Real World Applications for Visual Basic:
Calculating Overall Equipment Effectiveness

INTRODUCTION

The Industrial Engineering program at Iowa State focuses on providing students with real world industry examples. Microsoft Excel is arguably one of the most commonly used software programs within the working world. IE 148 adequately prepares students to use Excel properly in order to solve a multitude of common real world problems that one might experience on the job. However, a gap exists between building this foundation and continuing to improve these skills and further the education throughout the rest of the students' coursework. There are many instances where data used to solve problems will be generated by a computer on a much larger scale than what is taught in the classroom. This document seeks to provide students with an opportunity to further develop their problem solving skills. One way to further these skills is by applying VBA knowledge acquired during the freshman year to later courses in the core curriculum. This will better prepare students for problems they may encounter in their first internship experience.

BACKGROUND

A productivity metric is a type of measurement used to gauge a company's throughput per unit of time. Every company has a set of productivity metrics that they use to determine their system's productivity. It is a common role for an Industrial Engineer in a manufacturing environment to interpret these metrics in order to help identify areas for improvement as well as track improvements over time.

Productivity standards can be ambiguous because each company has the ability to define their own. These standards allow a company to see whether or not it is improving when it comes to its own productivity. One common way to determine a company's productivity is to calculate overall equipment effectiveness (OEE).

OEE is determined by combining three individual calculations. These three calculations are for availability, efficiency, and quality. Below are the components of each of these three calculations. It is important to remember that each company can define the terms of each equation as they see fit.

Availability takes into account loss due to downtime. It is calculated by taking the operating time (uptime of the machine) and dividing by planned production time (hours of operation). The formula is as follows:

Availability = Operating Time / Planned Production Time

Efficiency accounts for speed loss. It is calculated by taking the ideal cycle time divided by the division of operating time over total pieces produced. The formula is as follows:

Efficiency = Ideal Cycle Time / (Operating Time / Total Pieces Produced)

The final metric is quality. Quality accounts for quality loss. It is calculated by taking the number of good pieces produced over the total pieces produced. The formula is as follows:

Quality = Number of Good Pieces Produced / Total Pieces Produced

After these three individual calculations have been computed, they are multiplied together to determine the overall equipment effectiveness. The formula is as follows:

OEE = Availability * Effectiveness * Quality

One of the major causes for companies to use OEE metrics is to reduce and/or eradicate the 'Six Big Losses'(*"Six...Losses"*, 2012). These so called "Six Big Losses" are sorted into categories based on which of the three metrics they alter; two losses per metric (*"Six...Losses"*, 2012).

The losses that affect availability are breakdowns and setup/adjustments. A few examples of breakdowns could be: tooling failures, unplanned maintenance, and equipment failure. Examples of setup/adjustment include setup time, material shortages, operator shortages, and warm up time ("*Six...Losses*", 2012).
The losses in regard to performance include small stops and reduced speed. A few examples of small stops are obstructed product flow, component jams, misfeeds, general blockage, and cleaning. Examples of reduced speed include tough running, equipment wear, and operator inefficiency ("*Six...Losses*", 2012).

The two categories that hinder quality are startup rejects and production rejects. A few examples of startup rejects are scrap pieces, reworked parts, in-progress issues, and incorrect assembly. Examples of production rejects are the same as startup examples but occur during steady-state production, not during setup/warmup ("*Six...Losses*", 2012).

DISCUSSION

Now that OEE has been introduced, the next step is to look at a specific example of an OEE problem. The following problem statement explains an example OEE situation with a large number of data points. The best way to solve a large scale OEE problems is through VBA in Excel. The steps for solving this problem follow the problem statement below.

Problem Statement

Globex Corporation has just begun a new lean manufacturing initiative. Part of this initiative is focused on developing Key Performance Indicators (KPIs) that allow management to track the performance of specific work centers in order to help identify problem areas. As an Industrial Engineer with the company, your task is to take daily production data, as shown in Tables 1 below, and develop a weekly OEE report for a work center that consists of four machines that make similar parts. The production operations software compiles downtime and quality information into the excel file listed in Table 2 below. With the provided excel file of production data, use VBA to develop an OEE data display for each machine. Tables 1 and 2 below show the given production data.

Table 1: Weekly Downtime Data from the Four Machines

Table 2: Quality Data for Each Part

Date	Job #	Job Qty	% Scrap
10/1/2015	P3650	1000	6%
10/1/2015	P7550	1200	4%
10/1/2015	P1200	800	15%
10/1/2015	P5500	700	8%
10/2/2015	P3650	1000	6%
10/2/2015	P7550	1200	4%
10/2/2015	P1200	800	15%
10/2/2015	P5500	700	8%
10/3/2015	P3650	1000	6%
10/3/2015	P7550	1200	4%
10/3/2015	P1200	800	15%
10/3/2015	P5500	700	8%
10/4/2015	P3650	1000	6%
10/4/2015	P7550	1200	4%
10/4/2015	P1200	800	15%
10/4/2015	P5500	700	8%
10/5/2015	P3650	1000	6%
10/5/2015	P7550	1200	4%
10/5/2015	P1200	800	15%
10/5/2015	P5500	700	8%

SOLUTION

As explained earlier, OEE is a multiplier of Availability x Efficiency x Quality that is used to indicate the overall effectiveness of the work center. Developing the VBA code to solve the problem can be broken down into three categories: variable definition, sorting techniques, and subroutines.

Variable definition

The first step is to identify what variables are needed in order to solve the problem. It is important to remember to name the variables clearly in order to help differentiate between them while writing the code. First, define a variable for each of the components of the OEE equation: availability, efficiency, and quality. These values will each be independently calculated as a ratio within separate subroutines. These should be defined as doubles

because they are non-integer values. Variables defined as doubles are capable of holding more information that integer values.

Dim Availability As Double
Dim Quality As Double
Dim Efficiency As Double

The next step is to define a variable for each additional value below used in the calculations.

Availability = Operating Time / Planned Production Time
Efficiency = Ideal Cycle Time / (Operating Time / Total Pieces Produced)
Quality = Number of Good Pieces Produced / Total Number of Pieces Produced

In order to sort the data define an integer variable for the machine and day as well.

Sorting techniques
There are two sorting functions that can easily be utilized in this scenario to separate the data by machine and by day. Nesting *For Next* loops within the *Select Case* function and vice versa will allow the code to navigate to the data of a specific machine and day.

SubRoutines
A subroutine is a section of the program that provides instructions to carry out a specific task. There are only three subroutines required to solve the problem. Write the first sub to calculate availability, the second to calculate quality, and the third to calculate overall OEE. Since the variables used to calculate performance are defined in the A and Q subs, we can simply define the efficiency value within the final OEE sub.

Availability
The main purpose of this sub is to analyze the down time logs from the "efficiency" tab of the excel report to calculate operating time.

Operating Time = Planned Production Time - Down Time.

Planned production time in this case is representative of a typical 8 hour shift in a manufacturing environment. Use the *Select Case* function to select the machine. Once the machine has been identified, use a *For Next* loop to reference each cell. Subtract the time of the previous stoppage from the current start time in order to determine the downtime. Looking at machine one for example:

Select Case Machine

Case 1
For i = 3 To 7
        DT = DT + Worksheets("Efficiency").Range("C" & i).Value - Worksheets("Efficiency").Range("D" & (i –
                1)).Value
Next i
End Select

This will calculate a running sum of the total downtime for machine one on day one. Repeat this for each day and machine by changing the values of *i* to correspond with the rows of the efficiency tab. Change the range letter to represent the start and stop time columns for each machine.

At the end of each case, calculate the availability for each machine and each day using the modified availability equation.

Availability = (Planned Production Time – Down Time) / Planned Production Time

Quality

The quality data can be sorted by nesting two *Select Case* functions. First select the day, then select the machine. The two variables needed for the quality calculation are the total number of parts produced as well as the number of parts that passed the quality inspection. Multiplying the scrap rate by the total number of parts produced will determine how many parts did not pass the quality inspection.
For example,
Select Case Day
Case 1 'Indicates Day 1
   Select Case Machine
      Case 1 'Indicates Machine 1
         NumProduced = Worksheets("Quality").Range("C2").Value 'Pulls total quantity produces from file
         Scrap = Worksheets("Quality").Range("D2").Value * NumProduced 'Pulls scrap rate from file
         Quality = (NumProduced - Scrap) / NumProduced 'Calculates # of good pieces
      Case 2 'Indicates Machine 2
         NumProduced = Worksheets("Quality").Range("C3").Value
         Scrap = Worksheets("Quality").Range("D3").Value * NumProduced
         Quality = (NumProduced - Scrap) / NumProduced
      Case 3 'Indicates Machine 3
         NumProduced = Worksheets("Quality").Range("C4").Value
         Scrap = Worksheets("Quality").Range("D4").Value * NumProduced
         Quality = (NumProduced - Scrap) / NumProduced
      Case 4 'Indicates Machine 4
         NumProduced = Worksheets("Quality").Range("C5").Value
         Scrap = Worksheets("Quality").Range("D5").Value * NumProduced
         Quality = (NumProduced - Scrap) / NumProduced
   End Select
End Select

OEE

The final sub will calculate the efficiency value and then write the values into a new sheet that will display all of the information in one place to allow the decision maker to evaluate OEE as a key performance indicator. The efficiency metric will be calculated using the following equation:

Efficiency = (NumProduced) / (OpTime * Cycle)

Create a new sheet with a table for each machine. Use the example below in Table 3 as a guide.

Table 3: Example of How to Organize Output Data

Machine 1	A	E	Q	OEE		Machine 2	A	E	Q	OEE
Monday						Monday				
Tuesday						Tuesday				
Wednesday						Wednesday				
Thursday						Thursday				
Friday						Friday				
Weekly Average										

Machine 3	A	E	Q	OEE		Machine 4	A	E	Q	OEE
Monday						Monday				
Tuesday						Tuesday				
Wednesday						Wednesday				
Thursday						Thursday				
Friday						Friday				

Once again, nest the Select function within a For loop to cycle through each day and each machine. Use the call function to reference the availability and quality subs. For each case, specify the range that each value will go into. For example, for Monday and machine one,

```
Worksheets("OEE").Range("C3").Value = Availability
Worksheets("OEE").Range("D3").Value = Efficiency
Worksheets("OEE").Range("E3").Value = Quality
Worksheets("OEE").Range("F3").Value = Avail * Efficiency * Quality
```

In order to calculate the weekly average, use the average function and select all of the cells in OEE column as the range. The final product will allow managers to see how well each machine is performing on a weekly basis and help them identify areas for improvement.

A finished code solution can be found in Appendix A.

Results
Once OEE values have been calculated using VBA in Excel, the problem in still not complete. It is important to know how to interpret OEE values and the values of the components that make up the OEE value in order to improve a system. Attaining OEE values merely explains how a system is currently functioning. Being able to change factors within the system to increase the values of the components that make up OEE and in turn, increase the OEE value itself is where true improvement occurs. Looking at the specific results from this example problem, it is observed in Table 4 below that the average weekly OEE values range from 0.34 to 0.55 for the four machines.

Machine 1 has the most consistent results day to day with a weekly average OEE value of 0.46, which is between the highest and lowest observed values. Machine 2 has the highest weekly average OEE value, 0.55, and this value would be even greater if there had not been a decrease in the efficiency on Friday. After observing this, it is important to go back and review why the efficiency dropped on Friday in order to make improvements in the future. Machines 3 and 4 have similar day to day OEE values as well as similar weekly averages. It might appear that these two systems are operating in the same way but that is not the case. Machine 3 has higher availability values while Machine 4 has higher quality values. With these two machines, it would be beneficial to look at how quality for Machine 3 could be improved and how availability in Machine 4 could be improved.

Table 4: Average weekly OEE values from the four machines

Machine 1	A	E	Q	OEE	Machine 2	A	E	Q	OEE
Monday	0.76	0.69	0.94	0.49	Monday	0.76	0.83	0.96	0.60
Tuesday	0.76	0.69	0.94	0.49	Tuesday	0.76	0.83	0.96	0.60
Wednesday	0.76	0.69	0.94	0.49	Wednesday	0.76	0.83	0.96	0.60
Thursday	0.76	0.69	0.94	0.49	Thursday	0.76	0.83	0.96	0.60
Friday	0.76	0.48	0.92	0.34	Friday	0.76	0.48	0.92	0.34
Weekly Average				0.46					0.55

Machine 3	A	E	Q	OEE	Machine 4	A	E	Q	OEE
Monday	0.62	0.67	0.85	0.35	Monday	0.55	0.66	0.92	0.34
Tuesday	0.62	0.67	0.85	0.35	Tuesday	0.55	0.66	0.92	0.34
Wednesday	0.62	0.67	0.85	0.35	Wednesday	0.55	0.66	0.92	0.34
Thursday	0.62	0.67	0.85	0.35	Thursday	0.55	0.66	0.92	0.34
Friday	0.62	0.59	0.92	0.34	Friday	0.55	0.66	0.92	0.34
Weekly Average				0.35					0.34

Feasibility
The goal of this document is to provide industrial engineering students with the opportunity to revisit the VBA skills learned in IE 148 later in their education. Here, the example of later application is the topic of OEE, which is covered in IE 222. After drafting this assignment, it was shown to industrial engineering students who have already completed IE 148 and IE 222 in order to receive their feedback. Their ideas for improving clarity and further defining variables were taken into consideration in order to ensure the helpfulness of this document.

CONCLUSION
VBA within Excel has many applications and solving OEE equations with a large amount of data is just one of its uses. VBA will be used in various industrial engineering classes and across many industries after college. It is important to understand the basics of coding with VBA in order to apply its usefulness as often as possible. One limitation of this document is that the parameters for OEE have been defined one way here and may be defined differently at companies where students intern. On the other hand, if one's company does not have these parameters yet defined, this document provides a reference for defining them.

References

Six Big Losses. 2012. Itasca, IL: Vorne Industries, Inc. Retrieved from:
    http://www.oee.com/oee-six-big-losses.html

```vba
Public MachineNum As Integer
Public OpTime As Double
Public DT As Double
Public SchedTime As Double
Public NumProduced As Double
Public CycleTime As Double
Public Scrap As Integer
Public Avail As Double
Public Quality As Double
Public Efficiency As Double
Public Machine As Integer
Public Day As Integer
Public Cycle As Double


Sub Qual()
Select Case Day
Case 1
   Select Case Machine
      Case 1
         NumProduced = Worksheets("Quality").Range("C2").Value
         Scrap = Worksheets("Quality").Range("D2").Value * NumProduced
         Quality = (NumProduced - Scrap) / NumProduced
      Case 2
         NumProduced = Worksheets("Quality").Range("C3").Value
         Scrap = Worksheets("Quality").Range("D3").Value * NumProduced
         Quality = (NumProduced - Scrap) / NumProduced
      Case 3
         NumProduced = Worksheets("Quality").Range("C4").Value
         Scrap = Worksheets("Quality").Range("D4").Value * NumProduced
         Quality = (NumProduced - Scrap) / NumProduced
      Case 4
         NumProduced = Worksheets("Quality").Range("C5").Value
         Scrap = Worksheets("Quality").Range("D5").Value * NumProduced
         Quality = (NumProduced - Scrap) / NumProduced
   End Select
Case 2
   Select Case Machine
      Case 1
         NumProduced = Worksheets("Quality").Range("C2").Value
         Scrap = Worksheets("Quality").Range("D2").Value * NumProduced
         Quality = (NumProduced - Scrap) / NumProduced
      Case 2
         NumProduced = Worksheets("Quality").Range("C3").Value
         Scrap = Worksheets("Quality").Range("D3").Value * NumProduced
         Quality = (NumProduced - Scrap) / NumProduced
      Case 3
         NumProduced = Worksheets("Quality").Range("C4").Value
         Scrap = Worksheets("Quality").Range("D4").Value * NumProduced
```

```vb
                Quality = (NumProduced - Scrap) / NumProduced
            Case 4
                NumProduced = Worksheets("Quality").Range("C5").Value
                Scrap = Worksheets("Quality").Range("D5").Value * NumProduced
                Quality = (NumProduced - Scrap) / NumProduced
        End Select
    Case 3
        Select Case Machine
            Case 1
                NumProduced = Worksheets("Quality").Range("C2").Value
                Scrap = Worksheets("Quality").Range("D2").Value * NumProduced
                Quality = (NumProduced - Scrap) / NumProduced
            Case 2
                NumProduced = Worksheets("Quality").Range("C3").Value
                Scrap = Worksheets("Quality").Range("D3").Value * NumProduced
                Quality = (NumProduced - Scrap) / NumProduced
            Case 3
                NumProduced = Worksheets("Quality").Range("C4").Value
                Scrap = Worksheets("Quality").Range("D4").Value * NumProduced
                Quality = (NumProduced - Scrap) / NumProduced
            Case 4
                NumProduced = Worksheets("Quality").Range("C5").Value
                Scrap = Worksheets("Quality").Range("D5").Value * NumProduced
                Quality = (NumProduced - Scrap) / NumProduced
        End Select
    Case 4
        Select Case Machine
            Case 1
                NumProduced = Worksheets("Quality").Range("C2").Value
                Scrap = Worksheets("Quality").Range("D2").Value * NumProduced
                Quality = (NumProduced - Scrap) / NumProduced
            Case 2
                NumProduced = Worksheets("Quality").Range("C3").Value
                Scrap = Worksheets("Quality").Range("D3").Value * NumProduced
                Quality = (NumProduced - Scrap) / NumProduced
            Case 3
                NumProduced = Worksheets("Quality").Range("C4").Value
                Scrap = Worksheets("Quality").Range("D4").Value * NumProduced
                Quality = (NumProduced - Scrap) / NumProduced
            Case 4
                NumProduced = Worksheets("Quality").Range("C5").Value
                Scrap = Worksheets("Quality").Range("D5").Value * NumProduced
                Quality = (NumProduced - Scrap) / NumProduced
        End Select
End Select
End Sub
Sub Availability()
'Calculate Operating Time
```

```vba
Select Case Machine
Case 1
   DT = 0
     For i = 3 To 7
        DT = DT + Worksheets("Efficiency").Range("C" & i).Value - Worksheets("Efficiency").Range("D" &
(i - 1)).Value
     Next i
   DT = Left(Format((DT), "hh:mm"), 2) * 60 + Right(Format((DT), "hh:mm"), 2)

   SchedTime = 480
   OpTime = 480 - DT
   Avail = OpTime / SchedTime
Case 2
   DT = 0
     For i = 3 To 7
        DT = DT + Worksheets("Efficiency").Range("K" & i).Value - Worksheets("Efficiency").Range("L" &
(i - 1)).Value
     Next i
   DT = Left(Format((DT), "hh:mm"), 2) * 60 + Right(Format((DT), "hh:mm"), 2)

   SchedTime = 480
   OpTime = 480 - DT
   Avail = OpTime / SchedTime
Case 3
   DT = 0
     For i = 3 To 7
        DT = DT + Worksheets("Efficiency").Range("S" & i).Value - Worksheets("Efficiency").Range("T" &
(i - 1)).Value
     Next i
   DT = Left(Format((DT), "hh:mm"), 2) * 60 + Right(Format((DT), "hh:mm"), 2)

   SchedTime = 480
   OpTime = 480 - DT
   Avail = OpTime / SchedTime
Case 4
   DT = 0
     For i = 3 To 7
        DT = DT + Worksheets("Efficiency").Range("AA" & i).Value -
Worksheets("Efficiency").Range("AB" & (i - 1)).Value
     Next i
   DT = Left(Format((DT), "hh:mm"), 2) * 60 + Right(Format((DT), "hh:mm"), 2)

   SchedTime = 480
   OpTime = 480 - DT
   Avail = OpTime / SchedTime
End Select

End Sub
Sub OEE()
```

```
   Cycle = 4
For Day = 1 To 5
Select Case Day
Case 1
   For Machine = 1 To 4 'Calculate Metrics for each machine individually
      Call Availability
      Call Qual
      Efficiency = (NumProduced) / (OpTime * Cycle)
      Select Case Machine
        Case 1
           Worksheets("OEE").Range("C3").Value = Avail
           Worksheets("OEE").Range("D3").Value = Efficiency
           Worksheets("OEE").Range("E3").Value = Quality
           Worksheets("OEE").Range("F3").Value = Avail * Efficiency * Quality
        Case 2
           Worksheets("OEE").Range("I3").Value = Avail
           Worksheets("OEE").Range("J3").Value = Efficiency
           Worksheets("OEE").Range("K3").Value = Quality
           Worksheets("OEE").Range("L3").Value = Avail * Efficiency * Quality
        Case 3
           Worksheets("OEE").Range("O3").Value = Avail
           Worksheets("OEE").Range("P3").Value = Efficiency
           Worksheets("OEE").Range("Q3").Value = Quality
           Worksheets("OEE").Range("R3").Value = Avail * Efficiency * Quality
        Case 4
           Worksheets("OEE").Range("U3").Value = Avail
           Worksheets("OEE").Range("V3").Value = Efficiency
           Worksheets("OEE").Range("W3").Value = Quality
           Worksheets("OEE").Range("X3").Value = Avail * Efficiency * Quality
      End Select
   Next Machine
Case 2
   For Machine = 1 To 4 'Calculate Metrics for each machine individually
      Call Availability
      Call Qual
      Efficiency = (NumProduced) / (OpTime * Cycle)
      Select Case Machine
        Case 1
           Worksheets("OEE").Range("C4").Value = Avail
           Worksheets("OEE").Range("D4").Value = Efficiency
           Worksheets("OEE").Range("E4").Value = Quality
           Worksheets("OEE").Range("F4").Value = Avail * Efficiency * Quality
        Case 2
           Worksheets("OEE").Range("I4").Value = Avail
           Worksheets("OEE").Range("J4").Value = Efficiency
           Worksheets("OEE").Range("K4").Value = Quality
           Worksheets("OEE").Range("L4").Value = Avail * Efficiency * Quality
        Case 3
           Worksheets("OEE").Range("O4").Value = Avail
```

```vba
            Worksheets("OEE").Range("P4").Value = Efficiency
            Worksheets("OEE").Range("Q4").Value = Quality
            Worksheets("OEE").Range("R4").Value = Avail * Efficiency * Quality
          Case 4
            Worksheets("OEE").Range("U4").Value = Avail
            Worksheets("OEE").Range("V4").Value = Efficiency
            Worksheets("OEE").Range("W4").Value = Quality
            Worksheets("OEE").Range("X4").Value = Avail * Efficiency * Quality
        End Select
      Next Machine
  Case 3
    For Machine = 1 To 4 'Calculate Metrics for each machine individually
        Call Availability
        Call Qual
        Efficiency = (NumProduced) / (OpTime * Cycle)
        Select Case Machine
          Case 1
            Worksheets("OEE").Range("C5").Value = Avail
            Worksheets("OEE").Range("D5").Value = Efficiency
            Worksheets("OEE").Range("E5").Value = Quality
            Worksheets("OEE").Range("F5").Value = Avail * Efficiency * Quality
          Case 2
            Worksheets("OEE").Range("I5").Value = Avail
            Worksheets("OEE").Range("J5").Value = Efficiency
            Worksheets("OEE").Range("K5").Value = Quality
            Worksheets("OEE").Range("L5").Value = Avail * Efficiency * Quality
          Case 3
            Worksheets("OEE").Range("O5").Value = Avail
            Worksheets("OEE").Range("P5").Value = Efficiency
            Worksheets("OEE").Range("Q5").Value = Quality
            Worksheets("OEE").Range("R5").Value = Avail * Efficiency * Quality
          Case 4
            Worksheets("OEE").Range("U5").Value = Avail
            Worksheets("OEE").Range("V5").Value = Efficiency
            Worksheets("OEE").Range("W5").Value = Quality
            Worksheets("OEE").Range("X5").Value = Avail * Efficiency * Quality
        End Select
      Next Machine
  Case 4
    For Machine = 1 To 4 'Calculate Metrics for each machine individually
        Call Availability
        Call Qual
        Efficiency = (NumProduced) / (OpTime * Cycle)
        Select Case Machine
          Case 1
            Worksheets("OEE").Range("C6").Value = Avail
            Worksheets("OEE").Range("D6").Value = Efficiency
            Worksheets("OEE").Range("E6").Value = Quality
            Worksheets("OEE").Range("F6").Value = Avail * Efficiency * Quality
```
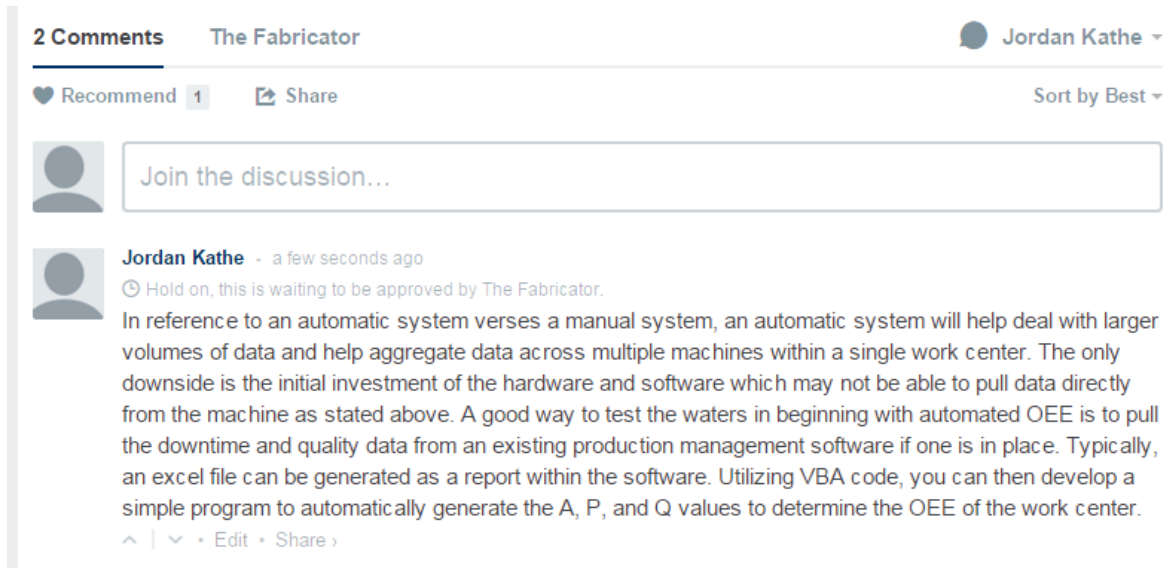
```vba
        Case 2
          Worksheets("OEE").Range("I6").Value = Avail
          Worksheets("OEE").Range("J6").Value = Efficiency
          Worksheets("OEE").Range("K6").Value = Quality
          Worksheets("OEE").Range("L6").Value = Avail * Efficiency * Quality
        Case 3
          Worksheets("OEE").Range("O6").Value = Avail
          Worksheets("OEE").Range("P6").Value = Efficiency
          Worksheets("OEE").Range("Q6").Value = Quality
          Worksheets("OEE").Range("R6").Value = Avail * Efficiency * Quality
        Case 4
          Worksheets("OEE").Range("U6").Value = Avail
          Worksheets("OEE").Range("V6").Value = Efficiency
          Worksheets("OEE").Range("W6").Value = Quality
          Worksheets("OEE").Range("X6").Value = Avail * Efficiency * Quality
      End Select
    Next Machine
Case 5
  For Machine = 1 To 4 'Calculate Metrics for each machine individually
      Call Availability
      Call Qual
      Efficiency = (NumProduced) / (OpTime * Cycle)
      Select Case Machine
        Case 1
          Worksheets("OEE").Range("C7").Value = Avail
          Worksheets("OEE").Range("D7").Value = Efficiency
          Worksheets("OEE").Range("E7").Value = Quality
          Worksheets("OEE").Range("F7").Value = Avail * Efficiency * Quality
        Case 2
          Worksheets("OEE").Range("I7").Value = Avail
          Worksheets("OEE").Range("J7").Value = Efficiency
          Worksheets("OEE").Range("K7").Value = Quality
          Worksheets("OEE").Range("L7").Value = Avail * Efficiency * Quality
        Case 3
          Worksheets("OEE").Range("O7").Value = Avail
          Worksheets("OEE").Range("P7").Value = Efficiency
          Worksheets("OEE").Range("Q7").Value = Quality
          Worksheets("OEE").Range("R7").Value = Avail * Efficiency * Quality
        Case 4
          Worksheets("OEE").Range("U7").Value = Avail
          Worksheets("OEE").Range("V7").Value = Efficiency
          Worksheets("OEE").Range("W7").Value = Quality
          Worksheets("OEE").Range("X7").Value = Avail * Efficiency * Quality
      End Select
    Next Machine
End Select
Next Day
End Sub
```

Appendix B

http://www.thefabricator.com/article/shopmanagement/automating-oee-for-the-job-shop

Figure 1: Screenshot of Online Comment Posted by the Group