct line price. Both of these are set by using the SELECT statement to pull from both the Item table as well as the INSERTED pseudo-table. The trigger then uses an if statement to determine if the line price of the new or updated row is correct. If it's not, it rolls back the transaction and raises an error that indicates the line price is not correct. You've seen all of these constructs before, so you're not witnessing just another use case.

Let's try it out. We'll try to insert a line item with an invalid line price, as follows.



Screenshot: Test the Price Validation Trigger

```
INSERT INTO Line_item(item_id,order_id,item_quantity,line_price)
VALUES (3,7,5,100);
```

```
Msg 50000, Level 14, State 1, Procedure line_price_trg, Line 238
The line price is not correct.
Msg 3609, Level 16, State 1, Line 224
The transaction ended in the trigger. The batch has been aborted.
```

We attempted to insert a line item with a line price of 100, and the trigger rejected it because the line price should be 25. Why? Item with ID 3 has a price of 5, and there is a quantity of 5, so the line price would be 25 and not 100. We successfully used a trigger to perform a cross-table validation, simply by combining constructs we were already familiar with.

With all of these skills, you may begin feel very powerful. Just make sure to use your powers for good and not evil. You can use similar logic to create your cross-validation trigger.

Step 9 – History Trigger

To demonstrate capturing history, imagine that we would like to store a history of price changes for each item, so that we know the price of an item at any point in time despite any price updates. Abstractly, these fields should be included in a history table – a reference (foreign key) to the table being changed, the old value of the column, the new value of the column, and the date of change. You can think of this set of fields as a design pattern for history tables. For our example, we would create an Item_price_history table that stores a reference to the item, its old price, its new price, and the date of the change.

Before showing you code, let's make sure to differentiate history and auditing, which have two different purposes. A history table records changes over time but remains active in the schema, with proper foreign keys for references. The fields are setup so that SQL queries and transactions can use the table along with the other tables in the schema, that is, so that the table can be used regularly like any other table in the schema. The purpose of a history table is to make prior values available to the people and applications that use the database in a way that coexists with the current values.

An audit table also records changes over time, but it does not remain active in the schema. The purpose of an audit table is to simply record that a change happened in a way that people can manually review the changes later in case of any concern or dispute. An audit table has no foreign keys, and acts more like a log which contains the full value of each field. Since an audit table does not make use of foreign keys, and flattens out the needed fields, it survives schema changes over time well. For example, as already mentioned a history table for price changes would have a foreign key to the item, but an audit table would instead have the description of the item along with any other information needed to identify the item. Someone could manually review the audit table to see which prices changes over time for which items.

It's a best practice to be aware of which kind of table you're creating – history or audit – and follow the design patterns for that table. Some organizations inadvertently create hybrid tables that perhaps start out strictly for auditing, but then later add in foreign keys, and this can cause problems as changes are made to the database. In this step, we are creating a history table that remains active in the schema.

First, let's look at the code for creating the Item_price_history table, below.

Code: Create the Item_price_history Table

```
CREATE TABLE Item_price_history (
item_id DECIMAL(12) NOT NULL,
old_price DECIMAL(10,2) NOT NULL,
new_price DECIMAL(10,2) NOT NULL,
change_date DATE NOT NULL,
FOREIGN KEY (item_id) REFERENCES Item(item_id));
```

You're very familiar with table creation syntax at this point, so there's no need to belabor the basics of this SQL. Instead, we'll focus on what's important here. We opted to avoid giving this table a primary key; a primary key is not necessary to record the history. In some real-world schemas, the standards employed by the organization may mandate a primary key, especially if the schema will be mapped by an object-relational mapping tool within an application. There is a foreign key to the Item which has been changed. The old_price and new_price columns have the same datatype as the original Item.price column, since it will be a record of the change.

Once the table is created, we then define a trigger on the Item table that inserts a row into the Item_price_history table whenever an item price is updated. The code for the trigger is below.

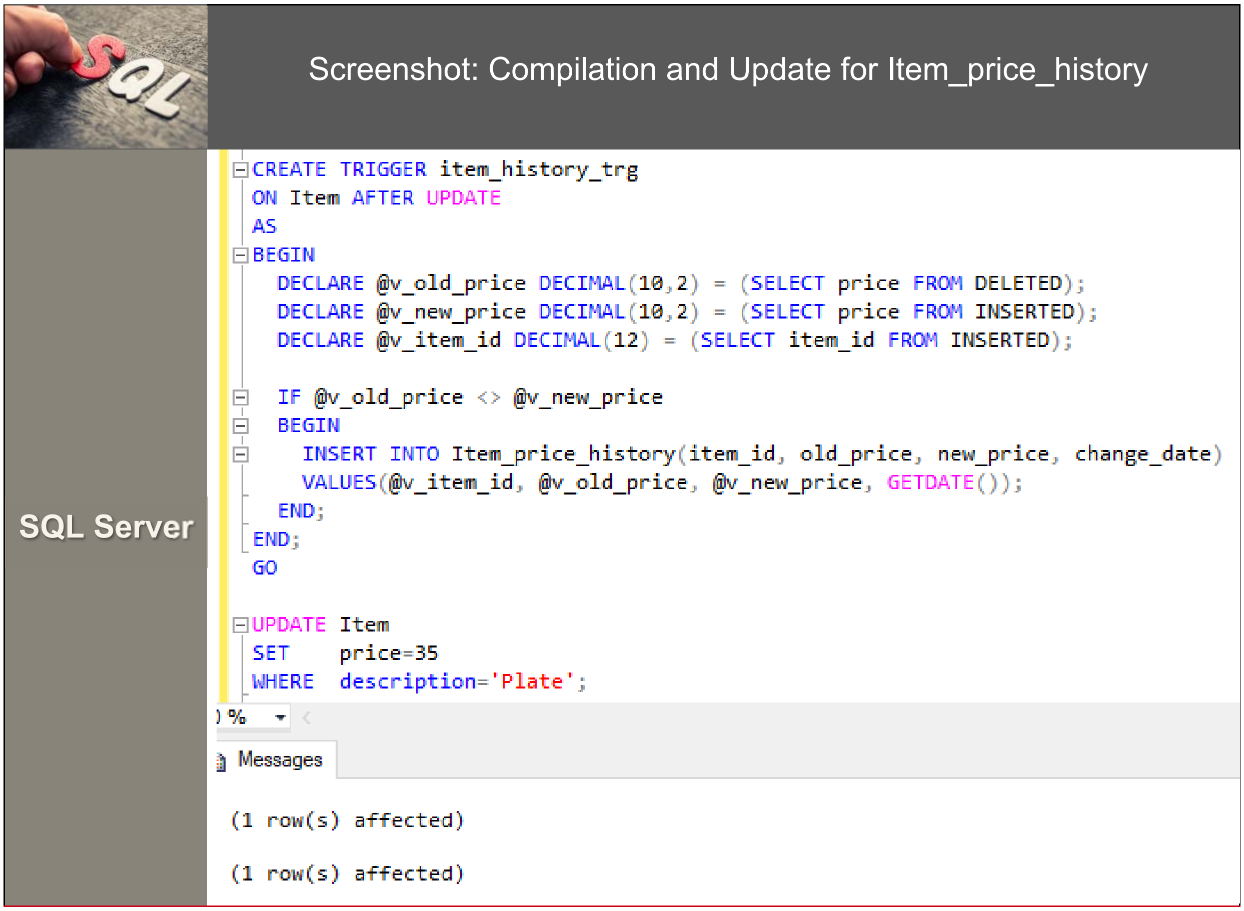
Code: The Item_price_history Trigger

```
CREATE TRIGGER item_history_trg
ON Item AFTER UPDATE
AS
BEGIN
  DECLARE @v_old_price DECIMAL(10,2) = (SELECT price FROM DELETED);
  DECLARE @v_new_price DECIMAL(10,2) = (SELECT price FROM INSERTED);
  DECLARE @v_item_id DECIMAL(12) = (SELECT item_id FROM INSERTED);

  IF @v_old_price <> @v_new_price
  BEGIN
    INSERT INTO Item_price_history(item_id, old_price, new_price, change_date)
    VALUES(@v_item_id, @v_old_price, @v_new_price, GETDATE());
  END;
END;
```

This trigger only fires on updates, because we only want to record changes in price. We've opted not record the initial price so we don't have the trigger fire on insert; however, one variation of the history table would record every price including the initial one. In that case, the trigger would be modified to also trigger on insert, and the old_price column would be nullable so that when the first price is created, the old_price is null (since there is no price).

DELETED is a pseudo-table that records the row before it was updated, in case of an update. If we had assigned the trigger fire on DELETE as well, then it would record the row before it was deleted. We use the DELETED pseudo-table to extract the old price, and the INSERTED pseudo-table to extract the new price and the item id. If the old price is different than the new price, it is recorded as an insert into the history table. The function "GETDATE()" is used to retrieve the current date.

Let's test that our trigger works by modifying the price of an item in the Item table. The compilation and update are illustrated first, below.

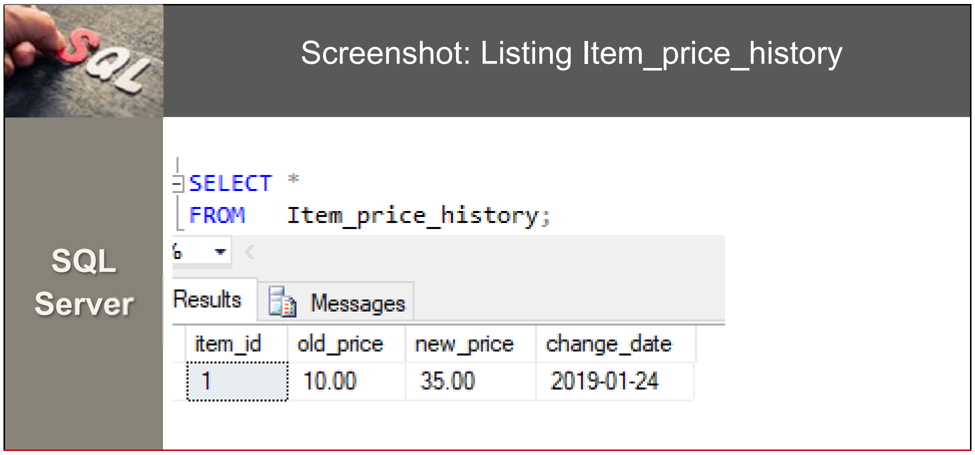


Screenshot: Compilation and Update for Item_price_history

```
CREATE TRIGGER item_history_trg
ON Item AFTER UPDATE
AS
BEGIN
  DECLARE @v_old_price DECIMAL(10,2) = (SELECT price FROM DELETED);
  DECLARE @v_new_price DECIMAL(10,2) = (SELECT price FROM INSERTED);
  DECLARE @v_item_id DECIMAL(12) = (SELECT item_id FROM INSERTED);

  IF @v_old_price <> @v_new_price
  BEGIN
    INSERT INTO Item_price_history(item_id, old_price, new_price, change_date)
    VALUES(@v_item_id, @v_old_price, @v_new_price, GETDATE());
  END;
END;
GO

UPDATE Item
SET    price=35
WHERE  description='Plate';
```

```
(1 row(s) affected)

(1 row(s) affected)
```

Next, the listing of the table itself is included, to show that the trigger recorded the update.



Screenshot: Listing Item_price_history

```
SELECT *
FROM   Item_price_history;
```

item_id	old_price	new_price	change_date
1	10.00	35.00	2019-01-24

We now see a row in the history table indicating the item with ID 1 (Plate) had an old price of 10, a new price of 35, and the change happened on the specific date. With this structure, all such price changes will be recorded over time. And following this pattern, we could record a history for whatever column we like for whatever table we need. Amazing!

You can follow this pattern to create and populate the history table for your lab.

Step 10 – Creating Normalized Table Structure

The scope and technical complexity on how to perform normalization from scratch is too broad and deep to be a part of this document. Please use the textbook, online lectures, and live classroom sessions to learn about normalization, how to identify and represent functional dependencies, and the steps to follow to normalize a table. Keep in mind that it is best practice to normalize tables to BCNF when possible. If a table is not normalized to BCNF for specific reasons, we should be aware of those reasons and make a conscious choice to do so.