Offloading Mobile App Components to Conserve Constrictive Mobile Resources

By

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Declarations

I hereby certify that this material, which I now submit for assessment

of the programme of study leading to the award of Master of Science in Web Technologies is entirely my own work and has not been taken

from the work of others save and to the extent that such work has been citied and acknowledged within the text of my work.

Signed: .....

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Student Number:

Abstract

This dissertation aims to answer the question - Under what resource is it energy efficient to migrate a partition from an application to remote device or to run the application locally? This aim was achieved by combining a close examination of the relevant literature and developing an application to test.

Chapter 2 reviews the relevant academic articles and papers on partitioning mobile applications, and mobile client architecture. This background helped develop an understanding of up-to-date knowledge in this area. It also provided a solid research foundation to base this dissertation on.

Chapter 3 sets out the available research methods and justifies the research methods selected to answer this research question. Also this chapter outlines of the experiments carried out to answer the research question.

Chapter 4 lays out the architecture design of the application to be built to help answer the research question. The application to be built will be capable of running a computation either locally on a mobile device or availing of a remote instance hosted on Microsoft Azure.

Chapter 5 describes in detail the type of experiments outlined in chapter 3. The devices environment, and software tools are also discussed.

Chapter 6 sets out the experiment environment, as well as their results. The results are displayed in comparison charts and tables. The findings are discussed at the end of the chapter.

Chapter 7 concludes with the answer to the research question based on the findings at the end of chapter 6. This chapter also discusses future work based on the findings of this dissertation.

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Chapter 1 – Introduction

Mobile technology has advanced rapidly in the last few years. However due to the size of mobile devices, they have constricted resources, battery power in particular. One possible solution to save the mobile device's battery power is to offload components from a mobile application to a remote node. Unfortunately, a possible side effect is that the energy required could be greater to offload application components than actually using the device's local resources. The aim of this dissertation is to answer the question - Under what resource is it energy efficient to migrate a partition from an application to remote device or to run the application locally? It would be hoped by achieving this aim that a cost efficient formula could be found and potentially used in an application.

The research was set out in the following manner. Firstly, in chapter 2, relevant academic papers and articles were reviewed and discussed in order to provide a strong foundation for this dissertation. Chapter 2 reviews four paper on offloading mobile application components. Each paper reviewed is discussed in separate sections. The chapter also reviews the different types of mobile application client architectures. The chapter then surmises which direction to take the research based on the background review.

Chapter 3, entitled Research Methodologies, reviews the different types of research methods that can be used. The methods discussed are Quantitative, Qualitative and Mixed Method Research. This chapter will decide which method best suits the dissertations aim. Also outlined are the experiments required to reach the dissertation's aim.

Chapter 4, Design, reviews the design of the application required to carry out the experiments. This will include the different components and software tools required to build the application.

Chapter 5, entitled Implementation, goes in to more detail regarding the experiments, outlined in chapter 3, required to complete the dissertation's aim. The chapter will discuss the devices involved in the experiments, specifications, how the experiments will be carried out and software tools required to record the results.

Chapter 6 will show how the experiment results were gathered and sets out a detailed analysis of the data. The final findings will be outlined at the end of the chapter.

Chapter 7 will conclude with the answer to the question posed, based on the final findings from chapter 6. This chapter will also discuss potential future works based on this research.

Chapter 2 – Background

A mobile application "is either written as a monolithic process, cramming all it needs to do on to the mobile device; or it is split in the traditional client server paradigm, pushing most computation to the remote server" (Princeton, Dept. of Computer Science, 2011, p181/182). Since all mobile devices (known as device/devices from hereon in) have different specifications, such as memory size or CPU power, it is hard to design an application to meet every device's specifications; some devices could handle more heavy computation (CPU cycles) than others. In theory the split would be different for these devices with higher specified CPU than others with a less powerful CPU. It would make more sense for the device to have the capability to decide what should stay and what should be hosted on a server. This would apply to the native mobile applications hosted locally on the device. Another local resource that is critical is the device's finite battery capacity. The heavier the computation being processed the more energy is consumed. As well as heavy computation, the amount of data transfer between the device and server will also have an impact on the energy consumption. This paper aims to find the 'sweet spot' or trade off point as to when and which components should be offloaded to a server to save the energy consumption of the device. The application performing this procedure must not impede on the device's constricting resources, including its battery.

The following papers, *Calling the cloud: Enabling mobile devices as interfaces,* 2009 and *A Runtime Partitioning Technique for Mobile Web Services*, 2011 discuss techniques in offloading, or automatically partitioning, components from a device, both papers objectives were to have the mobile applications obtain better response times. The techniques and algorithms involved in completing an offload were very similar as well as using middleware programing to carry out their objective. *CloneCloud: Elastic Execution between Mobile Device and Cloud*, 2011 also uses some similar techniques to the first two papers, however instead of using middleware, the papers proposal involves cloning the whole device on to a cloud platform. The offloaded components, or partition, is migrated to this platform and re-integrated back into the original device after computation has completed on the clone. The first two paper's approach will be very similar to this paper albeit with a different objective. This paper's objective will be similar to *Energy efficiency of mobile clients in cloud computing,* 2010, outlined at the end of the pervious paragraph.

2.1 Partitioning

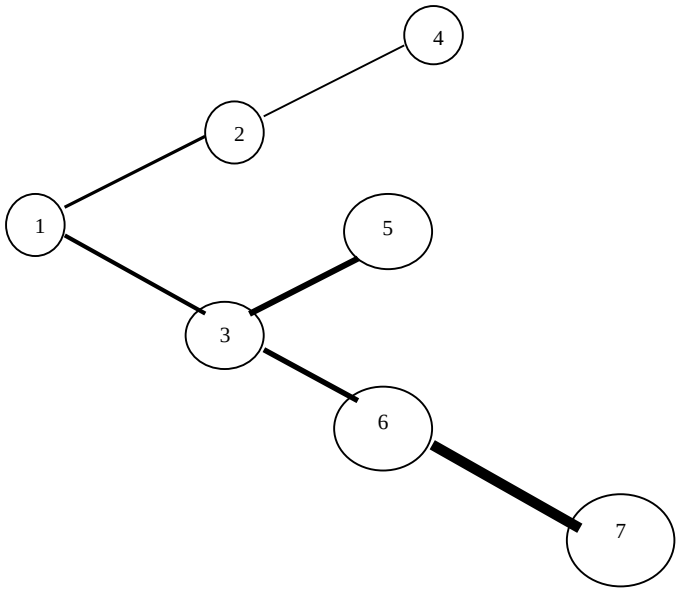
The idea of offloading parts of an application to different machines, known as partitioning of an application, is not a new technology. It is a process where components of an application are distributed across multiple machines and has been used by many companies in distributed computing for years. The advantages are distributed computing:

1. Allow Application scalability
2. Support multiple, diverse hardware/software configuration
3. Ease of maintenance
4. Object/component reuse

The second advantage applies to mobile computing, where an application can use multiple hardware and software from different machines to execute components with heavy computation.

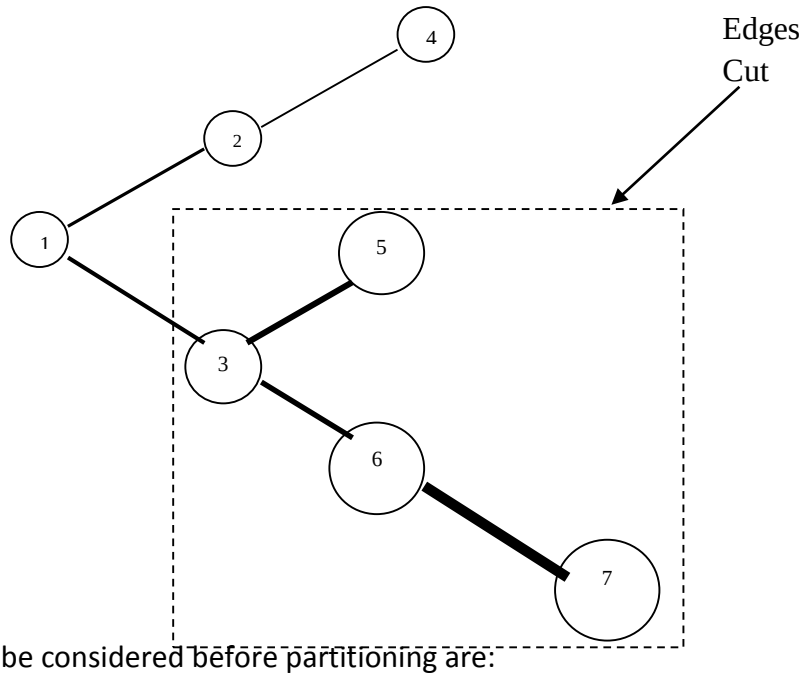
There are two types of partitioning, design-time and run-time. Design-time partitioning involves mapping all the components to be partitioned and are decided while the application is being designed. Run-time partitioning is where the components are mapped out as the application is executed (Asif, M. and Majurndar, S., 2011). Both partitioning options "use system load information and device characteristics for achieving an effective partitioned system" (Asif, M. and Majurndar, S, 2011, p82). Design-time partitioning is the easier to implement, as it will not take the device's specifications (or constraints) into consideration before execution. With this option the decision is made to offload, partition or run locally and does not deviate from this decision. Run-time partitioning involves monitoring the device and application at different times throughout the applications run-time. A partition could be offloaded if deemed necessary at any of these monitoring times. A graph based algorithm is used to decide what components are to be offloaded. A data flow graph is used to show all the components and which components communicate with other components. The graph G in figure 1 is made up of two finite sets known as Vertices (V, singularly known as a Vortex) and Edges (E, singularly known as an Edge). V represents all the components of the application while E represents the line of communications between components. All circles numbered 1 – 7 are in the set V and all the lines are in the set E

Figure 1



The heavier V the more computations this component requires. Also the weight of E indicates the amount of data transfer between components. The partitioning algorithm decides where to cut the graph depending on the situation. This is known as the "Edges Cut" (Asif, M. and Majurndar, S, 2011, p83) or "optimal cut" (Giurgiu, I., Riva, O., Juric, D., Krivulev, and Alonso, G., 2009, p2). Everything inside the cut is offloaded to the server, known as a partition, as shown in figure 2.

Figure 2



The main factors to be considered before partitioning are:

1. Communication (how much data to be transferred between components)
2. Processing (how many CPU cycles in a component are required to execute)
3. Source Vortex (first component to be executed in the application)
4. Vertex Distance (least amount of edges required to get to Source Vertex to any given vertices)
5. Graph size (maximum number of the Vertex distance in any of the Vertices from 1 - 7)

Each model proposed by each paper profiles each component before applying their partitioning algorithm. It is necessary to identify which component has the heaviest computation involved, which components are involved in the heaviest data transfer, which components starts the application computations and the size of the application. After this point each paper starts to go in different directions to achieve their objective.

2.2 *Runtime Partitioning Technique for Mobile Web Services*, 2011

Before starting into the algorithm, the middleware programing needs the following inputs;

1. Graph model G with sets of V and E (something similar to what was outlined above).
2. Number of execution plans, N_E (number of different predefined execution plans)
3. Upper Bound on Processing costs (maximum processing cost, CPU cycles, that can be offloaded) on each plan.
4. Objective function (defines the goal of the algorithm).

To calculate the Upper Bound on processing costs, first the Fixed Size step has to be calculated which is determined by the number of execution plans. The Fixed Size Step (F.S.S.) separates the Upper Bound on processing costs of two consecutive execution plans.

F.S.S. = $\sum W_v / N_E$ (where $\sum W_v$ is the sum of all the weights of V from graph G)

The Upper Bound on Processing costs (U.B.) for each plan is found as:

U.B. = k * F.S.S (where k = 1,2,3…….N_E)

The objective function must meet two conditions:

1. The difference of the processing cost of the partition (P_i) ($\sum W_v$ in P_i) and the communications cost of P_i ($\sum W_E$ in P_i) must be maximised.
2. The processing costs < Upper Bound on Processing costs of N_E.

Now that all the inputs are gathered and components profiled the algorithm begins. The algorithm gathers together a number of potential partitions and compares them to the objective function. Algorithm steps:

1. All of vertices from graph G except for the source vortex are put in to a new set Q.
2. The boundary vertices, vertices with the maximum vertex distance, are put into a new set B. (the vertices furthest from the source vortex are more suitable to offload).
3. The heaviest vortex in new set B is set as B1, the starting point in B.
4. A set of vertices starting with B1 are put in to a new set X, this is the first candidate partition ($P_{1)}$.
5. $\alpha(P_{1)} = \sum W_v$ in P_1 - $\sum W_E$ in P_1, this is the difference between the processing costs and communications in proposed partition. $\alpha(P_{1)}$ and $\sum W_v$ are added to the table of partitions (T).
6. To start the next iteration, a new set N is created. This is a set of vertices in Q but not in X but are connected to vertices in X. The vortex with the heaviest weight is the starting point and step 5 is repeated on these new vertices and the results added to T.
7. Repeat step 4 for the remaining number of vertices in Q, the results are added to T.
8. The partition the has the highest α (1st condition of objective function) and whose $\sum W_v$ is less or equal to Upper Bound on Processing costs is the most ideal partition.

2.3 *Calling the cloud: Enabling mobile devices as interfaces,* 2009

In this paper, the different types of partitioning are discussed, ALL or K – Step. ALL partitioning is essentially the same as design-time partitioning as discussed in the previous paper. K – Step is a very similar concept to run-time partitioning also discussed in the previous paper. In the proposal, Alfred-O platform is used to physically offload between the mobile and server. It is used traditionally to decompose and loosely couple Java applications in to software modules known as bundles. "AlfredO allows developers to decompose and distribute the presentation and logic tiers between the client and server side, while always keeping the data tier on the server"(Giurgiu, I., Riva, O., Juric, D., Krivulev, and Alonso, G., 2009, p3). This means this tool could be used to suit this papers proposal just as easily.

First, the bundles (B_i) are profiled under the following headings:

- Requires (Dependencies)

- Provides (Name of bundle)
- Memory (Memory consumption)
- Code (Amount of code used)
- Type (Moveable or non-moveable)

Non-moveable type bundles are the ones that involve the heaviest computation. These should always be hosted on the server never on the local device. The profiled bundles are used to create a graph G = {B,E}. Every vortex in set B is a bundle B_i and every edge in the set E represents a service dependency between B_i and B_j. Each B_i has five characteristics:

- Type: moveable or non-moveable.
- Memory: memory consumption on device for B_i.
- Code_size: size of compiled code for B_i.
- In_{ji}:data taken in by B_i from B_j.
- Out_{ij} : data send by B_i to B_j.

The objective function takes the minimum sum of the cost of data exchange, cost of fetch, install and start of bundles on device and cost of local proxies to interact with the bundles hosted on server.

Pre-Partitioning

To limit the amount of bundles the algorithm has to go through, in effect reducing the graph size without "eliminating optimal solutions" [Giurgiu, I., Riva, O., Juric, D., Krivulev, I., and Alsono, G., 2009, p1]. Bundles with high communication costs need to be found and kept on the server. Take Bundles B_i and B_j for example; if the edge between them has data $in_{ji} + out_{ij} > data_{max}$ then the bundles should be merged and become non-moveable.

ALL Partitioning

This type of partitioning is set up during the applications design stage. First the program generates a set of valid configurations of different bundles that are dependent on each other. Second it checks the bundles (k) from each configuration to make sure the meet the device constraints:

1. $\sum_{i=1}^{k} memory_i <= memory_{max}$;
2. $\sum_{i=1}^{k} code\_size_i <= code\_size_{max}$;

Lastly the remaining bundles after passing those constraints are evaluated with the objective function. The configuration that is closest to the objective function is the selected partition.

K-Step Partitioning

The ALL algorithm checks all configurations and identifies the optimal cut. K-Step algorithm reduces the configurations to find a local optimal, which is faster than but not as accurate as the ALL algorithm.
It finds the best configuration at different steps of the applications execution. It can also generate possible configurations on bundles waiting in a queue to be executed. At different steps of execution, the algorithm evaluates a new possible configuration by comparing the configuration to the objective function. If it passes the function, it will continue with new configuration but if the new proposed configuration fails, it is dropped. K could be any number from one to five so the algorithm could be one step through to a five step algorithm.

2.4 CloneCloud: Elastic Execution between Mobile Device and Cloud, 2011

The *CloneCloud* paper offers a flexible architecture solution that works out which part of the application should be off loaded (migrated) from the device and then suspends the applications operation and off loads this part (partition) to a cloned version of the device hosted on a cloud. The applications operation resumes using the clouds resources and when operation is finished the results are reintegrated back onto the user's device. "Automatically transforms' a single machine execution (e.g. computation on a smartphone) into a distributed execution" [*CloneCloud: Elastic Execution between Mobile Device and Cloud*, 2011].

The main components of the solution are:

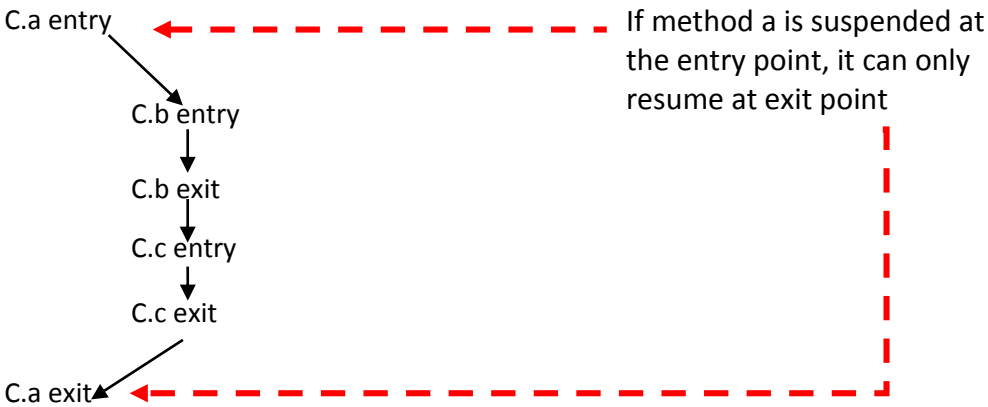
1. Static Analyser
2. Dynamic Profiler
3. Optimization Solver

Static Analyser decides where is the best place for the migration entry points and where the re-integrated exit points. In the analyser also determines the three main properties (or constraints) of a legal partition.

"PROPERTY 1 *Methods that access specific features of a machine must be pinned to the machine"* (Princeton, Dept. of Computer Science, 2011, p184). This means if a method is dependent on a local resource stored on the local device, than it must be executed on the mobile device. This is a very similar constraint to non-movable type bundles in the previous paper.

"PROPERTY 2 *Methods that share native state must be collocated at the same machine"* (Princeton, Dept. of Computer Science, 2011, p184).Some methods need to access the native state. Since the migration component does not migrate the native state, these methods must be collocated at the same machine as the native state.

"PROPERTY 3 *Prevent nested migration"* (Princeton, Dept. of Computer Science, 2011, p184).No nested suspensions or resumes allowed throughout the program. Once a program is suspended for migration, it cannot be suspended again without the program resuming. The diagram below shows a program C with methods *a*, which contains to nested methods *b* and *c*.



Dynamic Profiler collects data that will be used to create a cost model for the application under different execution settings. Cost metrics are execution time and energy consumed by the mobile device. A profile tree (similar to the graphs used in previously discussed papers) is produced. The profiler uses randomly chosen input data executed on the mobile device and cloud respectively.

Using the legal entry and exit points found in the Static Analyser and Profile trees in the Dynamic Analyser, the *Optimization Solver* picks which application methods to migrate to the cloned mobile architecture in the cloud. The chosen migration operates at the granularity of a thread. This allows a multi thread process to run on the mobile device, such as the User Interface (UI) and worker thread. The user could still use the UI as the worker thread is carrying out the partition without affecting the UI performance.

2.5 Energy efficiency of mobile clients in cloud computing, 2010

This paper looks at computation offloading whose main objective is to save battery life of the device whereas the pervious papers were more concerned about execution time and response time. A ratio relationship between the computing costs to communication costs is

used to find the balance of local computation and offloading computation. This means at some point or points in a program it is more energy efficient to use the mobile devices local resources to carry out computations. In different scenarios it is more efficient to offload computation (partition).

Another important variable to the trade off point, as well as the amount of transferred data between device and server, is the data traffic pattern. For example sending a sequence of small data pockets uses more power than sending the same data in a single burst.

Energy trade off analysis

1. Energy consumed by computation (E local)
2. Energy consumed by communication (E cloud)

For beneficial offloading E cloud < E local

D = amount of data to be transferred in bytes
C = computation requires for workload in CPU cycles
D off = measure for amount of data that can be transferred with given energy (bytes per Joule)
C off = measure for amount of computation with given energy (cycles per Joule)

E cloud = D/D off
E local = C/ C off

The relationship between computing and communication for offloading to be beneficial is
C/D > C off/D off

The paper used an energy profiler to record results from their experiments. The energy profiler was monitoring the battery usage during different scenarios of computation offloading. Different devices with different power and frequency usage were used and compared. They found that the device with the lowest power and frequency increased the computation energy efficiency (C off) of the mobile device. The energy profiler also found that the device with the highest bit rate of data traffic increased the energy efficiency of data communication (D off). This means a high burst of data traffic was more efficient than little bursts of small data packets.

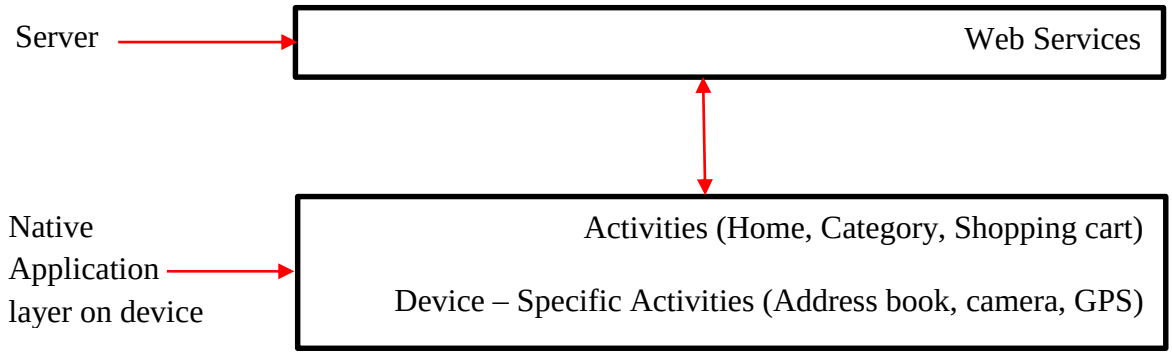
2.6 Mobile Application Architecture

There are three types of mobile application Architecture:

1. Native application architecture
2. Web application architecture
3. Hybrid application architecture

Native Application Architecture

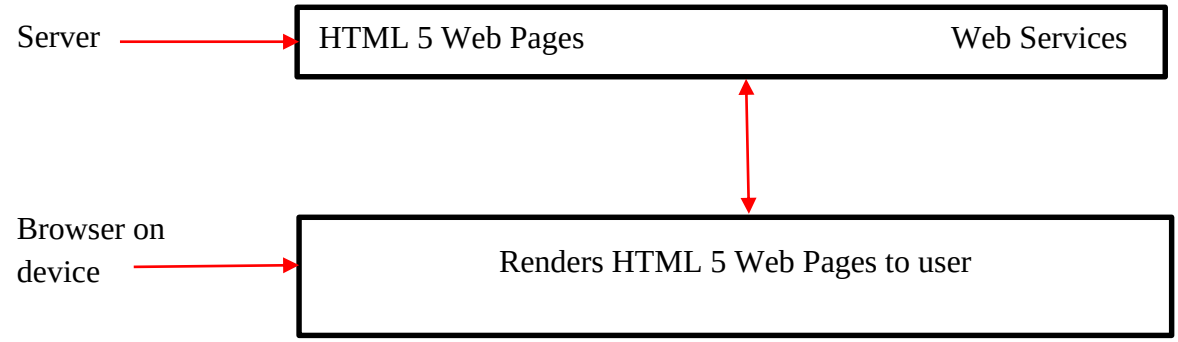
Native applications are built specially for a particular device and its operating system. They are installed onto the device from a web store, for example Google play or App store. When installed an icon is created on the home screen of the device. When the icon is clicked the application runs. A native is used where a rich experience is required by the user, when an application requires use of device features (address book, camera or GPS) or if the application is required to work offline. The native application layer is made up of activities and design specific activities. Each page in the application has its own activity, which contains code to execute onto that particular page. These activities have access to particular web service suited to the native applications functionality, i.e. what the application was designed to do. The device-specific activities are responsible for interaction with any of the device features that the native application needs to access. (Neilson Norman Group, 2012)



(Mehta, N., 2012)(IBM, 2012)

Web Application Architecture

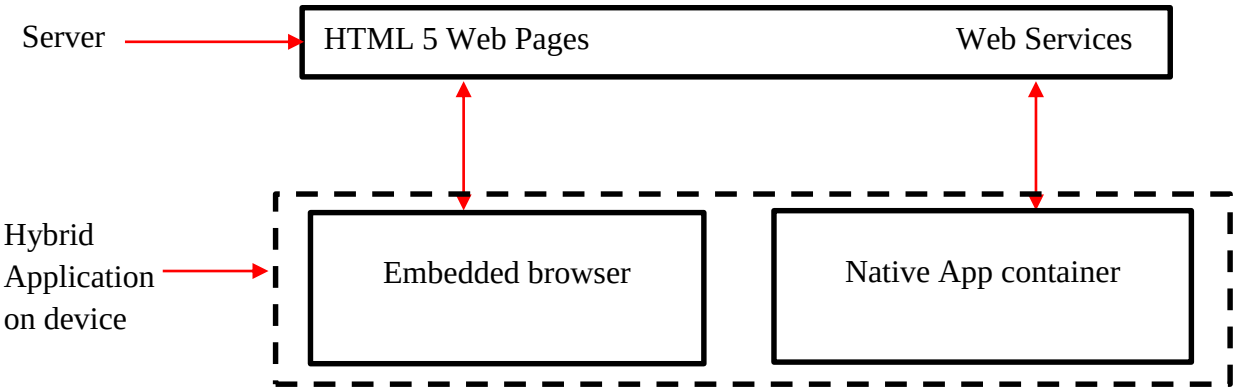
Web applications are actually not applications but websites created to give the appearance of a native application. The user is actually viewing HTML 5 web pages on a browser. The user is still able to access web services required. The 'application' is not installed onto the device. A first time user has to navigate to a particular URL through their browser. They are prompted to 'install to their device'. The icon that is installed to the device home screen is actually a bookmark to the website. As the application can be accessed through a browser, it allows the application to operate through a cross platform environment. (Neilson Norman Group, 2012)



(Mehta, N., 2012)(IBM, 2012)

Hybrid Application Architecture

Hybrid applications are a combination of a native application and web application. These applications have a native container, which allows hybrid applications to obtain native application characteristics. Like the native application, it can installed onto the device from a web store. Typically a user would not be able to tell the difference between a native and a hybrid application. The difference is the user is actually viewing is HTML rendered to a browser that is embedded into the application. This allows hybrid application to have native application features as well as being able to operate on a cross platform environment like a web application. (Neilson Norman Group, 2012)



(Mehta, N., 2012)(IBM, 2012)

2.7 Summary

The first two papers researched in this chapter were profiler CPU and memory usage to find a cost efficiency formula. This formula would migrate particular components of the application both before and during execution. The third paper groups together which components can be migrated and creates a background thread which migrates these components to a cloned device hosted in a cloud environment if it is deemed to optimize performance. These three papers are more concerned about performance optimization rather than energy optimization. However a lot of the findings can be implemented into this paper proposed application solution. For example the first three papers, *Runtime Partitioning Technique for Mobile Web Services, 2011*, *Calling the cloud: Enabling mobile devices as interfaces, 2009 and CloneCloud: Elastic Execution between Mobile Device and Cloud, 2011*, divide the components up into a group that can be migrated and another group which is dependent on the device. Similarly this paper's solution will keep the components required for user interaction on the local device, and give the business logic of the solution the option of running locally or remotely. The solution will follow the native application architecture outlined in the mobile application section. This paper will determine which one of the following options is the most energy efficient option to execute the application, much like the final paper, *Energy efficiency of mobile clients in cloud computing, 2010*.

Execution Option 1 – locally.
Execution Option 2 – remotely.

Taking these conclusions and objectives of the researched papers into account, this paper will find a cost efficiency formula by monitoring a specifically designed, computation heavy application, which will be described in detail in the next chapter. The application can be executed using options laid out above while been monitored by an energy profiler. In *Energy efficiency of mobile clients in cloud computing, 2010 paper,* it was found that there were issues with network strength particular with 3G mobile data networks. "The 3G network cases consume more energy than WLAN because of communication latencies" (Usenix, 2010, p4). As a result of this, the application will be run in different locations to test how the remote execution works in areas with high network latencies. The main metric to be monitored will be battery usage, as well as CPU load from 0% to 100% and memory (RAM) usage in Megabytes. The metrics measured will then be analysed to optimize the application to operate at an energy efficient level. The cost efficiency formula will be used to create a model which will be used in a redesigned application which will automatically decide which execution option is the most energy efficient. This cost efficiency formula will answer the question posed by this paper – Under what resource is it energy efficient to migrate a partition from an application to remote device or to run the application locally?

Chapter 3 Research Methodologies

This paper aims to answer the question posed at the end of chapter two, under what resource is it energy efficient to migrate a partition from an application to remote device or to run the application locally?
The three main research approach methods need to be reviewed to the one most suitable to answer the question posed. The three research approach methods reviewed are:

1. Quantitative Approach
2. Qualitative Approach
3. Mixed Methods Approach

3.1 Quantitative Approach

Quantitative research method is where statistical or mathematical techniques are used to measure particular variables. There are two types of variables.

1. Independent variables
2. Dependent variables

The independent variables are characteristics that have been identified to cause, influence or effect outcomes and the dependent variables are effected by the outcomes of these independent variables. Generally the strategies of inquiry are experiments and surveys designed to *"*collect data on predetermined instruments that yield statistical data*"* (Creswell, 2003, p18). Quantitative method are most commonly used in natural science research studies.

3.2 Qualitative Approach

Qualitative research method is used to gather data explaining behaviour and attitudes. Unlike Quantitative method, the data is not measurable. The main strategies of inquiry are surveys, interviews or case studies with test subjects. "The researcher collects open-ended, emerging data with primary intent of developing theme's from the data." (Creswell, 2003, p18). Surveys can be used as strategies of inquiry in Quantitative also. The difference between a Qualitative survey and a Quantitative survey is that qualitative question are designed to be open ended. Qualitative methods are most commonly used in social science studies.

3.3 Mixed Method Approach

A Mixed Method Approach is a combination of both Quantitative and Qualitative research methods. Historically, researchers would either use one approach or the other. In recent times, some questions posed by papers have led researchers to use data collected by one research method to back up data collected by the other. A Mixed Method approach would be ideal for a researcher testing the usability of a piece of software. The researcher could pick variables from the software to measure performance and also interview test subjects who have used the software. (Creswell, 2003)

3.4 Chosen Approach

After a careful review of the research methods, it has been deemed that the Quantitative approach is the most suitable to answer the question posed by the paper. To answer the question, the power used by the device to run the application locally and remotely must be recorded and compared. Data recorded from a Qualitative approach experiment would not be able to measure and therefore compare such data. There have been two dependent variables identified that would have a bearing on the power used during the experiments.

1. CPU load
2. Memory Usage

These two variables will be measured along with other dependent variable, the battery power consumed, by a power profiler. Another variable that will affect the experiments, is network coverage. The stronger the network signal, the more efficient the remote side of the application will be. The experiments will take place in various locations of different network strength. This will determine if the device uses more/less power while attempting to communicate remotely in places with weaker network signals. The device and server for instance will log how long the computation take. The device will also log how long it took from the moment the button was pressed until the moment the result appears on the device screen. These variables will also be used. The Independent variables have been identified as which mode the experiments will run. The other variables are dependent on which way the experiment will run. The Experiments will run in either of the two following modes:

1. Locally
2. Remotely

Microsoft Excel and IBM SPSS Statistics version 22 will be used to analysis the recorded data from the experiments. IBM SPSS (Statistical Package for the Social Science) Statistics Version 22 is a software package used for statistical analysis. Originally produced in 1968 by SPSS

Inc., which was acquired by IBM in 2009. The raw data will be first inputted in Excel, where it will be formatted in to a readable spreadsheet. Comparison charts will be created from the data of the spreadsheets. The new spreadsheets will be copied into SPSS where the data will be first tested for normality. A normal result will mean an Independent T-Test will be performed on the data. If the data is non-normal, a Mann-Whitney test will be performed.

Chapter 4 - Design

As specified in chapter two, a computation heavy application will be created. The application will be designed in such a way that if the user increases the input value, it will increase the parameters of the computation. This will make the application memory intensive as well as CPU intensive. The same computation will be hosted on azure and made available to the application. The computation will be a multiplication matrices program. This is where two different randomly generated sets of matrices will be multiplied together and the result will be displayed to the user. There will be an input field on the local application, allowing the user to input an integer. This integer will determine the amount of rows and columns in each matrix generated to both local and remote computation. i.e. when three is entered there will be three rows and three columns of randomly generated numbers in each set. As well as the input field, there will be three buttons and placeholder, where the result will be passed into. One button will start the local computation, simply called “Local Start”. The second button, called “Remote Start”, starts the computation hosted remotely. (IdleWorx, 2011). Finally the “Reset” button clears the placeholder, so the application is ready for the next computation. The application installed on the mobile device will be known as App1 and computation hosted on Azure will be known as ServiceApp. App1 will be used in experiments, which will be discussed in detail in a later chapter. The experiments will be monitored by an energy profiler, known as Trepn Profiler. The metrics to be measured by the profiler are battery usage (measured in % remaining), CPU load (ranging from 0% to 100%) and memory usage (measured in Kilobytes). A thorough analysis of the profiled data will lead to the implementation of an energy efficient cost efficiency formula. This cost efficiency formula will not only be used in a re-designed application, known as App2 but will also answer the question posed at the end of the last chapter.

4.1 App1 and ServiceApp Architecture

Classes for App1:

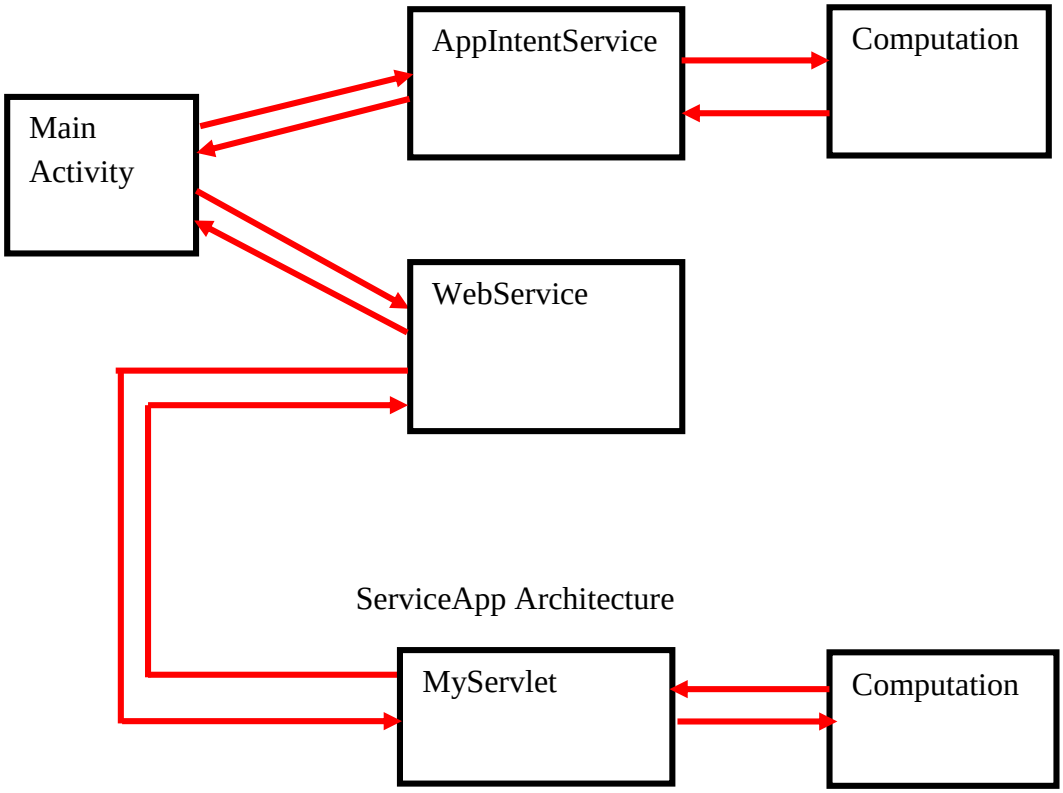
Main Activity.java
AppIntentService.java
WebService.java
Computation.java

Classes for ServiceApp:

MyServlet.java
Computation.java

See the diagram below, each block represents a class in the application, the red arrows show the direction and flow of communication between classes.

App1 Architecture



The Main Activity contains the logic for the User Interface (UI). The code initializes all the components that are on the device screen. The computation code will be located in a separate class of its own called Computation class. Both Computation classes in App1 and ServiceApp are identical. The computation method in the Computation class creates two sets of matrices. The size of each matrix is determined by the integer inputted in the Main Activity. For example, 5 will create two matrices with 5 rows and 5 columns. Both sets of matrices will contain random numbers. The two random generated matrices will then be multiplied together and the method returns the result. The Computation class also contains a method to format how the result will be shown on the screen. (Programming Simplified, 2015).

The reason why the computation code is not run on the Main Activity is because this class uses the UI or main thread. If code that requires high CPU load or high memory usage runs in this thread, the mobile device would hang or crash. All classes that contain such code are run on a background threads. These background threads are created by services such as Asynctask

or IntentService. IntentService class are designed to handle large amounts of data and are therefore better suited to implement in App1 than Aysnctask. In App1, there are two IntentServices called AppIntentService and WebService. The Main Activity will start both of these services. (Haseman, 2011).

The AppIntentService class contains the logic to create a background thread which will execute the local computation class and send the result back to the Main Activity. The integer inputted into the Main Activity is sent to this service, which in turn passes the integer into the computation class as a parameter which determines the size of the randomly generated matrices. The AppIntentService service uses a Local Broadcast Manager method to send the result to the Main Activity. (Haseman, 2011).

The WebService class logic is responsible for sending the inputted integer, received from the Main Activity, as query string to the ServiceApp Application. The service opens a HTTP connection to the servlet. The servlet runs computation class that is hosted on the same platform and returns the result using its HTTP get method. The servlet is also responsible for getting the parameter sent via query string and passing it through to the Computation class. The WebService uses a bufferedReader method to get the result from the servlet. A Local Broadcast Manager method similar to AppIntentService is used to post the result to the Main Activity. (The Open Tutorials, 2012).

A Broadcast receiver is an Android application component that responds to system wide broadcasts. They're are generally used to communicate between services on a device. However since they're broadcast globally through the system, they're are not suitable to be used to communicate between services in the same application. Also they are only designed for the minimal amount of work. Local Broadcast Manager is a helper class that is designed to work within an application and is more efficient. Two different receivers are registered on the Main Activity, one listens for a broadcast from AppIntentService while the second receiver listens out for the WebService. Depending on which service has been used, the corresponding receiver will display the result on Main Activity. (Developer. Android, 2015).

Another important part of the application is the AndroidManifest file. This is an xml based file that contains several types of important information that control the environment. It contains the Operating System version and SDK level the application is designed to run on. All activities and services must be registered in this file. The AndroidManifest also contains all the permission rules. For example, the remote side of the application needs to communicate with the servlet. So there is a permissions rule that allows the application access to the internet. Also the intents and intent filters required for the services to work are also registered.
(IBM, 2012).

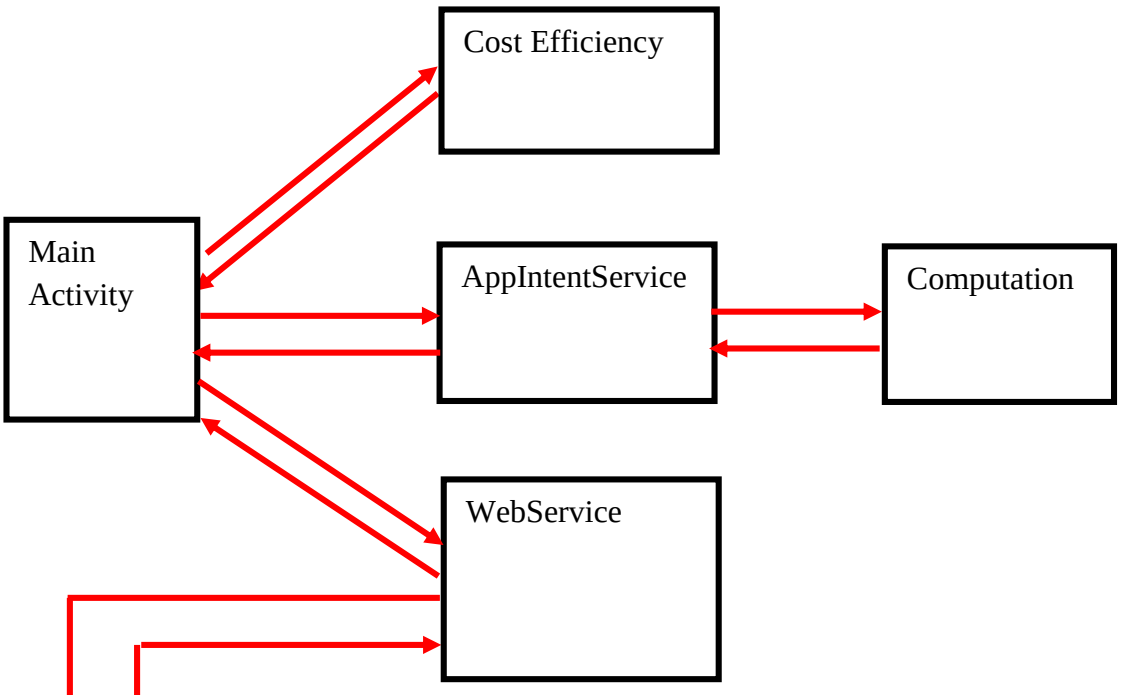
4.2 App2 Architecture

After the data from experiments with App1 and ServiceApp has been analysed, a cost efficiency formula will be calculated. This formula will be used in a redesigned application called App2. In this application there will be two buttons on screen instead of three. The "Reset" button will remain the same, but a new button will be introduced instead of "Local Start" and "Remote Start". This will be simply called "Start" and will activate a new IntentService called CostEfficiency.java.

The CostEfficiency service will contain the logic for running the formula in background thread. The service will also contain logic which will return the battery usage, CPU load and memory usage which will be needed to complete formula. The result will be posted back to the Main Activity. This result will determine which computation should be run.

Diagram of App2 and ServiceApp architecture showing classes and how the classes communicate below.

App2 Architecture



ServiceApp Architecture

There are two log files created and are hosted on Logentries.com. One log file, called HTCDetails, is for the App1 on mobile device and the second one, AzureDetails, is for ServiceApp hosted on Azure. Both Services contain timestamps, one at the start and one at the end. There is also a timestamp before and after both the local and remote Computation classes are executed. Using these timestamps, the time taken to carry out the computations and each service can be calculated. At the end of each service, a time stamped message is send to HTCDetail log. This message contains the parameter used, how long the computation took (in Nano Seconds and Milli Seconds) and how long the service took (in Milli Seconds and Seconds). The Servlet class on ServiceApp takes the timestamps before and after the remote computation. After the time taken is calculated, a message is sent to AzureDetails with the calculated time in Nano Seconds and Milli Seconds. There had to be two different logs as two different devices can send data to the same log. Each device has a unique token which allows it to communicate with a particular log. Hosting the log files on a 3rd party website, frees up valuable storage space on the mobile device. The logs can be downloaded from logentries dashboard in csv text file. The timings will be used in conjunction with metrics recorded by the Trepn Profiler to find the cost formula. The logs will also give the start time of each run, so they can be pinpointed on the csv files produced by the Trepn Profiler. (logentries, 2015)

4.4 Eclipse Luna

The IDE (Integrated Development Environment) to be used for creating both App1 and ServiceApp is Eclipse Luna version 4.4.2. Eclipse was first developed by IBM in the late 1990's. All versions of eclipse since 3.0 have been developed solely by the non-profit Eclipse Foundation. Eclipse platform is mostly written in Java but can used to create applications with different languages using different plugins. To create an environment to build the Android application, an ADT plugin needs to be installed. There also need to be an environment to create the servlet ServiceApp, which is created by the Eclipse Web Platform Tools plugin.

Eclipse platform also contains an Azure plugin. This allows applications designed in Eclipse to be deployed to Azure platform. (Eclipse Foundation, 2015)

Chapter 5 Implementation

The application that has been built using the architectural design detailed in chapter four will be used to conduct experiments. These experiments have been developed in order to collect data which will be used to find the cost efficiency and answer the question posed in chapter two. The experiments will start off with low memory usage and CPU computations and increase the memory usage and CPU computations. During the experiments, three variables will be measured.

1. Battery Usage (percentage remaining)
2. Normalized CPU Usage (load will be represented by a percentage)
3. Memory Usage (in Kilo Bytes)

Normalized CPU load is where the figure recorded is a ratio of the maximum possible load of the CPU. Standard load would record ratio of the load of the allocated to the application. An outside variable of these experiments is the strength of the network coverage. The experiment will be conducted in different locations with different network strength. This chapter will outline specifications of the mobile and remote devices, the different tools used to measure the variables and how the experiments were developed.

5.1 Device Specifications

The mobile device used in this experiment is a HTC One Mini M8. The specifications are as follows:

Operating System: Android OS Version 4.4.2.
Chipset: Qualcomm Snapdragon 400.
CPU: Dual-core 1.4.Ghz Krait 200.
Memory: 16 GB storage
1 GB RAM
Wi-Fi: Wi-Fi 802 II a/b/g/n, dual band, DLNA (GSMArena, 2015)

The Java Servlet containing the same computation class as App1 is hosted as a Cloud App on a Windows Azure Virtual Machine. The specifications are as follows:

Server: Apache Tomcat Version 7.0.6.2
CPU: A-series A1, small instance, 1 core

Note: The instance range has been set to scale up to A3, which contains 4 CPU cores. The instances or cores have set to scale up or down to keep CPU usage range between 60% and 80%.
Memory: 1.75 GB RAM
Note: If the instance A1 scales up to A3, the memory will go up to 7 GB of RAM. (Microsoft Azure, 2015)

5.2 Tools used for Experiments

5.2.1 Trepn Profiler

Trepn Profiler version 6.1 is a power and performance profiler application for mobile devices. It was developed by Qualcomm Technologies Inc. This profiler was chosen as it works best with Snapdragon chipsets, also developed by Qualcomm, which is used in the HTC One Mini. Features of the Trepn Profiler that are significant to the experiments:

- Profile device or a particular application.
- Displays battery power (in watt or amperes)
- View CPU and GPU frequency and utilization
- Display network usage (Wi-Fi and mobile data)
- Runs on Android 4.0 or higher
- Advanced mode allows the user to select data points (for example battery usage, CPU usage, memory usage) to be measure and saved for later analysis

The advanced mode is extremely useful to the experiments. The three data points (or variables) selected can be measured and saved as a csv file. Although the profiler can show battery usage in both amperes usage and wattage usage, it could not be used in the experiments. This is because the Operating System (OS) and the App1 would be running together. It would be very hard to pinpoint which one, the OS or App1, would be using the most power. The battery remaining metric would give a clearer picture as to how much energy App1 would be using. The memory and CPU metrics could also be susceptible to surges and drops from OS. A baseline experiment without App1 running should show how the OS behaves and would help explain any surges or drops found in the experiments with App1. (Qualcomm, 2015)

5.2.2 Ookla Speedtest

The Ookla Speedtest determines how good the internet coverage is at each location where the experiments take place. The application measures the time taken in milli-seconds for the device to ping the nearest server, how many bits of data can be downloaded per second and

how many bits of data can be uploadeded per second. The better the network coverage the quicker it takes to ping a server and the higher the amounts of bits of data can be uploaded and downloaded. The ping time is a measure of the latency of the network coverage. (Speedtest, 2015).

5.3 Experiment Design

The experiments will be run in two different modes.

1. Locally
2. Remotely

In both modes, the application will run in different sizes. The sizes are determined by the parameter inputted before pressing the start button. The different sizes are:

1. 50
2. 100
3. 200
4. 400

There needs to be a sample range between 30 and 100 of each size. Sample range is the amount of samples or how many times the application has been run of that particular size. The higher the size the more accurate the final data will be. There are formulas for working out a sample size, they are outside the scope of this dissertation. In this experiment the sample range will be 45, any higher would provide too much data to go through in such a short time frame for this dissertation. The application needs to be run 45 times at each size. This means the application will run 180 times firstly in mode 1 and secondly run the same amount of times in mode 2.

The Trepn profiler will record the three variables, battery, CPU and memory usage. The data will be saved into two files, one for mode 1 and another for mode 2.

To test the variable values from mode 2 in areas with low network coverage, the application will be run twice, firstly using Wi-Fi and then with 3G mobile data, in two different locations.

1. National College of Ireland
2. Celbridge, Co. Kildare

Both of these locations have varying degrees of network coverage. National College of Ireland has better coverage with mobile data but Celbridge has better Wi–Fi signal. The Ookla speedtest will record the longitude and latitude of each location as well as ping time and download and upload speeds. Mode 1 is not effected by location so it shall only be run once. Hence there will be five experiments, where the application will be run 180 times in each experiment.

The log files from logentries.com and recorded data from Trepn Profiler will be cross referenced to find the battery, CPU and memory usage for each time the application was run. The results will be inputted into the IBM SPSS Statistics for comparison results, which will be shown in the next chapter.

Chapter 6-Evaluation

Upon completion of the experiments, the log files and metric readings, of the memory, CPU load and battery remaining, needed to be downloaded and combined together for data analysis. The log files, hosted on logentries .com, contain the start time for each application was run, with the parameter used. They also contain the computation time and the service time. The computation time shows how long it took to complete the computation class while the service time shows how long each Intent Service took to complete.

The metric readings, from the Trepn Profiler, were recorded every 200 mS throughout the length of each experiment. For example, the first experiment ran for nearly two hours, so there were over 6,000,000 readings for that particular experiment alone. The timings for each of these readings needed to be compared with the start time from the log files to pick out the metric readings as the application was executed.

There were six experiments run in total. The Ookla Speedtest was used to determine the network speed at the time of each experiment. To get a baseline the mobile device was monitored without App1 running and with all non-essential applications disabled. Disabling non-essential applications meant there was no background processes downloading or uploading data from the internet. The only internet data transfer in experiments with non-essential applications disabled will be from App1. However applications such as the Android Operating System (OS) could not be disabled. As a result the memory and CPU recordings will have sudden peaks while the OS is running processes and drops while it is in idle state. All experiments started with device at full power.

6.1 Experiment environments

The network type for the first four experiments were:
Network type: UPC 25Mb Wi-Fi broadband.
While the network type for the two final experiments were:
3 Network, 3G mobile data.

Experiment 1 (Exp1): Baseline recording of the memory, normalized CPU load, and battery remaining metrics of mobile device. All non-essential applications disabled and App1 was not running.
Ping Time: 25mS
Download speed: 30.49 Mbps
Upload speed: 6.51 Mbps

Experiment 2 (Exp2): Metrics of mobile device recorded. All applications re-enabled and App1 was not running.
Ping Time: 17mS
Download speed: 20.83 Mbps
Upload speed: 7.00 Mbps

Experiment 3 (Exp3): Metrics of mobile device recorded while App1 is running local computation. All were non-essential applications disabled.
Ping Time: 17mS
Download speed: 28.75 Mbps
Upload Speed: 6.61 Mbps

Experiment 4 (Exp4): Metrics of device recorded while App1 was running computation remotely. All non-essential applications were disabled.
Ping Time: 18mS
Download Speed: 19.27 Mbps
Upload Speed: 6.27 Mbps

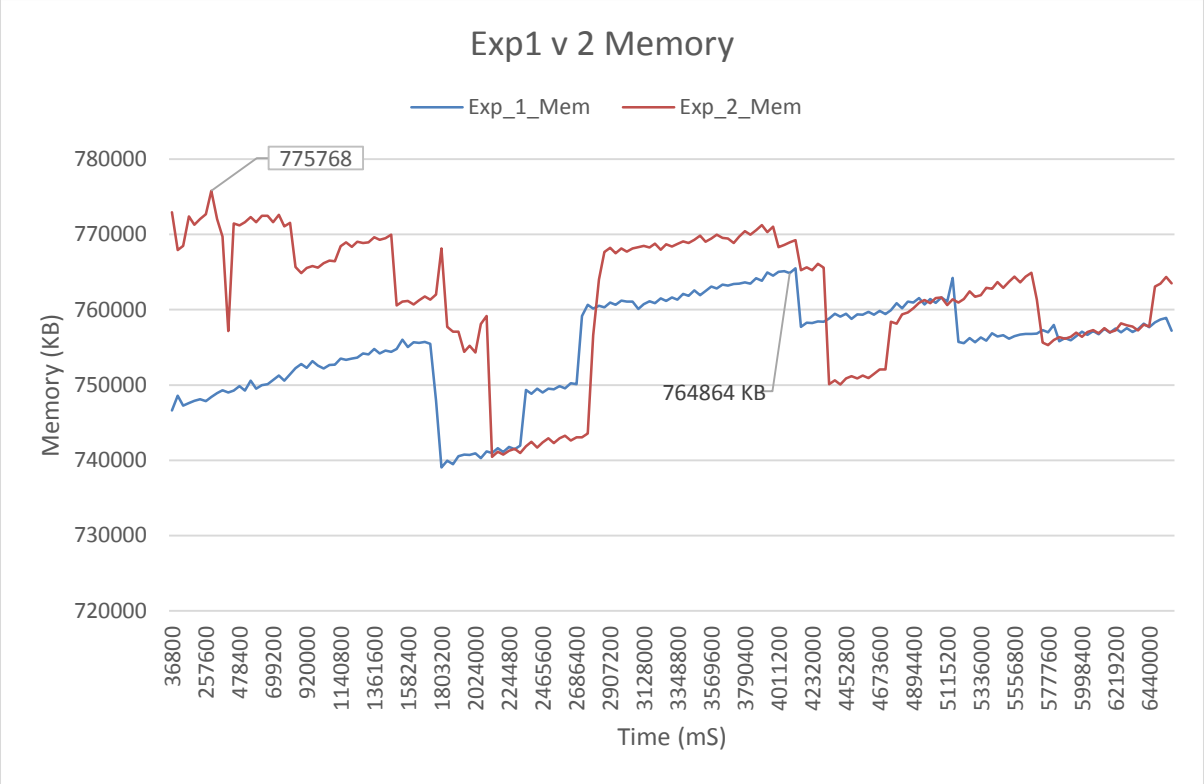
Experiment 5 (Exp5): Metrics of device recorded while App1 was running computation remotely.
All non-essential applications were disabled.
Ping Time: 68mS
Download Speed: 2.15 Mbps
Upload Speed: 1.45 Mbps

Experiment 6 (Exp6): Metrics of device while App1 was running remotely. All non-essential applications were disabled.
Ping Time: 71mS
Download Speed: 0.49 Mbps
Upload Speed: 0.13 Mbps

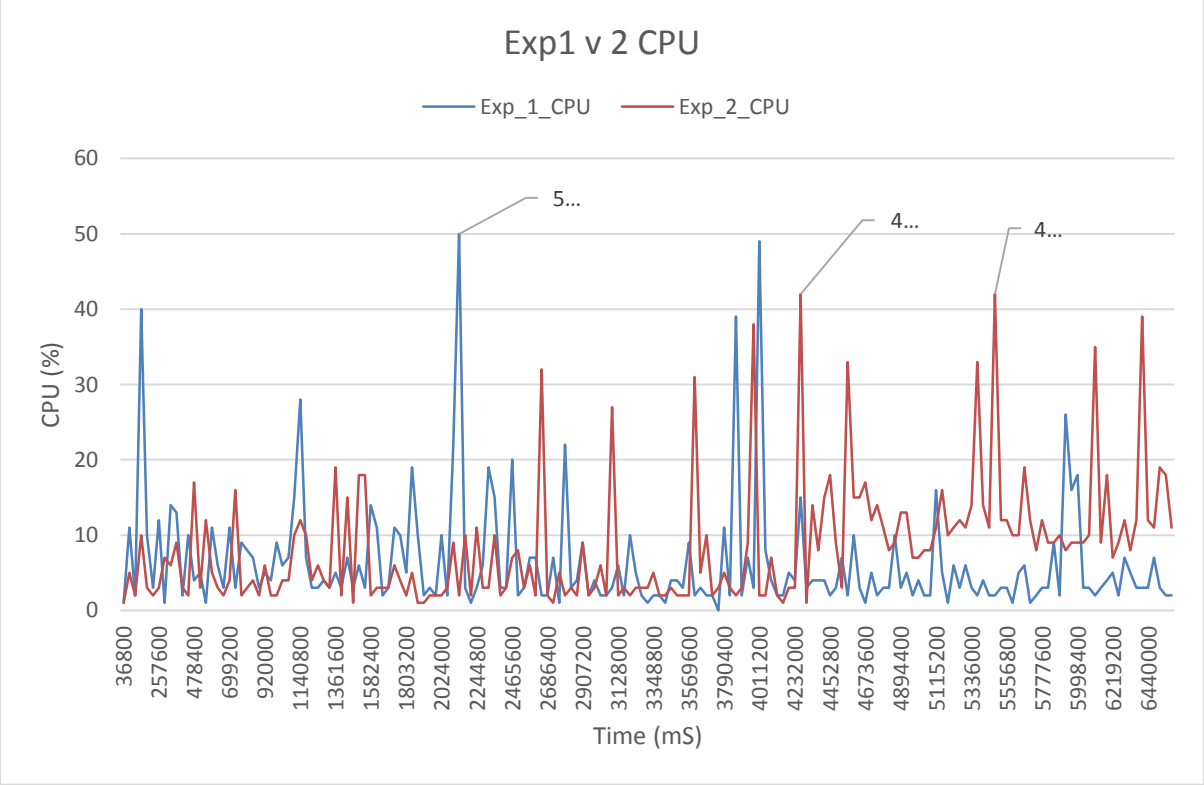
6.2 Data Analysis

6.2.1 Baseline Experiments

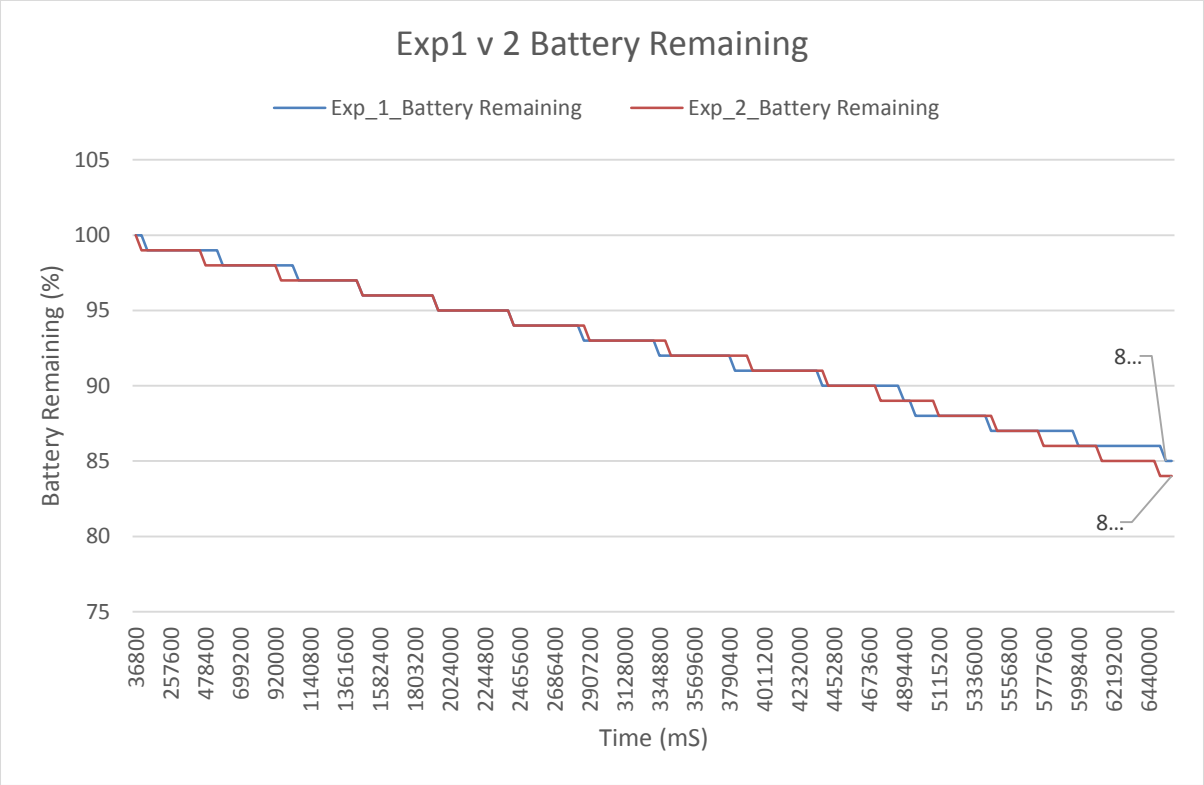
Exp1 and Exp2 were two experiments to get a baseline metric of Memory usage, Normalized CPU Usage and Battery Remaining without App1 running. Exp1 had all non-essential applications disabled while Exp2 was run while the mobile device was in normal use. The recorded data was inputted to a spreadsheet in Microsoft Excel. The following comparison charts were created using the spreadsheets.



The average Memory consumption for Exp1 is 755421.355 KB and average Memory consumption for Exp2 is 761662.622 KB as shown in Exp1 and Exp2 spreadsheets in disc attached. The maximum memory used during both experiments are labelled on the chart.



The CPU chart on the previous page has the maximum load achieved during each experiment. The average CPU load in Exp1 was 6.438% and 8.494% in Exp2.



The Battery Remaining Chart shows the minimum value remaining on both experiments. The average value for battery remaining for Exp1 was 92.45% and 92.33% in Exp2.

6.2.2 Local v Remote Experiments

IBM SPSS Statistics was used to analysis the data recorded in Exp4, Exp5, and Exp6 (which all ran remotely) compared to data recorded from Exp3 (which ran locally). Three data sets were created:

1. Exp3 v 4
2. Exp3 v 5
3. Exp3 v 6

Each row in the data set represents each time the application was run and contains seven variables.

1. Mode: the values for Mode were 1 = “locally” and 2 = “Remotely”. This variable was used to show which row in the dataset run locally or remotely.
2. Size: this was the parameter inputted to the App1 before the start button was pressed. It was used to decide the size of the computation.
3. CompTime: the CompTime shows how long it took to complete the computation.
4. TotalTime: the TotalTime represents how long it took the Intent Service on the device to complete.
5. Memory: shows the average device memory for each run in KiloBytes.
6. CPU: shows the average Normalized CPU load for each run as a percentage.
7. Battery remaining: shows how much battery power was remaining on each run.

The mode variable was determined to be the Independent or Factor variable. The other variables results were determined by which mode they ran in, locally or remotely. This would make them Dependent or Test variables. Each Dependant Variable has to be tested to see if they differ based on what mode they ran on. Each data set was also divided up based on the size variable. This means when the tests were run the output would display results divided into the sizes used. (Laerd Statistics, 2013).

The type of tests required to analysis the data sets depends on how many groups are being tested and are these groups normally distributed. In the data sets the Independent variable, Mode, is split into two values, locally and remotely. These represent the two groups to be tested.
There are two tests used for comparing two groups of data:

1. Independent Samples T-Test
2. Mann-Whitney U Test

An Independent T-Test can only be used if both groups are normally distributed. If this is not the case, then a Mann-Whitney U Test is performed. To determine if the groups are distributed normally, SPSS can explore the descriptive statistics and tests the statistics for normality. The output displays three different tables (Case Processing Summary, Descriptives, and Tests of Normality) and a histogram for each group with a curve showing the groups distribution. (Laerd Statistics, 2013).

1. **Case Processing Summary**: this table shows how many cases or sample size were tested. The cases represent how many times the application was run.
2. **Descriptives**: shows all the descriptive statistics for both distribution groups. The main statistic of interest is the mean of each group.
3. **Tests of Normality:** this table shows the statistics from normality tests. The main statistic of interest is the sig. (significance) value of the Shapiro-Wilk test from each group. If both of these values are over 0.05, than the two groups are normally distributed and T-Test can be performed. If one of the values is under 0.05, then only the Mann-Whitney U Test can be performed.

In both tests output, there are two key values, the mean for each group and sig. The mean shows the average value for each group and sig. will indicate if there is a significant difference between the two mean values. If the sig. is less, then there is a significant difference between the two groups mean value. (Laerd Statistics, 2013).

6.3 Exp3 v 4 Output Results

Memory variable tests

Normality Test for size 50

Table 1

Case Processing Summary[a]

		Cases					
		Valid		Missing		Total	
	Mode	N	Percent	N	Percent	N	Percent
Memory	Local	45	100.0%	0	0.0%	45	100.0%
	Remotely	45	100.0%	0	0.0%	45	100.0%

a. Size = 50

Table 2

Descriptives[a]

	Mode			Statistic	Std. Error
Memory	Local	Mean		754238.49	958.222
		95% Confidence Interval for Mean	Lower Bound	752307.32	
			Upper Bound	756169.66	
		5% Trimmed Mean		753858.32	
		Median		750840.00	
		Variance		41318486.76	
		Std. Deviation		6427.946	
		Minimum		748568	
		Maximum		767160	
		Range		18592	
		Interquartile Range		8058	
		Skewness		1.201	.354
		Kurtosis		-.499	.695
	Remotely	Mean		758208.00	262.833
		95% Confidence Interval for Mean	Lower Bound	757678.29	
			Upper Bound	758737.71	
		5% Trimmed Mean		757973.33	
		Median		757685.00	
		Variance		3108660.682	
		Std. Deviation		1763.139	
		Minimum		756650	
		Maximum		764514	
		Range		7864	
		Interquartile Range		1137	
		Skewness		2.275	.354
		Kurtosis		5.068	.695

a. Size = 50

The Descriptives table is shown above. The **Mean** Memory value for local group at size 50 is 754238.48 Kilo Bytes and the **Mean** Memory value for remote group at the same size is 578208.00 Kilo Bytes.

Table 3

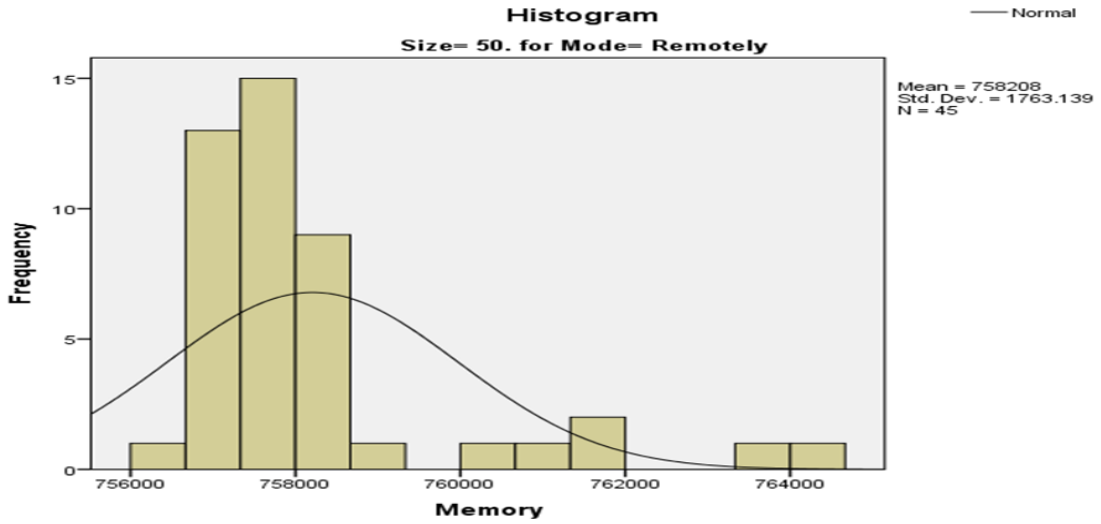
Tests of Normality[a]

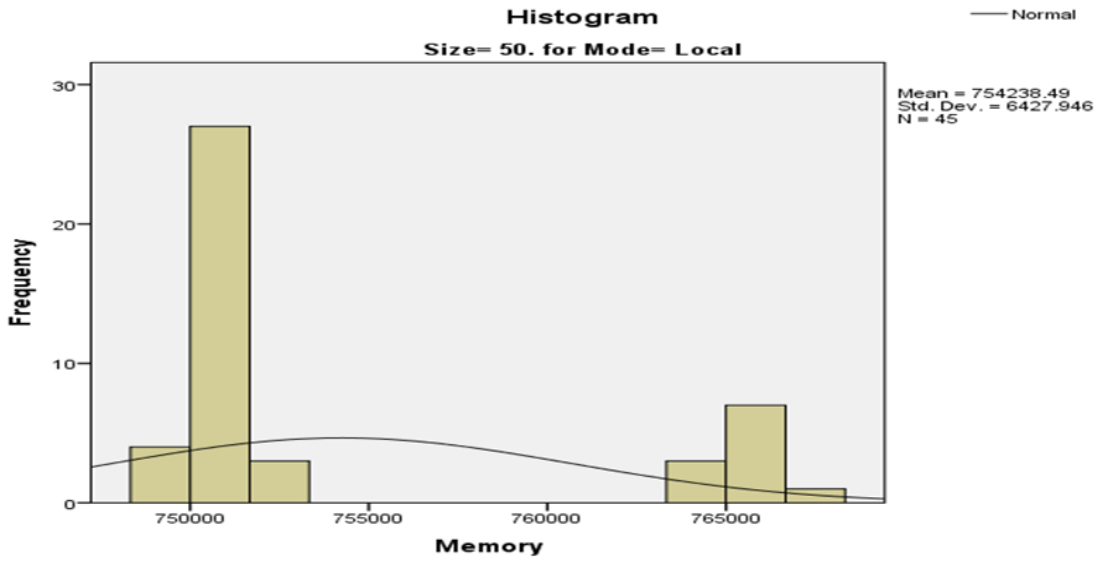
	Mode	Kolmogorov-Smirnov[b]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Memory	Local	.369	45	.000	.645	45	.000
	Remotely	.269	45	.000	.707	45	.000

a. Size = 50

b. Lilliefors Significance Correction

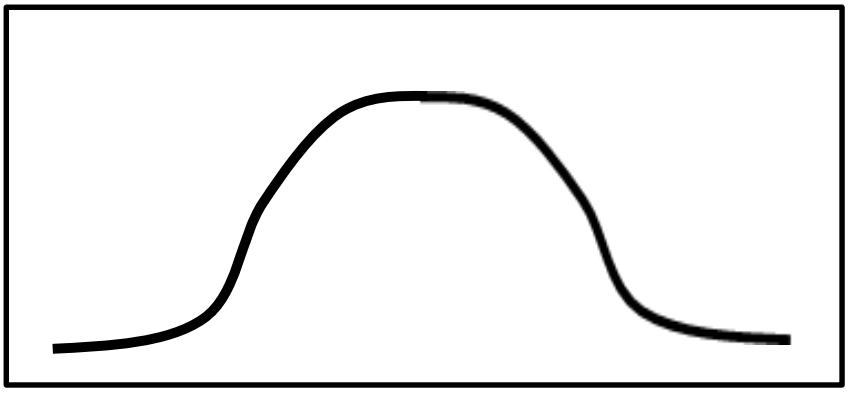
The **Sig.** value for both groups are under 0.05, which means there are non-normal and Mann-Whitney test is required. The histograms below show the distribution curve for both groups.





The distribution curve for both groups are both left of the centre of Histogram. The curve should look something like below.

Normal distribution curve example



Also to the right of the Histogram, the total mean value and the number of times the application was run is display as N

Normality Test for size 100

Table 4

Case Processing Summary[a]

		Cases					
		Valid		Missing		Total	
	Mode	N	Percent	N	Percent	N	Percent
Memory	Local	45	100.0%	0	0.0%	45	100.0%
	Remotely	44	100.0%	0	0.0%	44	100.0%

a. Size = 100

Table 5

Descriptives[a]

	Mode			Statistic	Std. Error
Memory	Local	Mean		768288.71	82.248
		95% Confidence Interval for Mean	Lower Bound	768122.95	
			Upper Bound	768454.47	
		5% Trimmed Mean		768293.28	
		Median		768148.00	
		Variance		304409.665	
		Std. Deviation		551.733	
		Minimum		767120	
		Maximum		769300	
		Range		2180	
		Interquartile Range		880	
		Skewness		.038	.354
		Kurtosis		-.795	.695
	Remotely	Mean		763024.50	190.771
		95% Confidence Interval for Mean	Lower Bound	762639.77	
			Upper Bound	763409.23	
		5% Trimmed Mean		763123.94	
		Median		763246.00	
		Variance		1601309.698	
		Std. Deviation		1265.429	
		Minimum		759092	
		Maximum		765000	
		Range		5908	
		Interquartile Range		1486	
		Skewness		-1.316	.357
		Kurtosis		2.276	.702

a. Size = 100

Table 6

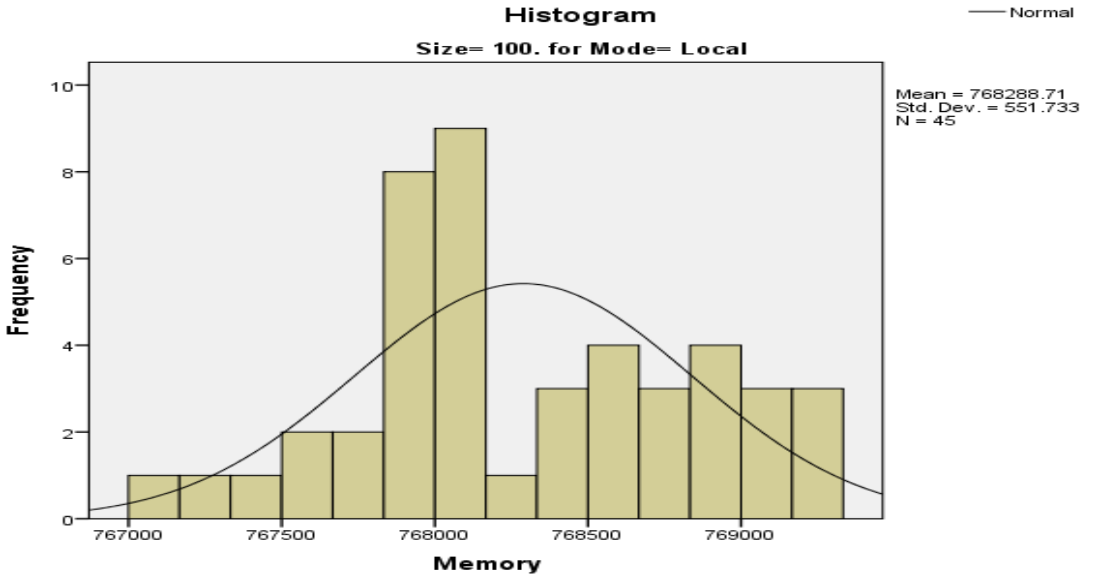
Tests of Normality[a]

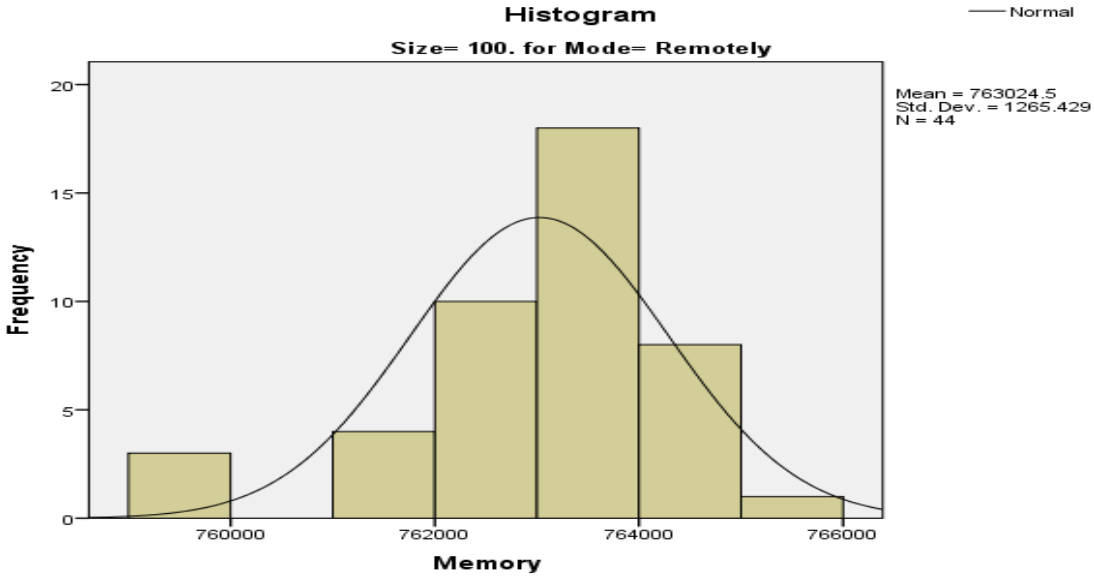
	Mode	Kolmogorov-Smirnov[b]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Memory	Local	.128	45	.061	.970	45	.301
	Remotely	.146	44	.020	.899	44	.001

a. Size = 100

b. Lilliefors Significance Correction

The **Local Mean** value is 768288.71 Kilo Bytes and the **Remote Mean** value is 763024.5. The remote **Sig.** value is under 0.05 and the Histogram for remote group also show the remote group is non-normal so a Mann-Whitney U Test will be carried out for size 100.





Normality Test for size 200

Table 7

Case Processing Summary[a]

		Cases					
		Valid		Missing		Total	
	Mode	N	Percent	N	Percent	N	Percent
Memory	Local	47	100.0%	0	0.0%	47	100.0%
	Remotely	44	100.0%	0	0.0%	44	100.0%

a. Size = 200

Table 8

Descriptives[a]

	Mode			Statistic	Std. Error
Memory	Local	Mean		765475.70	361.172
		95% Confidence Interval for Mean	Lower Bound	764748.70	
			Upper Bound	766202.70	
		5% Trimmed Mean		765682.78	
		Median		766708.00	
		Variance		6130915.866	
		Std. Deviation		2476.069	
		Minimum		755732	
		Maximum		768156	
		Range		12424	
		Interquartile Range		3732	
		Skewness		-1.529	.347
		Kurtosis		3.531	.681
	Remotely	Mean		767497.39	852.681
		95% Confidence Interval for Mean	Lower Bound	765777.79	
			Upper Bound	769216.98	
		5% Trimmed Mean		768549.10	
		Median		768315.00	
		Variance		31990850.99	
		Std. Deviation		5656.046	
		Minimum		742034	
		Maximum		771675	
		Range		29641	
		Interquartile Range		2161	
		Skewness		-4.133	.357
		Kurtosis		17.077	.702

a. Size = 200

Table 9

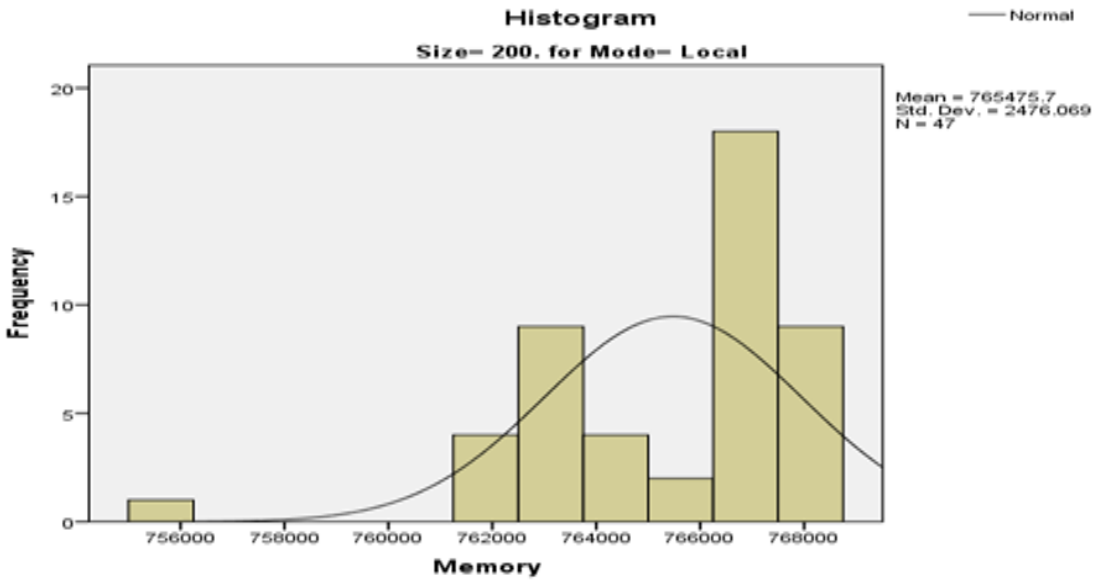
Tests of Normality[a]

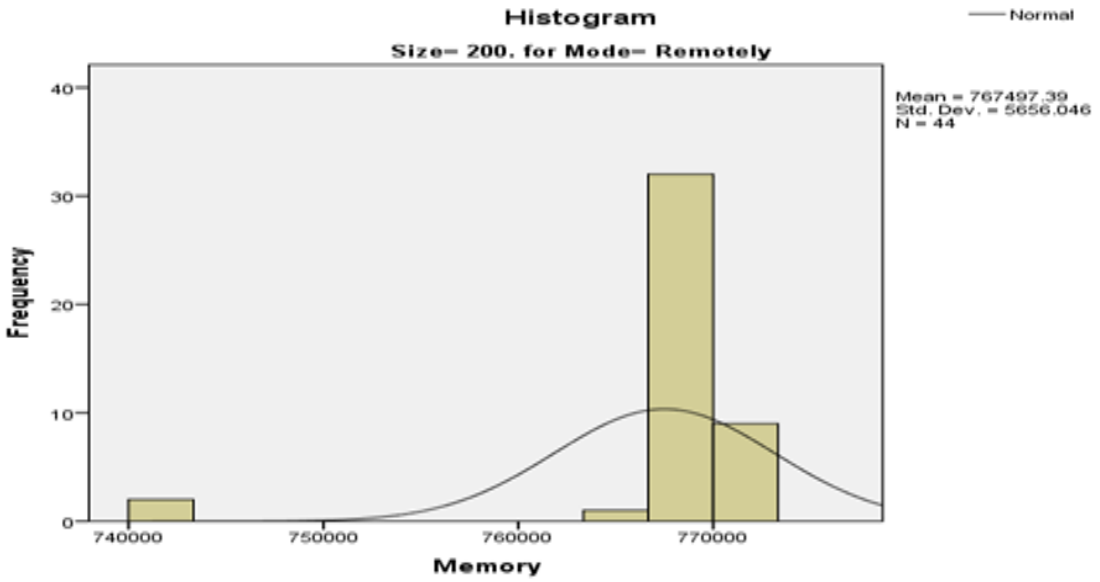
	Mode	Kolmogorov-Smirnov[b]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Memory	Local	.219	47	.000	.832	47	.000
	Remotely	.384	44	.000	.427	44	.000

a. Size = 200

b. Lilliefors Significance Correction

The **Local Mean** memory value is 765475.7 and **Remote Mean** memory value is 76747.39. Both groups **Sig.** value is under 0.05 and the Histograms show the two groups are non-normal so the Mann-Whitney test while be carried out.





Normality Tests for size 400

Table 10

Case Processing Summary[a]

		Cases					
		Valid		Missing		Total	
	Mode	N	Percent	N	Percent	N	Percent
Memory	Local	41	100.0%	0	0.0%	41	100.0%
	Remotely	45	100.0%	0	0.0%	45	100.0%

a. Size = 400

Table 11

Descriptives[a]

	Mode			Statistic	Std. Error
Memory	Local	Mean		760926.07	856.271
		95% Confidence Interval for Mean	Lower Bound	759195.48	
			Upper Bound	762656.66	
		5% Trimmed Mean		761137.67	
		Median		761414.00	
		Variance		30061201.92	
		Std. Deviation		5482.810	
		Minimum		748680	
		Maximum		768920	
		Range		20240	
		Interquartile Range		8745	
		Skewness		-.466	.369
		Kurtosis		-.469	.724
	Remotely	Mean		752902.31	699.067
		95% Confidence Interval for Mean	Lower Bound	751493.43	
			Upper Bound	754311.19	
		5% Trimmed Mean		752754.34	
		Median		751243.00	
		Variance		21991256.67	
		Std. Deviation		4689.484	
		Minimum		746048	
		Maximum		763128	
		Range		17080	
		Interquartile Range		7758	
		Skewness		.428	.354
		Kurtosis		-1.070	.695

a. Size = 400

Table 12

Tests of Normality[a]

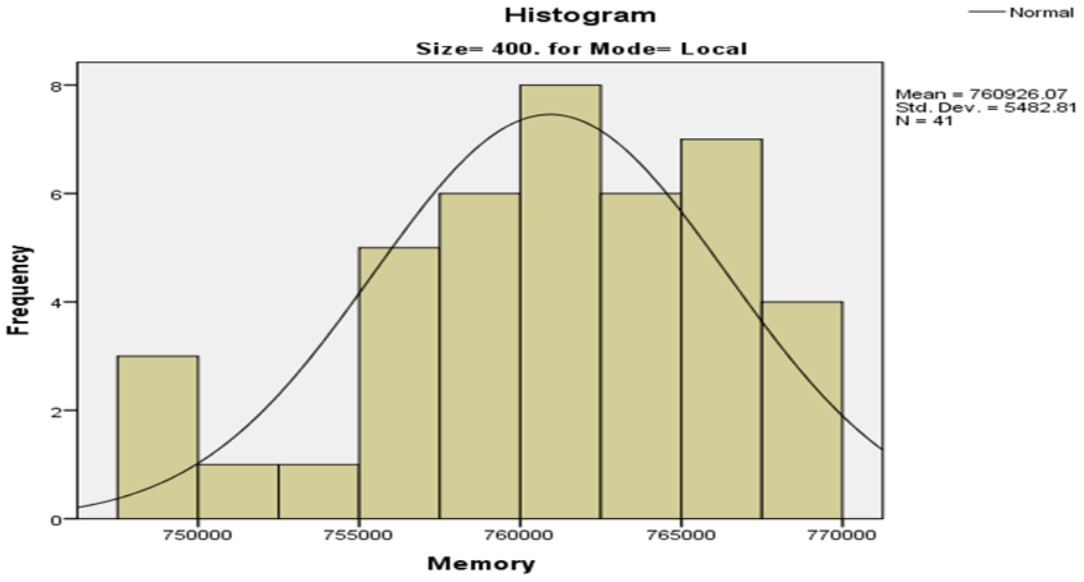
	Mode	Kolmogorov-Smirnov[b]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Memory	Local	.103	41	.200*	.946	41	.051
	Remotely	.169	45	.003	.922	45	.005

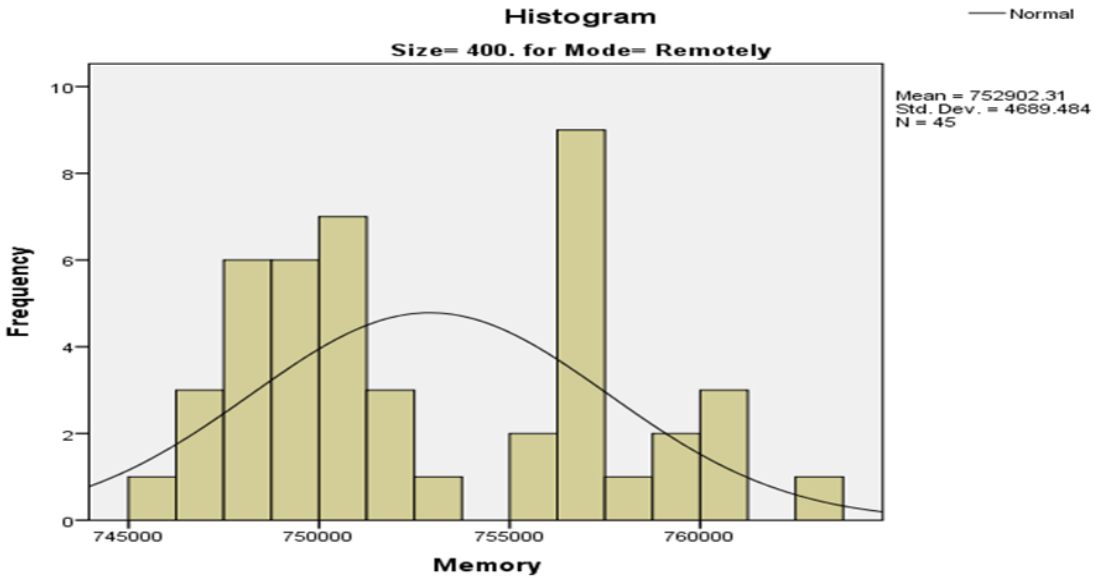
*. This is a lower bound of the true significance.

a. Size = 400

b. Lilliefors Significance Correction

The **Remote Mean** memory value is 760926.07 Kilo Bytes and **Local Mean** Memory is 752902.31 Kilo Bytes. The **Remote Sig**. value is under 0.05 and Remote Histogram show a non- normal curve. This means a Mann-Whitney test needs to be performed.





Test results for Exp3 v 4 Memory variable

Table 13

Ranks[a]

	Mode	N	Mean Rank	Sum of Ranks
Memory	Local	45	33.98	1529.00
	Remotely	45	57.02	2566.00
	Total	90		

a. Size = 50

Test Statistics[a,b]

	Memory
Mann-Whitney U	494.000
Wilcoxon W	1529.000
Z	-4.184
Asymp. Sig. (2-tailed)	.000

a. Size = 50

b. Grouping Variable: Mode

Table 14

Ranks[a]

	Mode	N	Mean Rank	Sum of Ranks
Memory	Local	45	67.00	3015.00
	Remotely	44	22.50	990.00
	Total	89		

a. Size = 100

Test Statistics[a,b]

	Memory
Mann-Whitney U	.000
Wilcoxon W	990.000
Z	-8.124
Asymp. Sig. (2-tailed)	.000

a. Size = 100

b. Grouping Variable: Mode

Table 14

Ranks[a]

	Mode	N	Mean Rank	Sum of Ranks
Memory	Local	47	29.68	1395.00
	Remotely	44	63.43	2791.00
	Total	91		

a. Size = 200

Test Statistics[a,b]

	Memory
Mann-Whitney U	267.000
Wilcoxon W	1395.000
Z	-6.091
Asymp. Sig. (2-tailed)	.000

a. Size = 200

b. Grouping Variable: Mode

Table 15

Ranks[a]

	Mode	N	Mean Rank	Sum of Ranks
Memory	Local	41	59.71	2448.00
	Remotely	45	28.73	1293.00
	Total	86		

a. Size = 400

Test Statistics[a,b]

	Memory
Mann-Whitney U	258.000
Wilcoxon W	1293.000
Z	-5.745
Asymp. Sig. (2-tailed)	.000

a. Size = 400

b. Grouping Variable: Mode

At size 50 and 200, local mode uses significantly less memory then remote mode. However at size 100 and 400, the remote mode uses significantly less memory than the local mode.

CPU Variable Tests

Normality Tests for size 50

Table 16

Case Processing Summary[a]

		Cases					
		Valid		Missing		Total	
	Mode	N	Percent	N	Percent	N	Percent
CPU	Local	45	100.0%	0	0.0%	45	100.0%
	Remotely	45	100.0%	0	0.0%	45	100.0%

a. Size = 50

Table 17

Descriptives[a]

	Mode			Statistic	Std. Error
CPU	Local	Mean		37.31	3.153
		95% Confidence Interval for Mean	Lower Bound	30.96	
			Upper Bound	43.67	
		5% Trimmed Mean		37.80	
		Median		50.00	
		Variance		447.401	
		Std. Deviation		21.152	
		Minimum		3	
		Maximum		65	
		Range		62	
		Interquartile Range		42	
		Skewness		-.543	.354
		Kurtosis		-1.407	.695
	Remotely	Mean		42.09	2.466
		95% Confidence Interval for Mean	Lower Bound	37.12	
			Upper Bound	47.06	
		5% Trimmed Mean		43.27	
		Median		50.00	
		Variance		273.583	
		Std. Deviation		16.540	
		Minimum		2	
		Maximum		60	
		Range		58	
		Interquartile Range		14	
		Skewness		-1.335	.354
		Kurtosis		.377	.695

a. Size = 50

Table 18

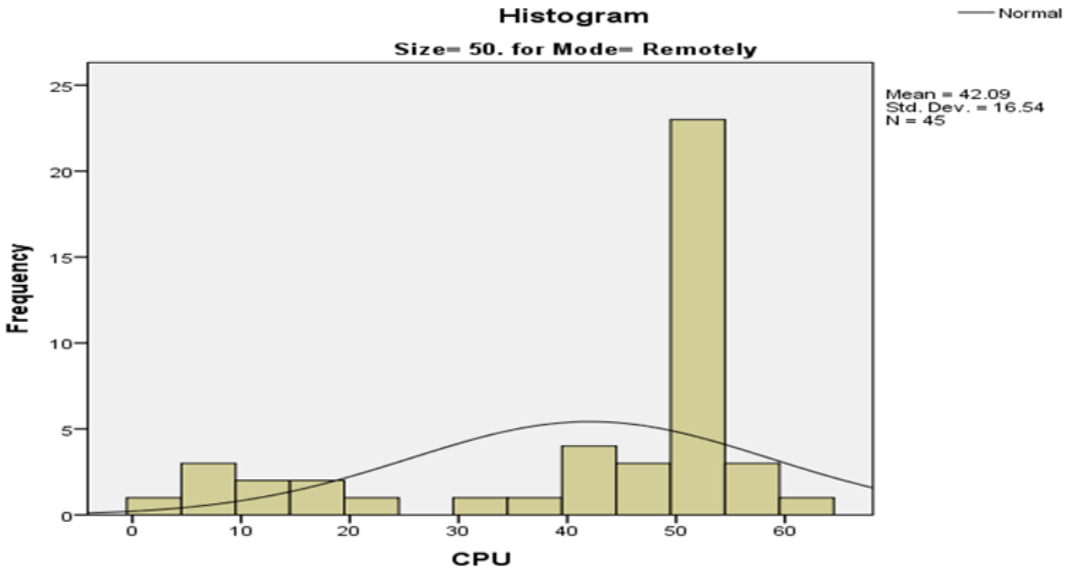
Tests of Normality[a]

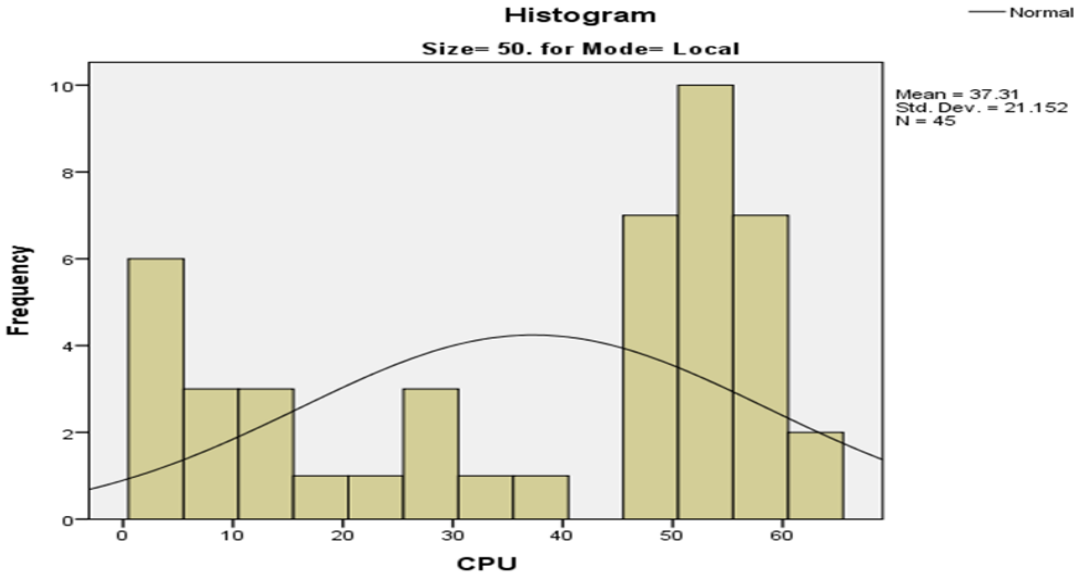
	Mode	Kolmogorov-Smirnov[b]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
CPU	Local	.259	45	.000	.836	45	.000
	Remotely	.284	45	.000	.761	45	.000

a. Size = 50

b. Lilliefors Significance Correction

The **Sig.** value for both groups are under 0.05 in the table above and the Histograms below show that the **Local Mean** was 37.31% and ran 45 times and Remote was 42.09% and ran 45 times. The distribution curves are both off to the right.





Normality tests for size 100

Table 19

Case Processing Summary[a]

		Cases					
		Valid		Missing		Total	
	Mode	N	Percent	N	Percent	N	Percent
CPU	Local	45	100.0%	0	0.0%	45	100.0%
	Remotely	44	100.0%	0	0.0%	44	100.0%

a. Size = 100

Table 20

Descriptives[a]

	Mode			Statistic	Std. Error
CPU	Local	Mean		52.69	1.262
		95% Confidence Interval for Mean	Lower Bound	50.15	
			Upper Bound	55.23	
		5% Trimmed Mean		53.61	
		Median		53.00	
		Variance		71.674	
		Std. Deviation		8.466	
		Minimum		6	
		Maximum		64	
		Range		58	
		Interquartile Range		7	
		Skewness		-3.863	.354
		Kurtosis		21.224	.695
	Remotely	Mean		50.39	1.540
		95% Confidence Interval for Mean	Lower Bound	47.28	
			Upper Bound	53.49	
		5% Trimmed Mean		52.05	
		Median		52.00	
		Variance		104.336	
		Std. Deviation		10.214	
		Minimum		5	
		Maximum		61	
		Range		56	
		Interquartile Range		5	
		Skewness		-3.453	.357
		Kurtosis		13.222	.702

a. Size = 100

Table 21

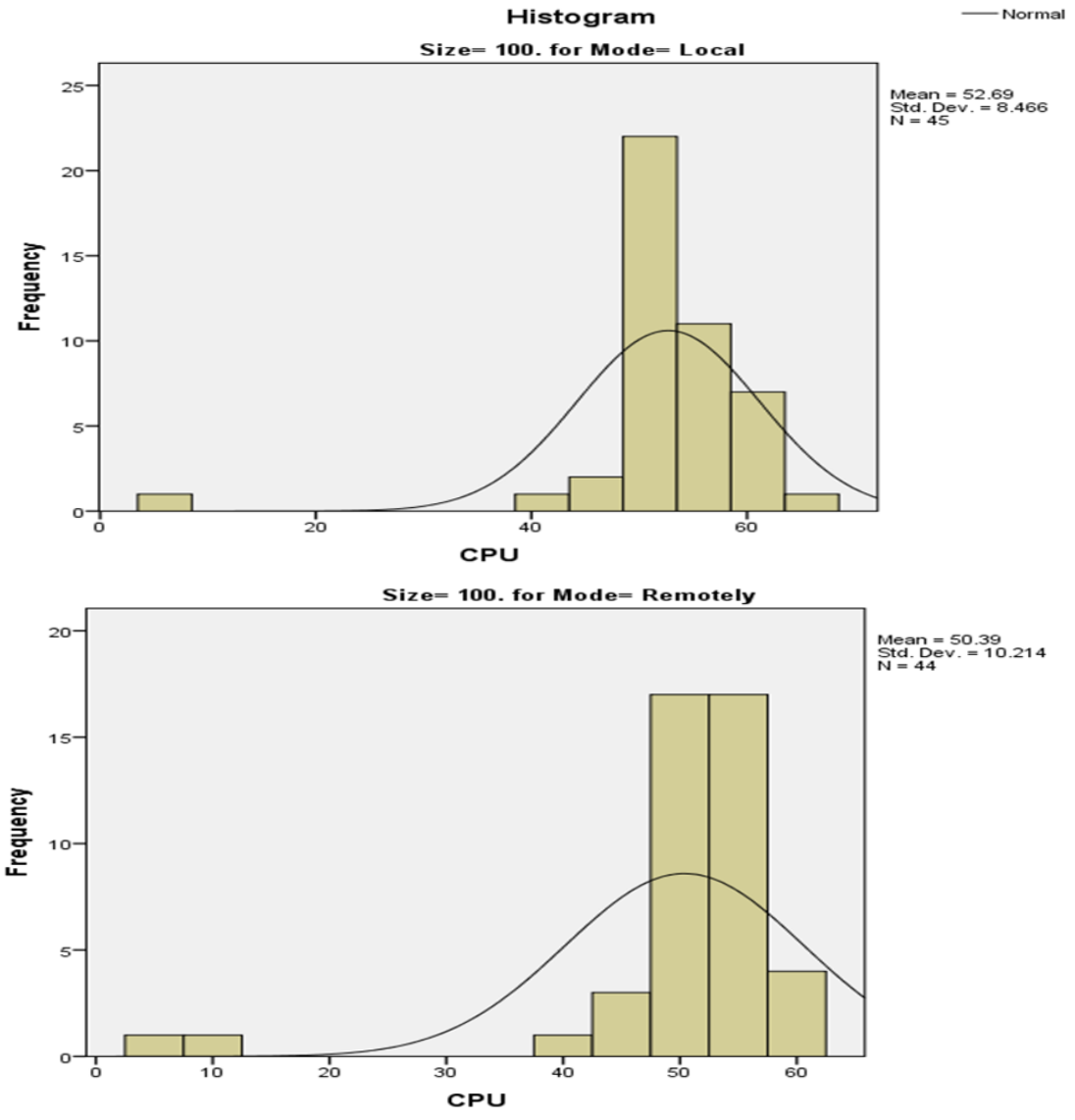
Tests of Normality[a]

	Mode	Kolmogorov-Smirnov[b]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
CPU	Local	.264	45	.000	.641	45	.000
	Remotely	.310	44	.000	.591	44	.000

a. Size = 100

b. Lilliefors Significance Correction

Both **Sig.** values are under 0.05 in the Test of Normality table above. The Histograms both show the distribution curves are also both off. The **Local Mean** is 52.69% and ran 45 times while the **Remote Mean** was 50.39% and ran 45 times.



Normality Tests for size 200

Table 22

Case Processing Summary[a]

		Cases					
		Valid		Missing		Total	
	Mode	N	Percent	N	Percent	N	Percent
CPU	Local	47	100.0%	0	0.0%	47	100.0%
	Remotely	44	100.0%	0	0.0%	44	100.0%

a. Size = 200

Table 23

Descriptives[a]

	Mode			Statistic	Std. Error
CPU	Local	Mean		52.49	.867
		95% Confidence Interval for Mean	Lower Bound	50.74	
			Upper Bound	54.23	
		5% Trimmed Mean		53.09	
		Median		53.00	
		Variance		35.342	
		Std. Deviation		5.945	
		Minimum		22	
		Maximum		61	
		Range		39	
		Interquartile Range		5	
		Skewness		-3.049	.347
		Kurtosis		14.803	.681
	Remotely	Mean		52.30	.897
		95% Confidence Interval for Mean	Lower Bound	50.49	
			Upper Bound	54.10	
		5% Trimmed Mean		53.20	
		Median		54.00	
		Variance		35.422	
		Std. Deviation		5.952	
		Minimum		18	
		Maximum		57	
		Range		39	
		Interquartile Range		4	
		Skewness		-4.727	.357
		Kurtosis		26.550	.702

a. Size = 200

Table 24

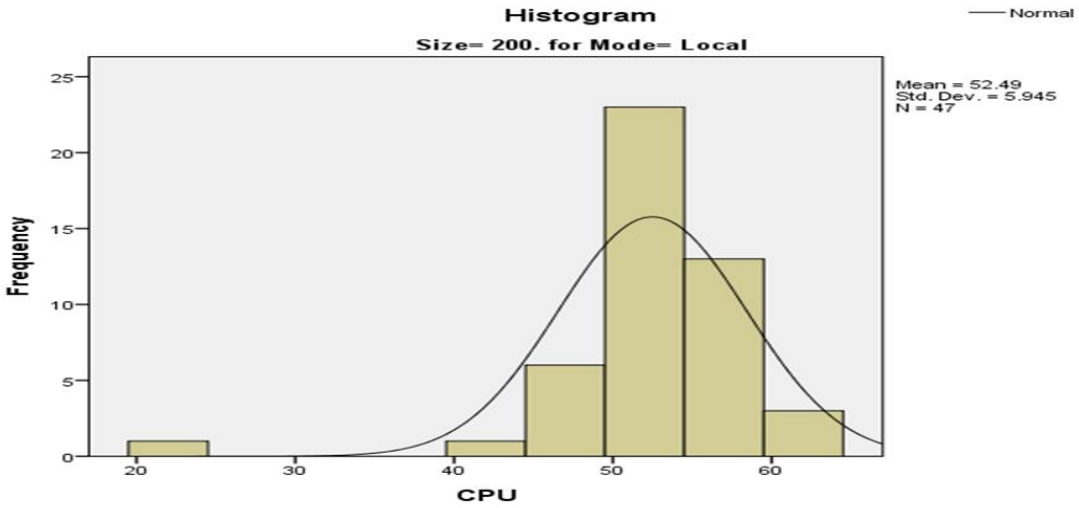
Tests of Normality[a]

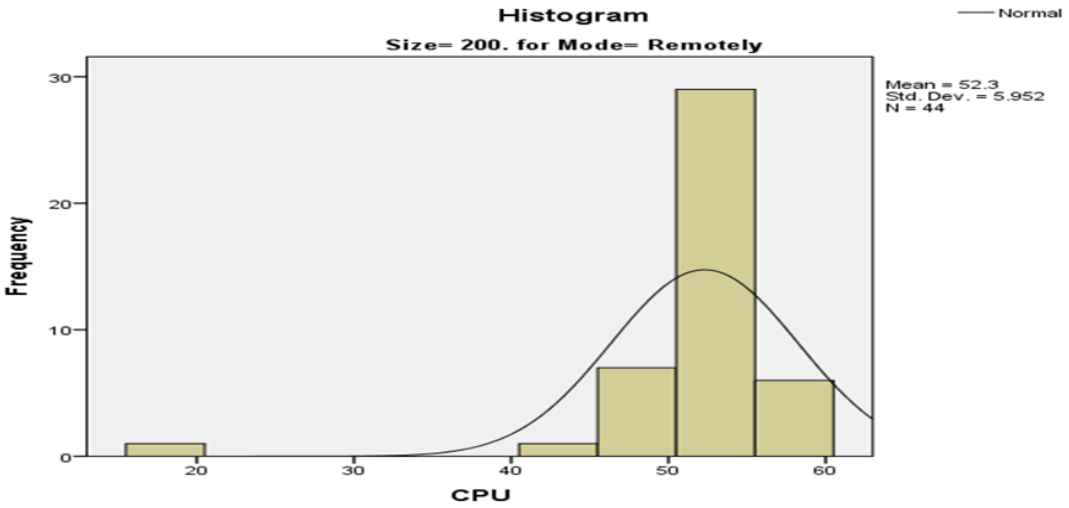
	Mode	Kolmogorov-Smirnov[b]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
CPU	Local	.194	47	.000	.735	47	.000
	Remotely	.304	44	.000	.504	44	.000

a. Size = 200

b. Lilliefors Significance Correction

The **Sig.** value for both groups are under 0.05 and distribution curves are non-normal means that a Mann-Whitney U Test needs to be carried out. The Histograms also show that the **Local Mean** value was 52.49% and The **Remote Mean** was 52.3%. The Local group was run 47 times while the Remote group was run 44 times.





Normality Tests for size 400

Table 25

Case Processing Summary[a]

		Cases					
		Valid		Missing		Total	
	Mode	N	Percent	N	Percent	N	Percent
CPU	Local	41	100.0%	0	0.0%	41	100.0%
	Remotely	45	100.0%	0	0.0%	45	100.0%

a. Size = 400

Table 26

Descriptives[a]

	Mode			Statistic	Std. Error
CPU	Local	Mean		54.12	.517
		95% Confidence Interval for Mean	Lower Bound	53.08	
			Upper Bound	55.17	
		5% Trimmed Mean		53.73	
		Median		53.00	
		Variance		10.960	
		Std. Deviation		3.311	
		Minimum		51	
		Maximum		73	
		Range		22	
		Interquartile Range		2	
		Skewness		4.803	.369
		Kurtosis		27.566	.724
	Remotely	Mean		53.09	.250
		95% Confidence Interval for Mean	Lower Bound	52.59	
			Upper Bound	53.59	
		5% Trimmed Mean		53.15	
		Median		53.00	
		Variance		2.810	
		Std. Deviation		1.676	
		Minimum		48	
		Maximum		56	
		Range		8	
		Interquartile Range		2	
		Skewness		-.752	.354
		Kurtosis		.911	.695

a. Size = 400

Table 27

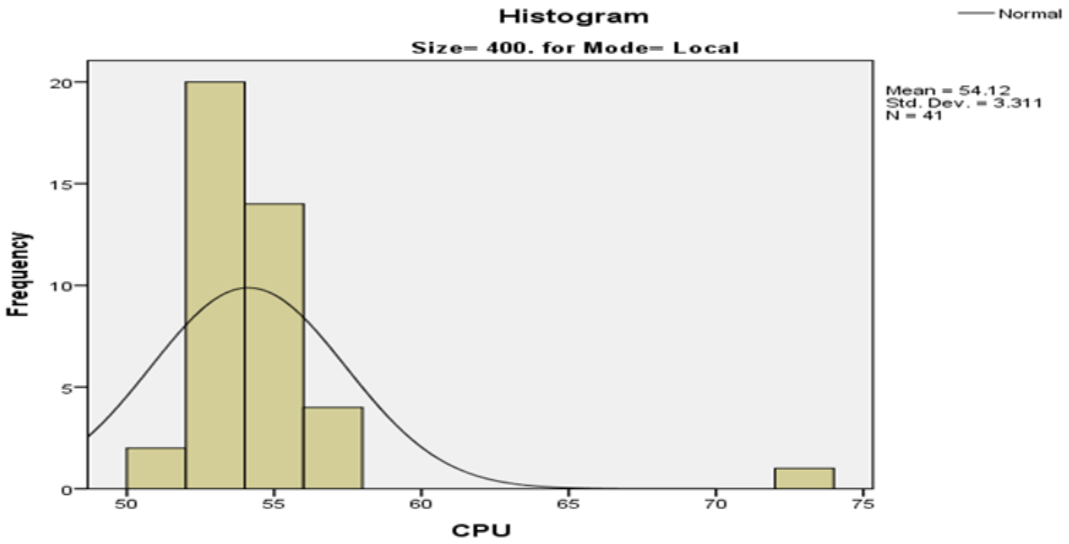
Tests of Normality[a]

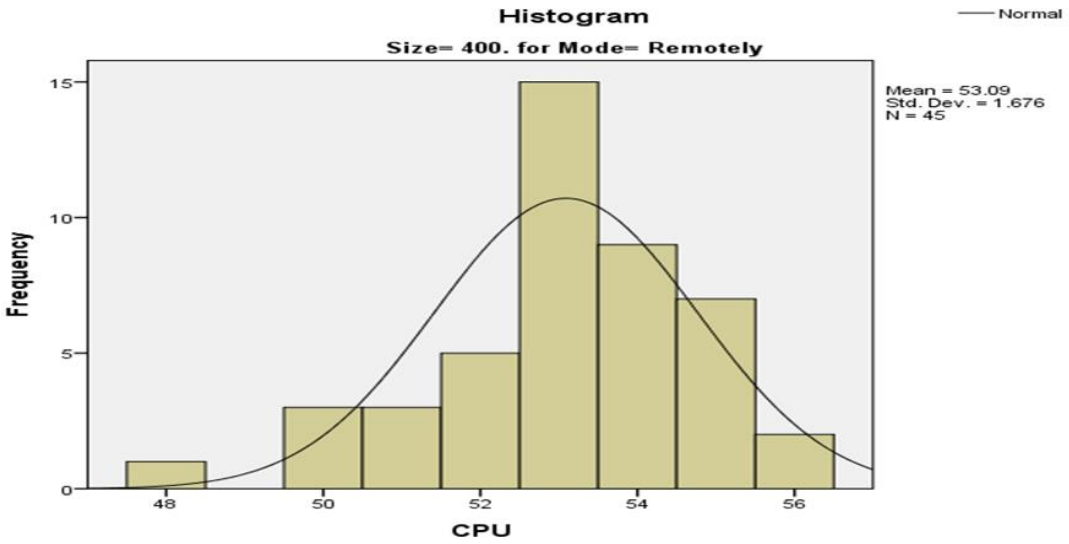
	Mode	Kolmogorov-Smirnov[b]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
CPU	Local	.273	41	.000	.504	41	.000
	Remotely	.212	45	.000	.931	45	.010

a. Size = 400

b. Lilliefors Significance Correction

The **Local Sig.** value is under 0.05 and the curve on Histogram below shows this group is non-normal which means Mann-Whitney Test has to be performed. The **Local Mean** was 54.12 and **Remote Mean** was 53.09





Test results for Exp3 v 4 CPU variable

Table 28

Ranks[a]

	Mode	N	Mean Rank	Sum of Ranks
CPU	Local	45	45.06	2027.50
	Remotely	45	45.94	2067.50
	Total	90		

a. Size = 50

Test Statistics[a,b]

	CPU
Mann-Whitney U	992.500
Wilcoxon W	2027.500
Z	-.162
Asymp. Sig. (2-tailed)	.871

a. Size = 50

b. Grouping Variable: Mode

Table 29

Ranks[a]

	Mode	N	Mean Rank	Sum of Ranks
CPU	Local	45	48.74	2193.50
	Remotely	44	41.17	1811.50
	Total	89		

a. Size = 100

Test Statistics[a,b]

	CPU
Mann-Whitney U	821.500
Wilcoxon W	1811.500
Z	-1.389
Asymp. Sig. (2-tailed)	.165

a. Size = 100

b. Grouping Variable: Mode

Table 30

Ranks[a]

	Mode	N	Mean Rank	Sum of Ranks
CPU	Local	47	45.80	2152.50
	Remotely	44	46.22	2033.50
	Total	91		

a. Size = 200

Test Statistics[a,b]

	CPU
Mann-Whitney U	1024.500
Wilcoxon W	2152.500
Z	-.076
Asymp. Sig. (2-tailed)	.940

a. Size = 200

b. Grouping Variable: Mode

Table 31

Ranks[a]

	Mode	N	Mean Rank	Sum of Ranks
CPU	Local	41	47.46	1946.00
	Remotely	45	39.89	1795.00
	Total	86		

a. Size = 400

Test Statistics[a,b]

	CPU
Mann-Whitney U	760.000
Wilcoxon W	1795.000
Z	-1.446
Asymp. Sig. (2-tailed)	.148

a. Size = 400

b. Grouping Variable: Mode

All the **Sig**. values are over 0.05. This means there is no significant difference between the device CPU loads on any of the sizes throughout this experiment.

Computation Times Variables Test

Normality Tests for size 50

Table 32

Case Processing Summary[a]

		Cases					
		Valid		Missing		Total	
	Mode	N	Percent	N	Percent	N	Percent
CompTime	Local	45	100.0%	0	0.0%	45	100.0%
	Remotely	45	100.0%	0	0.0%	45	100.0%

a. Size = 50

Table 33

Descriptives[a]

	Mode			Statistic	Std. Error
CompTime	Local	Mean		12.20000	1.319856
		95% Confidence Interval for Mean	Lower Bound	9.54000	
			Upper Bound	14.86000	
		5% Trimmed Mean		11.34568	
		Median		8.00000	
		Variance		78.391	
		Std. Deviation		8.853864	
		Minimum		4.000	
		Maximum		37.000	
		Range		33.000	
		Interquartile Range		10.000	
		Skewness		1.320	.354
		Kurtosis		.915	.695
	Remotely	Mean		.30338	.010369
		95% Confidence Interval for Mean	Lower Bound	.28249	
			Upper Bound	.32428	
		5% Trimmed Mean		.29931	
		Median		.30260	
		Variance		.005	
		Std. Deviation		.069555	
		Minimum		.206	
		Maximum		.513	
		Range		.307	
		Interquartile Range		.107	
		Skewness		.570	.354
		Kurtosis		.503	.695

a. Size = 50

Table 34

Tests of Normality[a]

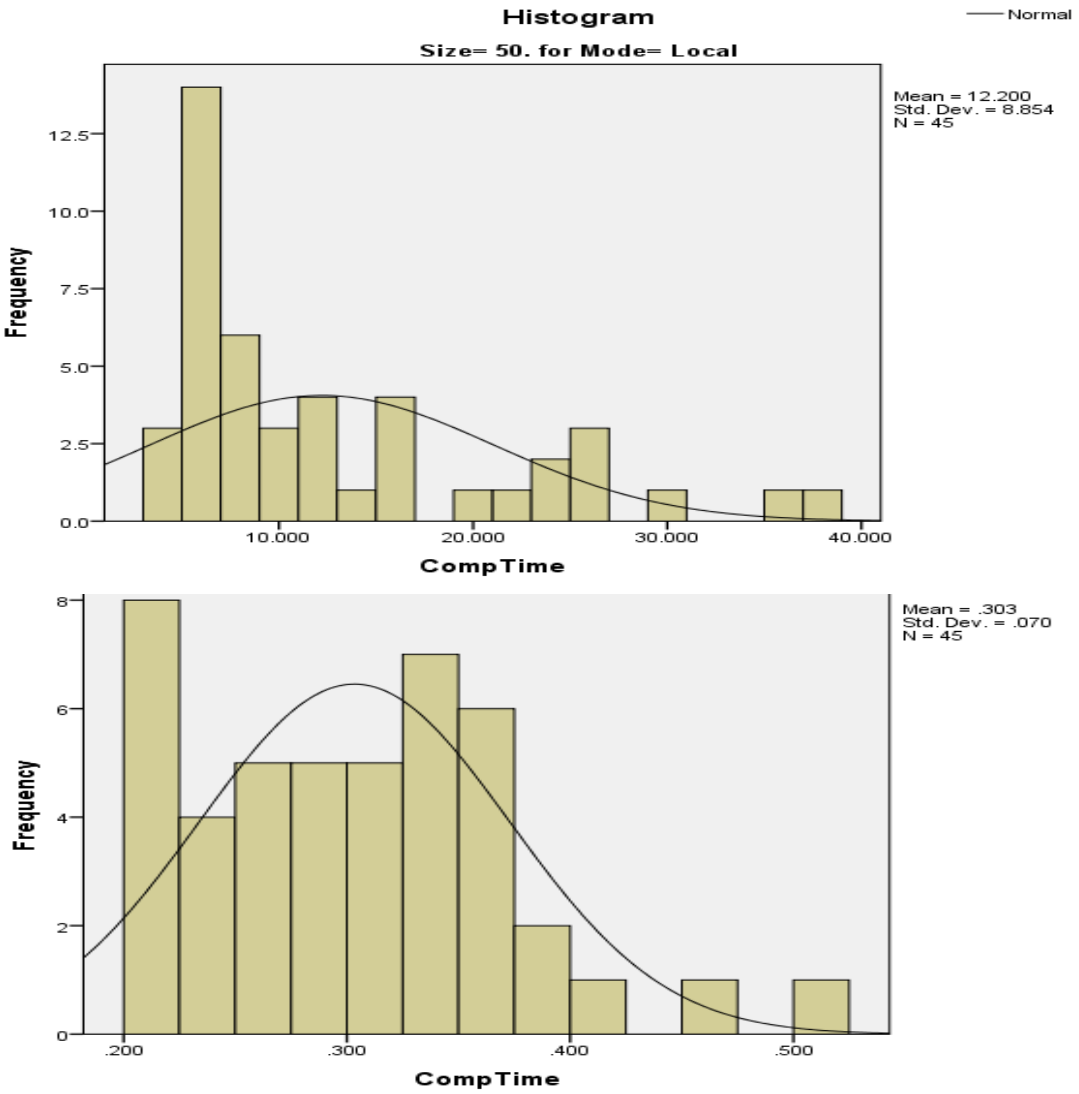
	Mode	Kolmogorov-Smirnov[b]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
CompTime	Local	.210	45	.000	.815	45	.000
	Remotely	.100	45	.200*	.943	45	.029

*. This is a lower bound of the true significance.

a. Size = 50

b. Lilliefors Significance Correction

In the Tests of Normality table above, the Local **Sig.** value is under 0.05 which means it is non-normal and only a Mann-Whitney U Test can be performed. The **Local Mean** value is 12.2 and **Remote Mean** is 0.303



Tests of Normality for size 100

Table 35

Case Processing Summary[a]

		Cases					
		Valid		Missing		Total	
	Mode	N	Percent	N	Percent	N	Percent
CompTime	Local	45	100.0%	0	0.0%	45	100.0%
	Remotely	44	100.0%	0	0.0%	44	100.0%

a. Size = 100

Table 36

Descriptives[a]

	Mode			Statistic	Std. Error
CompTime	Local	Mean		19.22222	.704164
		95% Confidence Interval for Mean	Lower Bound	17.80307	
			Upper Bound	20.64137	
		5% Trimmed Mean		18.59259	
		Median		17.00000	
		Variance		22.313	
		Std. Deviation		4.723678	
		Minimum		16.000	
		Maximum		35.000	
		Range		19.000	
		Interquartile Range		2.000	
		Skewness		2.109	.354
		Kurtosis		3.813	.695
	Remotely	Mean		1.83855	.054561
		95% Confidence Interval for Mean	Lower Bound	1.72852	
			Upper Bound	1.94858	
		5% Trimmed Mean		1.81697	
		Median		1.76625	
		Variance		.131	
		Std. Deviation		.361915	
		Minimum		1.411	
		Maximum		2.775	
		Range		1.364	
		Interquartile Range		.671	
		Skewness		.536	.357
		Kurtosis		-.428	.702

a. Size = 100

Table 37

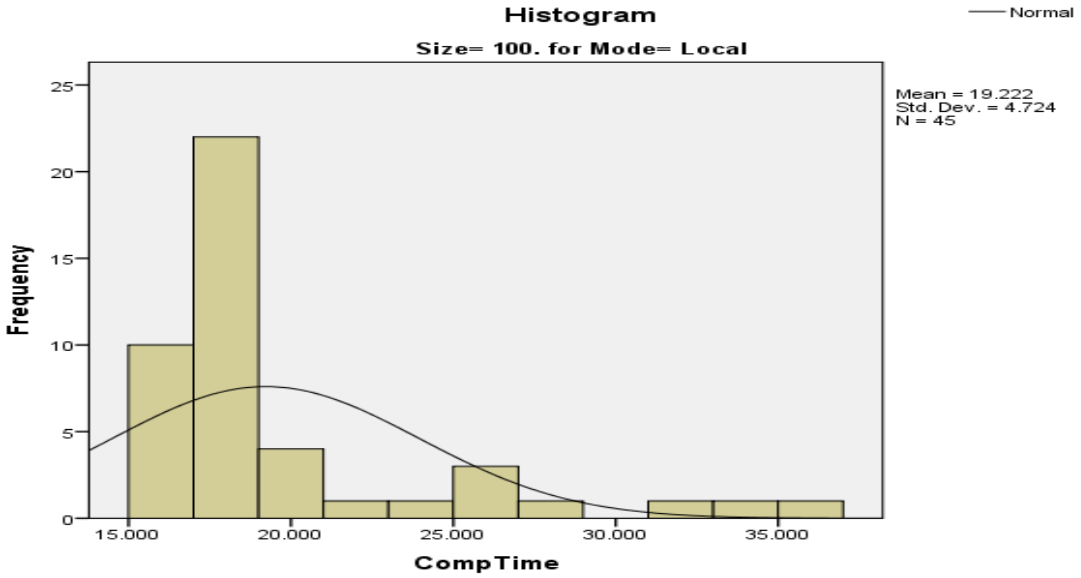
Tests of Normality[a]

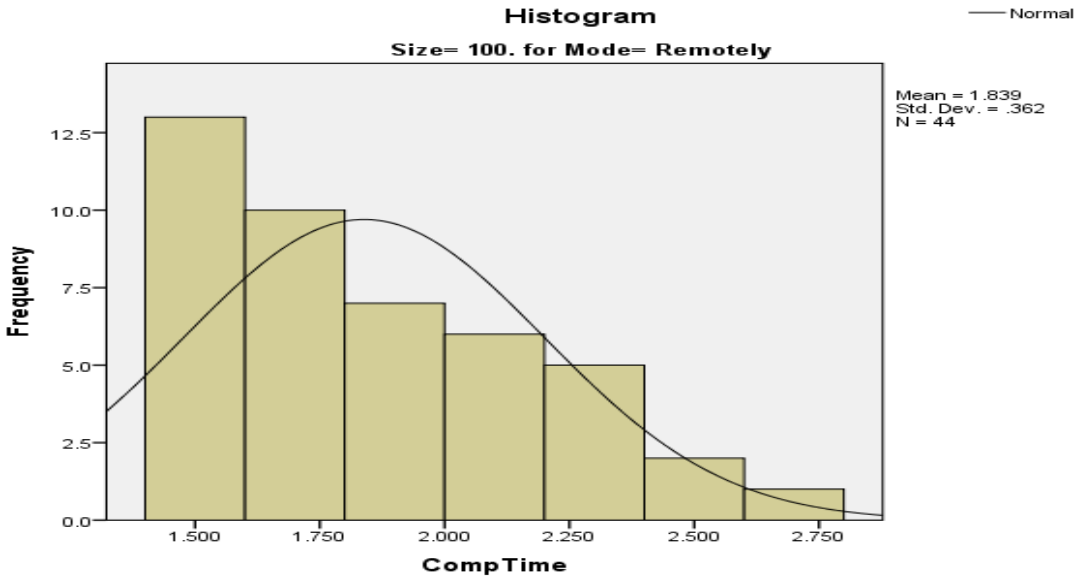
	Mode	Kolmogorov-Smirnov[b]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
CompTime	Local	.313	45	.000	.668	45	.000
	Remotely	.142	44	.026	.925	44	.007

a. Size = 100

b. Lilliefors Significance Correction

Both **Sig.** values are under 0.05. Both groups are have non-normal distribution curves in the Histograms below. The Mann-Whitney Tests will be performed as a result. The **Local Mean** value is 19.22 and **Remote Mean** is 1.839





Normality Tests for size 200

Table 38

Case Processing Summary[a]

		Cases					
		Valid		Missing		Total	
	Mode	N	Percent	N	Percent	N	Percent
CompTime	Local	47	100.0%	0	0.0%	47	100.0%
	Remotely	44	100.0%	0	0.0%	44	100.0%

a. Size = 200

Table 39

Descriptives[a]

	Mode			Statistic	Std. Error
CompTime	Local	Mean		11.89362	.365276
		95% Confidence Interval for Mean	Lower Bound	11.15835	
			Upper Bound	12.62888	
		5% Trimmed Mean		11.64421	
		Median		11.00000	
		Variance		6.271	
		Std. Deviation		2.504206	
		Minimum		10.000	
		Maximum		20.000	
		Range		10.000	
		Interquartile Range		3.000	
		Skewness		1.393	.347
		Kurtosis		1.273	.681
	Remotely	Mean		24.57016	.859533
		95% Confidence Interval for Mean	Lower Bound	22.83675	
			Upper Bound	26.30357	
		5% Trimmed Mean		24.42591	
		Median		25.00170	
		Variance		32.507	
		Std. Deviation		5.701497	
		Minimum		15.408	
		Maximum		36.583	
		Range		21.175	
		Interquartile Range		5.698	
		Skewness		.087	.357
		Kurtosis		-.325	.702

a. Size = 200

Table 40

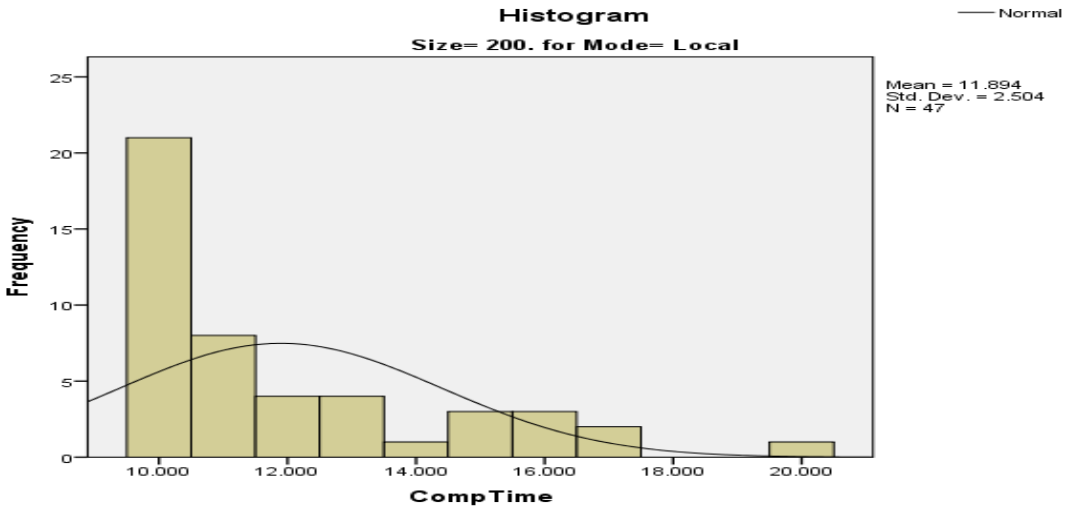
Tests of Normality[a]

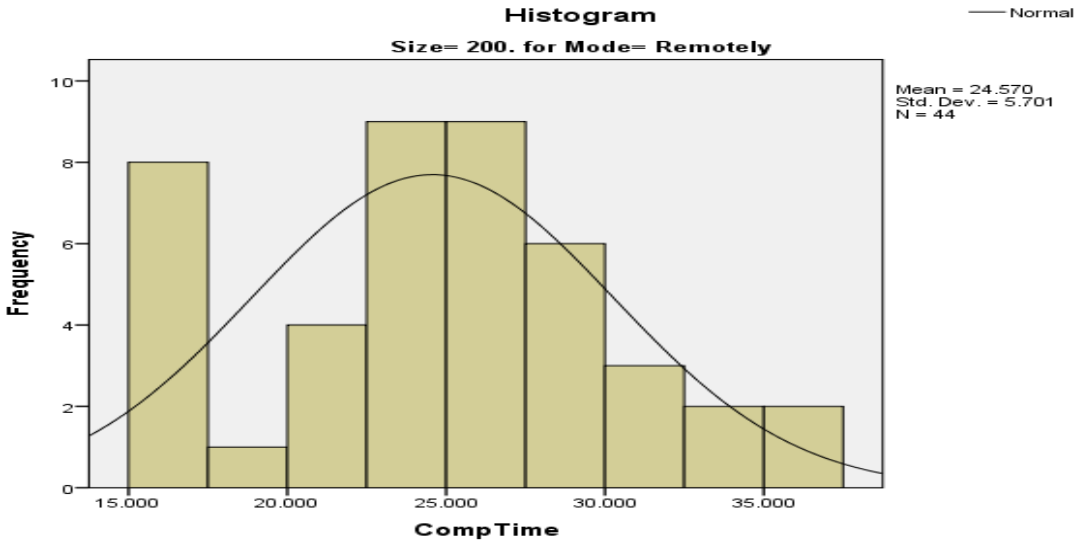
	Mode	Kolmogorov-Smirnov[b]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
CompTime	Local	.256	47	.000	.774	47	.000
	Remotely	.117	44	.153	.952	44	.064

a. Size = 200

b. Lilliefors Significance Correction

The Local Sig. value is under 0.05 and curve on the Local Histogram is non-normal meaning the Mann-Whitney Test is to be performed for this size. The **Local Mean** value is 11.894 and **Remote Mean** is 24.570





Normality Tests for size 400

Table 41

Case Processing Summary[a]

		Cases					
		Valid		Missing		Total	
	Mode	N	Percent	N	Percent	N	Percent
CompTime	Local	41	100.0%	0	0.0%	41	100.0%
	Remotely	45	100.0%	0	0.0%	45	100.0%

a. Size = 400

Table 42

Descriptives[a]

	Mode			Statistic	Std. Error
CompTime	Local	Mean		41.92683	.750114
		95% Confidence Interval for Mean	Lower Bound	40.41079	
			Upper Bound	43.44287	
		5% Trimmed Mean		41.39566	
		Median		40.00000	
		Variance		23.070	
		Std. Deviation		4.803073	
		Minimum		37.000	
		Maximum		57.000	
		Range		20.000	
		Interquartile Range		6.000	
		Skewness		1.638	.369
		Kurtosis		2.898	.724
	Remotely	Mean		320.84407	3.474614
		95% Confidence Interval for Mean	Lower Bound	313.84145	
			Upper Bound	327.84669	
		5% Trimmed Mean		318.25274	
		Median		318.77240	
		Variance		543.282	
		Std. Deviation		23.308416	
		Minimum		283.450	
		Maximum		406.017	
		Range		122.567	
		Interquartile Range		22.841	
		Skewness		2.042	.354
		Kurtosis		6.170	.695

a. Size = 400

Table 43

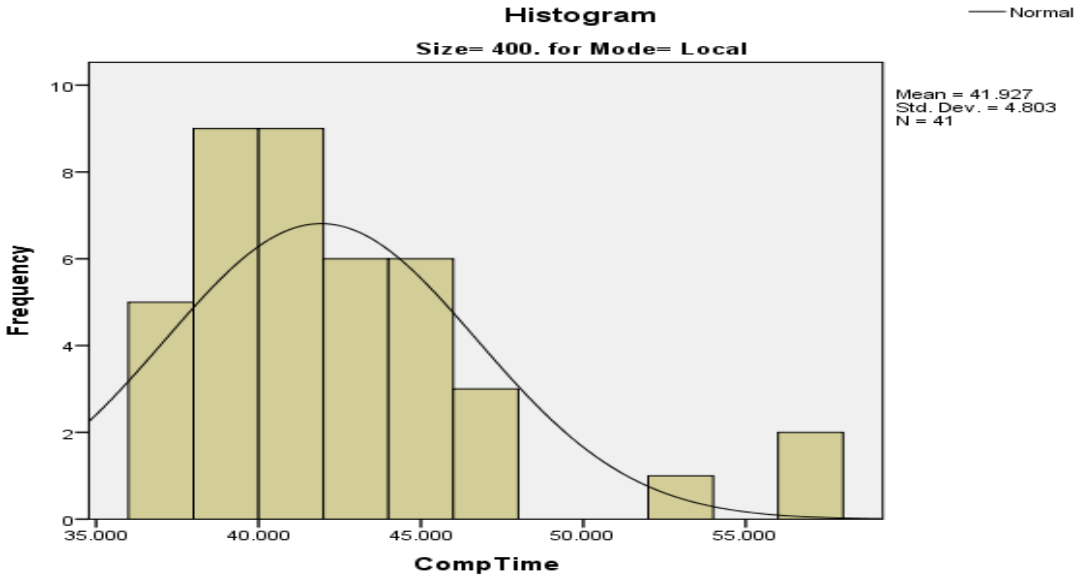
Tests of Normality[a]

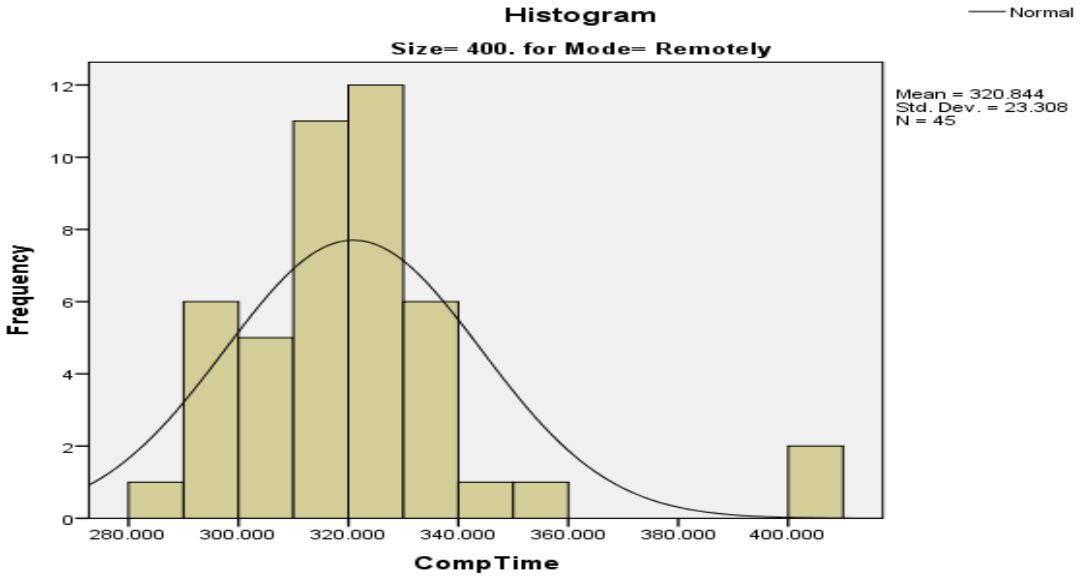
	Mode	Kolmogorov-Smirnov[b]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
CompTime	Local	.168	41	.005	.832	41	.000
	Remotely	.191	45	.000	.817	45	.000

a. Size = 400

b. Lilliefors Significance Correction

Both **Sig.** values are under 0.05 and curves in both Histograms are non-normal. This means the Mann-Whitney U Tests are to be performed for size of 400. The **Local Mean** value is 41.927 and the **Remote Mean** value is 320.844





Test results for Exp3 v 4 Computation Time variable

Table 44

Ranks[a]

	Mode	N	Mean Rank	Sum of Ranks
CompTime	Local	45	68.00	3060.00
	Remotely	45	23.00	1035.00
	Total	90		

a. Size = 50

Test Statistics[a,b]

	CompTime
Mann-Whitney U	.000
Wilcoxon W	1035.000
Z	-8.176
Asymp. Sig. (2-tailed)	.000

a. Size = 50

b. Grouping Variable: Mode

Table 45

Ranks[a]

	Mode	N	Mean Rank	Sum of Ranks
CompTime	Local	45	67.00	3015.00
	Remotely	44	22.50	990.00
	Total	89		

a. Size = 100

Test Statistics[a,b]

	CompTime
Mann-Whitney U	.000
Wilcoxon W	990.000
Z	-8.151
Asymp. Sig. (2-tailed)	.000

a. Size = 100

b. Grouping Variable: Mode

Table 46

Ranks[a]

	Mode	N	Mean Rank	Sum of Ranks
CompTime	Local	47	24.91	1171.00
	Remotely	44	68.52	3015.00
	Total	91		

a. Size = 200

Test Statistics[a,b]

	CompTime
Mann-Whitney U	43.000
Wilcoxon W	1171.000
Z	-7.923
Asymp. Sig. (2-tailed)	.000

a. Size = 200

b. Grouping Variable: Mode

Table 47

Ranks[a]

	Mode	N	Mean Rank	Sum of Ranks
CompTime	Local	41	21.00	861.00
	Remotely	45	64.00	2880.00
	Total	86		

a. Size = 400

Test Statistics[a,b]

	CompTime
Mann-Whitney U	.000
Wilcoxon W	861.000
Z	-7.981
Asymp. Sig. (2-tailed)	.000

a. Size = 400

b. Grouping Variable: Mode

In size 50 and 100, the Remote Means for computation time are significantly better than Local computation Times. In the bigger sizes of 200 and 400, the Local Means for computation times is significantly better that Remote Computation Times.

Total Times Variable Tests

Normality Tests for size 50

Table 48

Case Processing Summary[a]

		Cases					
		Valid		Missing		Total	
	Mode	N	Percent	N	Percent	N	Percent
TotalTime	Local	45	100.0%	0	0.0%	45	100.0%
	Remotely	45	100.0%	0	0.0%	45	100.0%

a. Size = 50

Table 49

Descriptives[a]

	Mode			Statistic	Std. Error
TotalTime	Local	Mean		23.60	1.656
		95% Confidence Interval for Mean	Lower Bound	20.26	
			Upper Bound	26.94	
		5% Trimmed Mean		22.62	
		Median		19.00	
		Variance		123.427	
		Std. Deviation		11.110	
		Minimum		12	
		Maximum		58	
		Range		46	
		Interquartile Range		16	
		Skewness		1.271	.354
		Kurtosis		.992	.695
	Remotely	Mean		188.60	15.566
		95% Confidence Interval for Mean	Lower Bound	157.23	
			Upper Bound	219.97	
		5% Trimmed Mean		173.17	
		Median		152.00	
		Variance		10903.655	
		Std. Deviation		104.421	
		Minimum		106	
		Maximum		589	
		Range		483	
		Interquartile Range		55	
		Skewness		2.626	.354
		Kurtosis		6.625	.695

a. Size = 50

Table 50

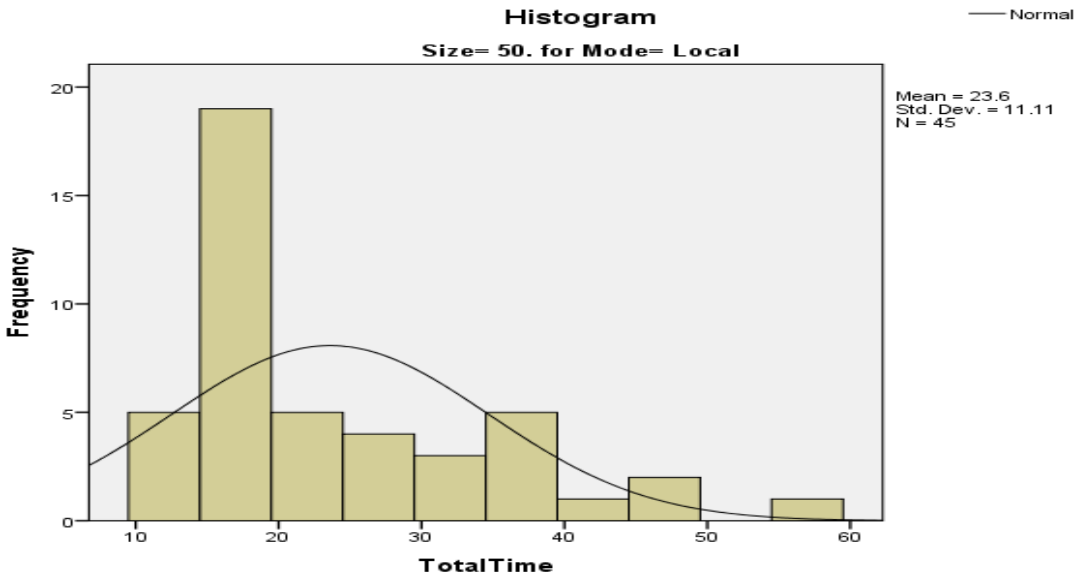
Tests of Normality[a]

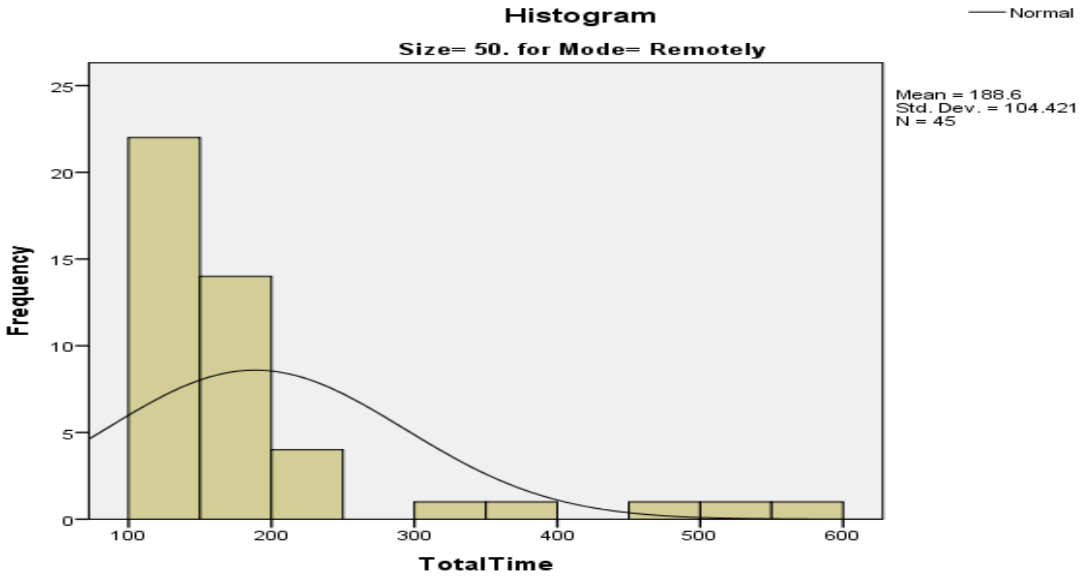
	Mode	Kolmogorov-Smirnov[b]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
TotalTime	Local	.215	45	.000	.842	45	.000
	Remotely	.278	45	.000	.620	45	.000

a. Size = 50

b. Lilliefors Significance Correction

Both Sig. values in the table above are under 0.05 and the curves in the Histograms below are non-normal. This means that only a Mann-Whitney test can be performed for this size of 50. The **Local Mean** value is 23.6 and **Remote Mean** is 188.6





Normality Tests for Size 100

Table 51

Case Processing Summary[a]

		Cases					
		Valid		Missing		Total	
	Mode	N	Percent	N	Percent	N	Percent
TotalTime	Local	45	100.0%	0	0.0%	45	100.0%
	Remotely	44	100.0%	0	0.0%	44	100.0%

a. Size = 100

Table 52

Descriptives[a]

	Mode			Statistic	Std. Error
TotalTime	Local	Mean		67.71	3.180
		95% Confidence Interval for Mean	Lower Bound	61.30	
			Upper Bound	74.12	
		5% Trimmed Mean		69.40	
		Median		72.00	
		Variance		455.028	
		Std. Deviation		21.331	
		Minimum		10	
		Maximum		99	
		Range		89	
		Interquartile Range		10	
		Skewness		-1.951	.354
		Kurtosis		3.218	.695
	Remotely	Mean		697.98	108.420
		95% Confidence Interval for Mean	Lower Bound	479.33	
			Upper Bound	916.63	
		5% Trimmed Mean		569.65	
		Median		468.00	
		Variance		517220.209	
		Std. Deviation		719.180	
		Minimum		357	
		Maximum		4066	
		Range		3709	
		Interquartile Range		161	
		Skewness		3.477	.357
		Kurtosis		12.586	.702

a. Size = 100

Table 53

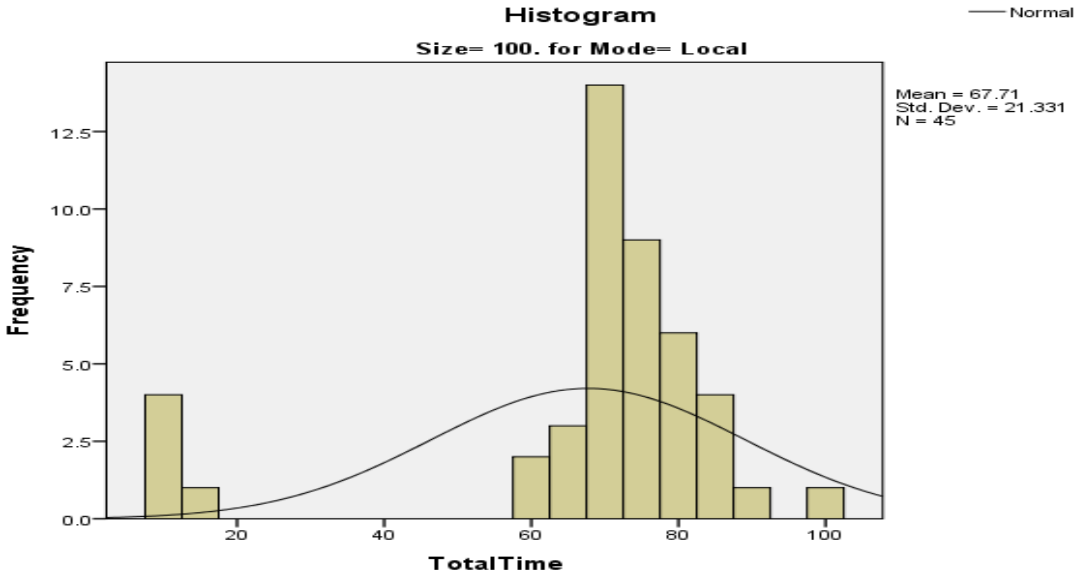
Tests of Normality[a]

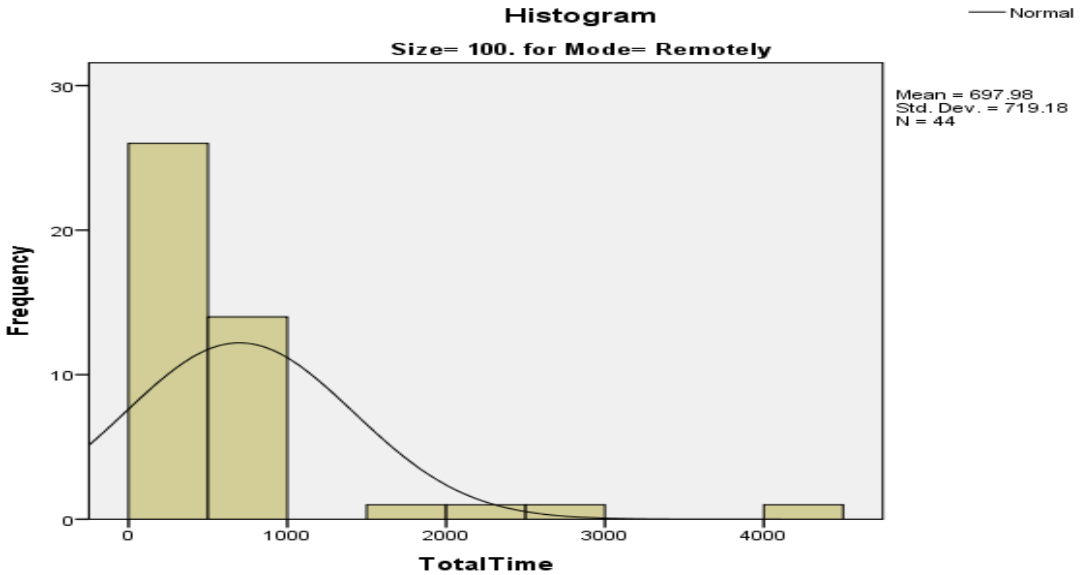
		Kolmogorov-Smirnov[b]			Shapiro-Wilk		
	Mode	Statistic	df	Sig.	Statistic	df	Sig.
TotalTime	Local	.290	45	.000	.702	45	.000
	Remotely	.388	44	.000	.466	44	.000

a. Size = 100

b. Lilliefors Significance Correction

As in the Tests of Normality for size 50, the **Sig**. values are under 0.05 and the curves in the Histogram below are non-normal. Only the Mann-Whitney Test can be performed for size 100. The **Local Mean** value is 67.71 and the **Remote Mean** is 697.98





Normality Tests for Size 200

Table 54

Case Processing Summary[a]

		Cases					
		Valid		Missing		Total	
	Mode	N	Percent	N	Percent	N	Percent
TotalTime	Local	47	100.0%	0	0.0%	47	100.0%
	Remotely	44	100.0%	0	0.0%	44	100.0%

a. Size = 200

Table 55

Descriptives[a]

	Mode			Statistic	Std. Error
TotalTime	Local	Mean		577.85	6.951
		95% Confidence Interval for Mean	Lower Bound	563.86	
			Upper Bound	591.84	
		5% Trimmed Mean		576.91	
		Median		570.00	
		Variance		2271.173	
		Std. Deviation		47.657	
		Minimum		502	
		Maximum		673	
		Range		171	
		Interquartile Range		80	
		Skewness		.301	.347
		Kurtosis		-1.087	.681
	Remotely	Mean		2465.09	169.059
		95% Confidence Interval for Mean	Lower Bound	2124.15	
			Upper Bound	2806.03	
		5% Trimmed Mean		2365.80	
		Median		2105.00	
		Variance		1257562.968	
		Std. Deviation		1121.411	
		Minimum		1309	
		Maximum		5861	
		Range		4552	
		Interquartile Range		1207	
		Skewness		1.359	.357
		Kurtosis		1.154	.702

a. Size = 200

Table 56

Tests of Normality[a]

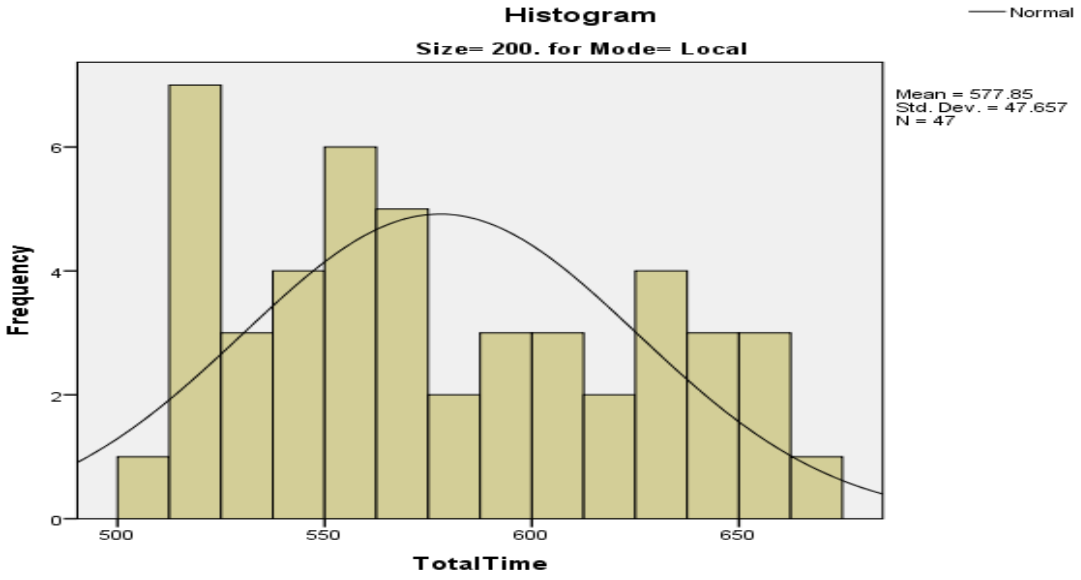
	Mode	Kolmogorov-Smirnov[b]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
TotalTime	Local	.096	47	.200*	.947	47	.033
	Remotely	.190	44	.000	.836	44	.000

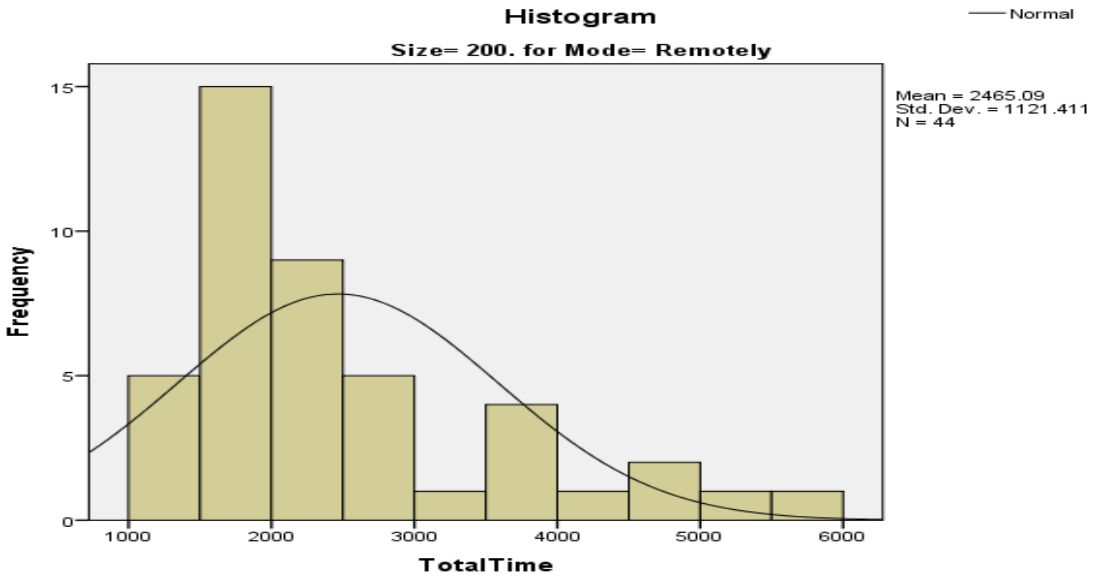
*. This is a lower bound of the true significance.

a. Size = 200

b. Lilliefors Significance Correction

The Remote **Sig.** value is under 0.05 and the curve for Remote Histogram is non-normal. As in the two previous Normality Tests, only a Mann-Whitney Test can be performed. The **Local Mean** value is 577.85 and the **Remote Mean** value is 465.09





Normality Tests for size 400

Table 58

Case Processing Summary[a]

		Cases					
		Valid		Missing		Total	
	Mode	N	Percent	N	Percent	N	Percent
TotalTime	Local	41	100.0%	0	0.0%	41	100.0%
	Remotely	45	100.0%	0	0.0%	45	100.0%

a. Size = 400

Table 59

Descriptives[a]

	Mode			Statistic	Std. Error
TotalTime	Local	Mean		5114.73	46.762
		95% Confidence Interval for Mean	Lower Bound	5020.22	
			Upper Bound	5209.24	
		5% Trimmed Mean		5092.83	
		Median		5044.00	
		Variance		89655.451	
		Std. Deviation		299.425	
		Minimum		4737	
		Maximum		5914	
		Range		1177	
		Interquartile Range		422	
		Skewness		.947	.369
		Kurtosis		.420	.724
	Remotely	Mean		6585.09	380.528
		95% Confidence Interval for Mean	Lower Bound	5818.18	
			Upper Bound	7351.99	
		5% Trimmed Mean		6199.94	
		Median		5746.00	
		Variance		6516081.583	
		Std. Deviation		2552.662	
		Minimum		5069	
		Maximum		20660	
		Range		15591	
		Interquartile Range		1217	
		Skewness		4.156	.354
		Kurtosis		21.245	.695

a. Size = 400

Table 60

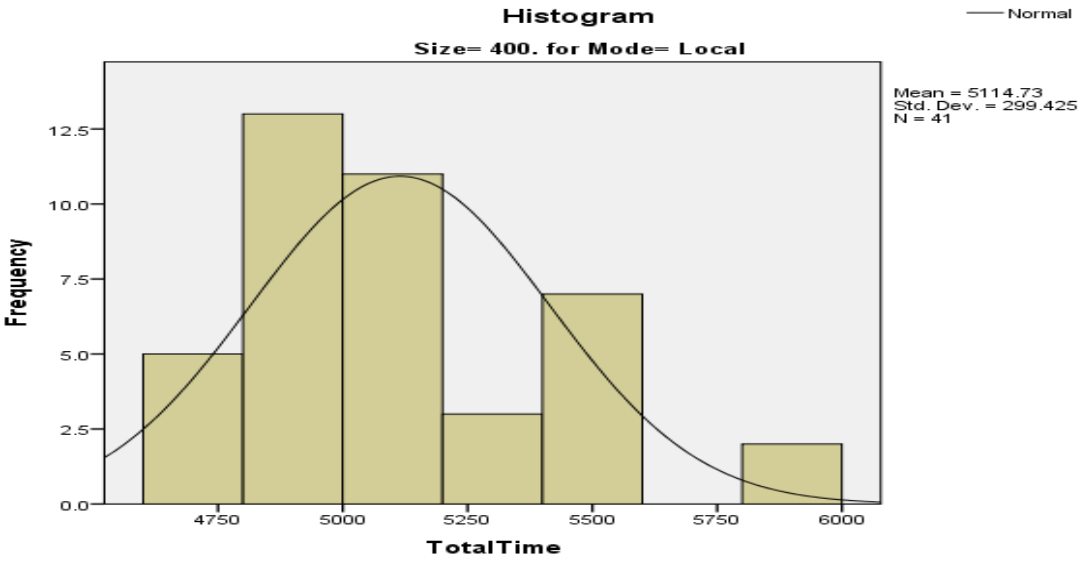
Tests of Normality[a]

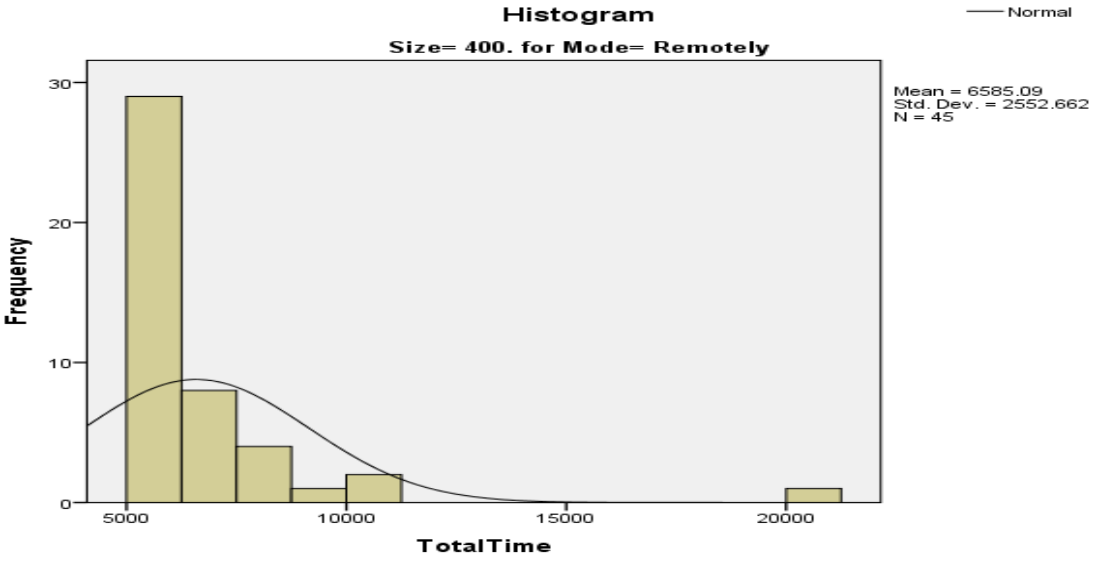
		Kolmogorov-Smirnov[b]			Shapiro-Wilk		
	Mode	Statistic	df	Sig.	Statistic	df	Sig.
TotalTime	Local	.132	41	.069	.914	41	.005
	Remotely	.276	45	.000	.541	45	.000

a. Size = 400

b. Lilliefors Significance Correction

Both **Sig.** values from the Table above are under 0.05 and the curves are non-normal in the Histograms for both groups below. Which means only the Mann-Whitney Test can be used for size 400. The **Local Mean** value is 5114.73 and the **Remote Mean** is 6585.09





Test results for Exp3 v 4 Total Time variable

Table 61

Ranks[a]

	Mode	N	Mean Rank	Sum of Ranks
TotalTime	Local	45	23.00	1035.00
	Remotely	45	68.00	3060.00
	Total	90		

a. Size = 50

Test Statistics[a,b]

	TotalTime
Mann-Whitney U	.000
Wilcoxon W	1035.000
Z	-8.176
Asymp. Sig. (2-tailed)	.000

a. Size = 50

b. Grouping Variable: Mode

Table 62

Ranks[a]

	Mode	N	Mean Rank	Sum of Ranks
TotalTime	Local	45	23.00	1035.00
	Remotely	44	67.50	2970.00
	Total	89		

a. Size = 100

Test Statistics[a,b]

	TotalTime
Mann-Whitney U	.000
Wilcoxon W	1035.000
Z	-8.126
Asymp. Sig. (2-tailed)	.000

a. Size = 100

b. Grouping Variable: Mode

Table 63

Ranks[a]

	Mode	N	Mean Rank	Sum of Ranks
TotalTime	Local	47	24.00	1128.00
	Remotely	44	69.50	3058.00
	Total	91		

a. Size = 200

Test Statistics[a,b]

	TotalTime
Mann-Whitney U	.000
Wilcoxon W	1128.000
Z	-8.212
Asymp. Sig. (2-tailed)	.000

a. Size = 200

b. Grouping Variable: Mode

Table 64

Ranks[a]

	Mode	N	Mean Rank	Sum of Ranks
TotalTime	Local	41	26.10	1070.00
	Remotely	45	59.36	2671.00
	Total	86		

a. Size = 400

Test Statistics[a,b]

	TotalTime
Mann-Whitney U	209.000
Wilcoxon W	1070.000
Z	-6.169
Asymp. Sig. (2-tailed)	.000

a. Size = 400

b. Grouping Variable: Mode

In all the sizes the Remote mode Total Timings are significantly higher than the Local Total Timings.

Battery Remaining Variable Tests

Normality Tests for size 50

Table 65

Case Processing Summary[a]

		Cases					
		Valid		Missing		Total	
	Mode	N	Percent	N	Percent	N	Percent
Batt_Remain	Local	45	100.0%	0	0.0%	45	100.0%
	Remotely	45	100.0%	0	0.0%	45	100.0%

a. Size = 50

Table 66

Descriptives[a]

	Mode			Statistic	Std. Error
Batt_Remain	Local	Mean		99.20	.060
		95% Confidence Interval for Mean	Lower Bound	99.08	
			Upper Bound	99.32	
		5% Trimmed Mean		99.17	
		Median		99.00	
		Variance		.164	
		Std. Deviation		.405	
		Minimum		99	
		Maximum		100	
		Range		1	
		Interquartile Range		0	
		Skewness		1.552	.354
		Kurtosis		.426	.695
	Remotely	Mean		99.44	.075
		95% Confidence Interval for Mean	Lower Bound	99.29	
			Upper Bound	99.60	
		5% Trimmed Mean		99.44	
		Median		99.00	
		Variance		.253	
		Std. Deviation		.503	
		Minimum		99	
		Maximum		100	
		Range		1	
		Interquartile Range		1	
		Skewness		.231	.354
		Kurtosis		-2.039	.695

a. Size = 50

Table 67

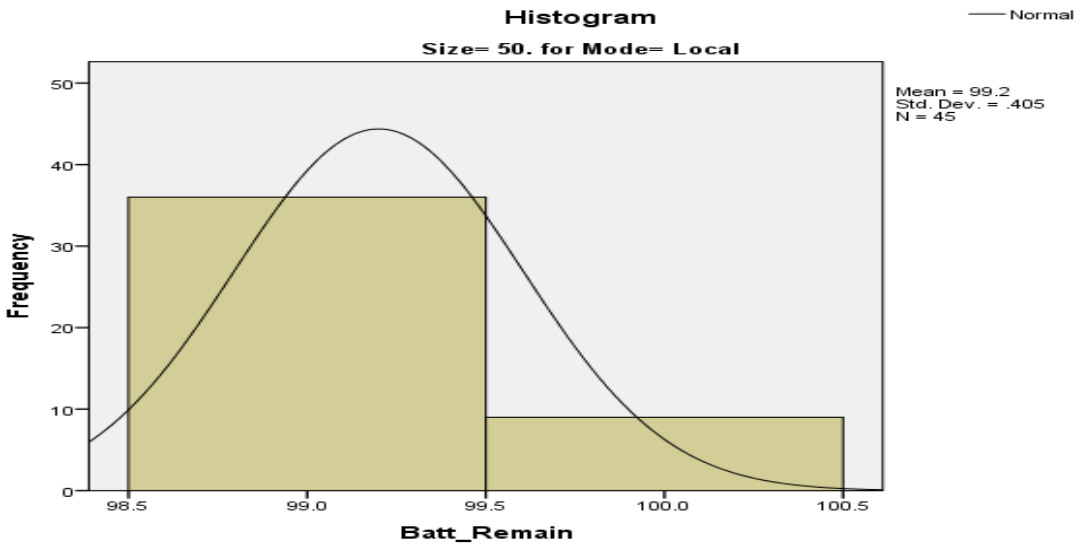
Tests of Normality[a]

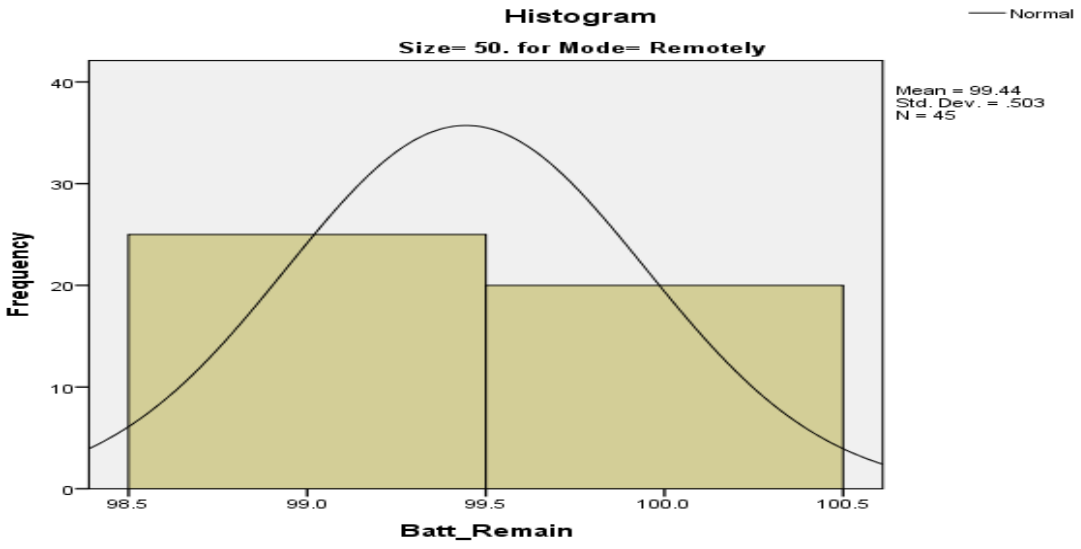
		Kolmogorov-Smirnov[b]			Shapiro-Wilk		
	Mode	Statistic	df	Sig.	Statistic	df	Sig.
Batt_Remain	Local	.489	45	.000	.491	45	.000
	Remotely	.367	45	.000	.632	45	.000

a. Size = 50

b. Lilliefors Significance Correction

Both Groups have **Sig.** Value lower than 0.05 in the table above and both groups Histograms have non-normal curves. As a result, the Mann-Whitney U Test will be performed for this size. The **Local Mean** value is 99.2 and **Remote Mean** value is 99.44





Normality Tests for Size 100

Table 68

Case Processing Summary[a]

		Cases					
		Valid		Missing		Total	
	Mode	N	Percent	N	Percent	N	Percent
Batt_Remain	Local	45	100.0%	0	0.0%	45	100.0%
	Remotely	44	100.0%	0	0.0%	44	100.0%

a. Size = 100

Table 69

Descriptives[a]

	Mode			Statistic	Std. Error
Batt_Remain	Local	Mean		98.31	.070
		95% Confidence Interval for Mean	Lower Bound	98.17	
			Upper Bound	98.45	
		5% Trimmed Mean		98.29	
		Median		98.00	
		Variance		.219	
		Std. Deviation		.468	
		Minimum		98	
		Maximum		99	
		Range		1	
		Interquartile Range		1	
		Skewness		.844	.354
		Kurtosis		-1.349	.695
	Remotely	Mean		98.34	.072
		95% Confidence Interval for Mean	Lower Bound	98.20	
			Upper Bound	98.49	
		5% Trimmed Mean		98.32	
		Median		98.00	
		Variance		.230	
		Std. Deviation		.479	
		Minimum		98	
		Maximum		99	
		Range		1	
		Interquartile Range		1	
		Skewness		.695	.357
		Kurtosis		-1.591	.702

a. Size = 100

Table 70

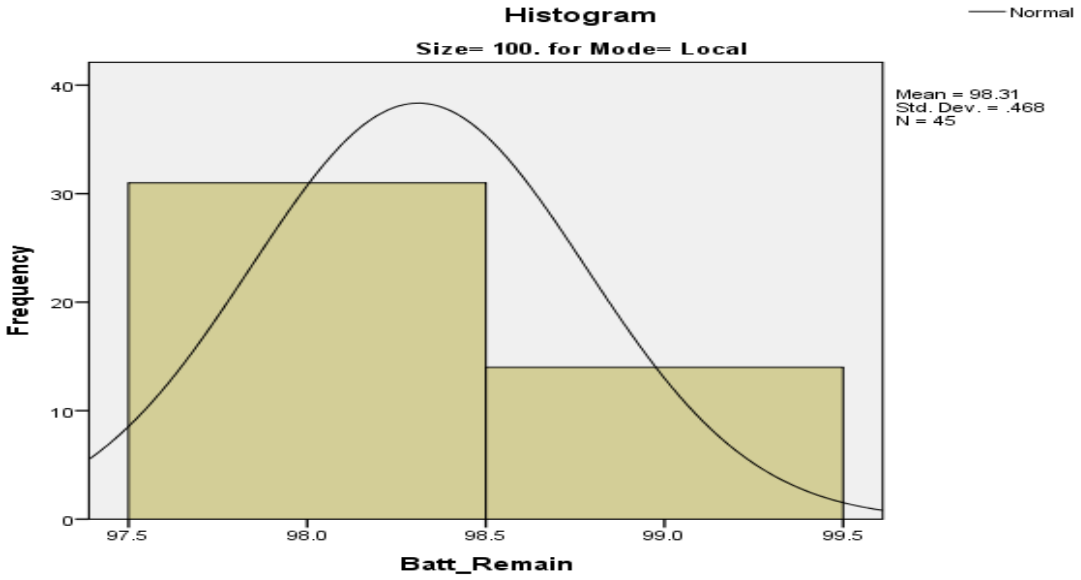
Tests of Normality[a]

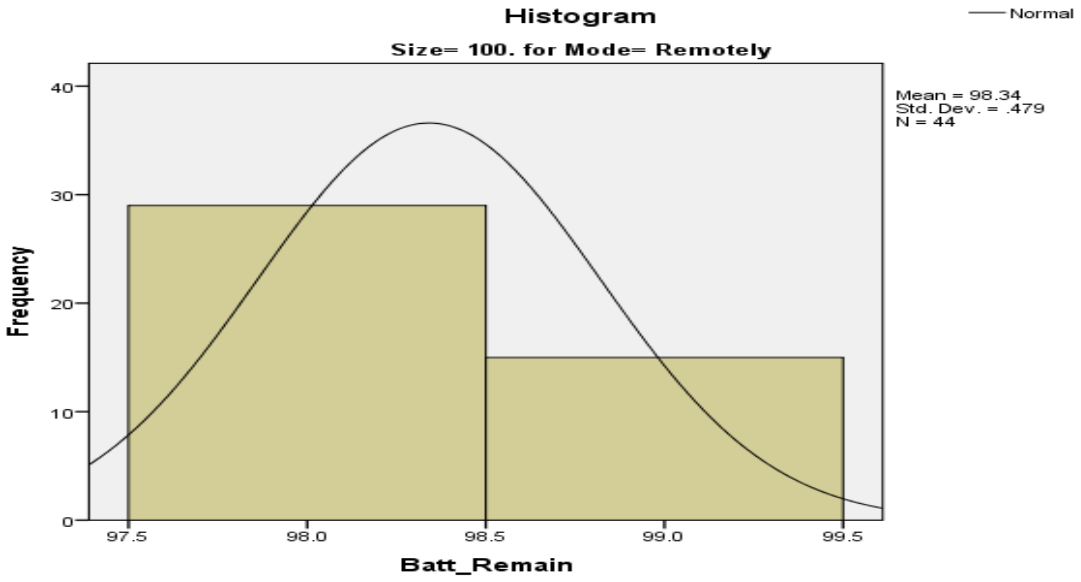
		Kolmogorov-Smirnov[b]			Shapiro-Wilk		
	Mode	Statistic	df	Sig.	Statistic	df	Sig.
Batt_Remain	Local	.436	45	.000	.583	45	.000
	Remotely	.421	44	.000	.599	44	.000

a. Size = 100

b. Lilliefors Significance Correction

As in the last size, both **Sig.** values are under 0.05 and both have non-normal curves in the Histograms. Only the Mann-Whitney Tests can be performed for this size. The **Local Mean** value is 98.31 and **Remote Mean** is 98.34





Normality Tests for Size 200

Table 71

Case Processing Summary[a]

		Cases					
		Valid		Missing		Total	
	Mode	N	Percent	N	Percent	N	Percent
Batt_Remain	Local	47	100.0%	0	0.0%	47	100.0%
	Remotely	44	100.0%	0	0.0%	44	100.0%

a. Size = 200

Table 72

Descriptives[a]

	Mode			Statistic	Std. Error
Batt_Remain	Local	Mean		95.17	.188
		95% Confidence Interval for Mean	Lower Bound	94.79	
			Upper Bound	95.55	
		5% Trimmed Mean		95.19	
		Median		95.00	
		Variance		1.666	
		Std. Deviation		1.291	
		Minimum		93	
		Maximum		97	
		Range		4	
		Interquartile Range		2	
		Skewness		-.078	.347
		Kurtosis		-1.085	.681
	Remotely	Mean		95.52	.217
		95% Confidence Interval for Mean	Lower Bound	95.09	
			Upper Bound	95.96	
		5% Trimmed Mean		95.53	
		Median		96.00	
		Variance		2.069	
		Std. Deviation		1.438	
		Minimum		93	
		Maximum		98	
		Range		5	
		Interquartile Range		3	
		Skewness		-.121	.357
		Kurtosis		-.930	.702

a. Size = 200

Table 73

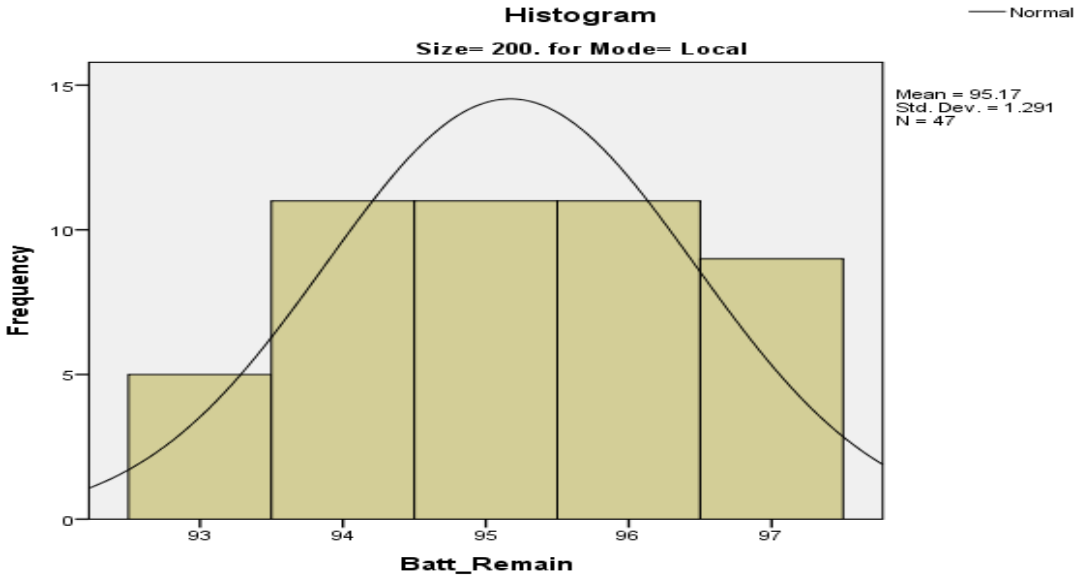
Tests of Normality[a]

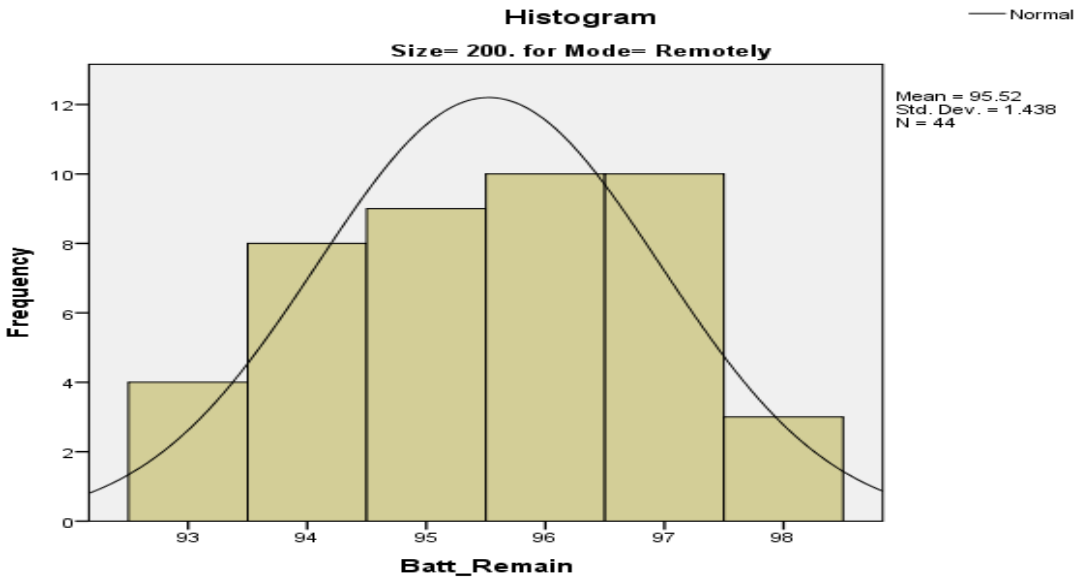
	Mode	Kolmogorov-Smirnov[b]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Batt_Remain	Local	.165	47	.002	.906	47	.001
	Remotely	.153	44	.012	.932	44	.012

a. Size = 200

b. Lilliefors Significance Correction

Both groups have **Sig.** values under 0.05 and both Histogram have produced non-normal curves. As with the previous two sizes, the Mann-Whitney Test has to be performed for size 200. The **Local Mean** value is 95.17 and the **Remote Mean** is 95.52.





Normality Tests for Size 400

Table 74

Case Processing Summary[a]

		Cases					
		Valid		Missing		Total	
	Mode	N	Percent	N	Percent	N	Percent
Batt_Remain	Local	41	100.0%	0	0.0%	41	100.0%
	Remotely	45	100.0%	0	0.0%	45	100.0%

a. Size = 400

Table 75

Descriptives[a]

	Mode			Statistic	Std. Error
Batt_Remain	Local	Mean		84.66	.762
		95% Confidence Interval for Mean	Lower Bound	83.12	
			Upper Bound	86.20	
		5% Trimmed Mean		84.65	
		Median		84.00	
		Variance		23.780	
		Std. Deviation		4.877	
		Minimum		77	
		Maximum		93	
		Range		16	
		Interquartile Range		9	
		Skewness		.077	.369
		Kurtosis		-1.244	.724
	Remotely	Mean		84.58	.724
		95% Confidence Interval for Mean	Lower Bound	83.12	
			Upper Bound	86.04	
		5% Trimmed Mean		84.59	
		Median		85.00	
		Variance		23.613	
		Std. Deviation		4.859	
		Minimum		76	
		Maximum		93	
		Range		17	
		Interquartile Range		9	
		Skewness		-.004	.354
		Kurtosis		-1.169	.695

a. Size = 400

Table 76

Tests of Normality[a]

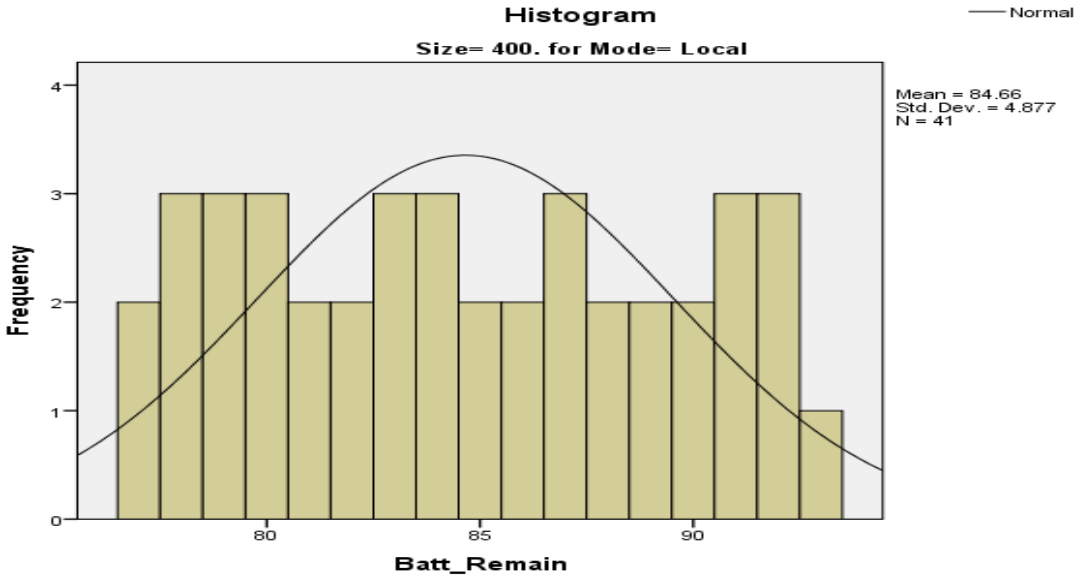
		Kolmogorov-Smirnov[b]			Shapiro-Wilk		
	Mode	Statistic	df	Sig.	Statistic	df	Sig.
Batt_Remain	Local	.099	41	.200*	.946	41	.049
	Remotely	.093	45	.200*	.957	45	.097

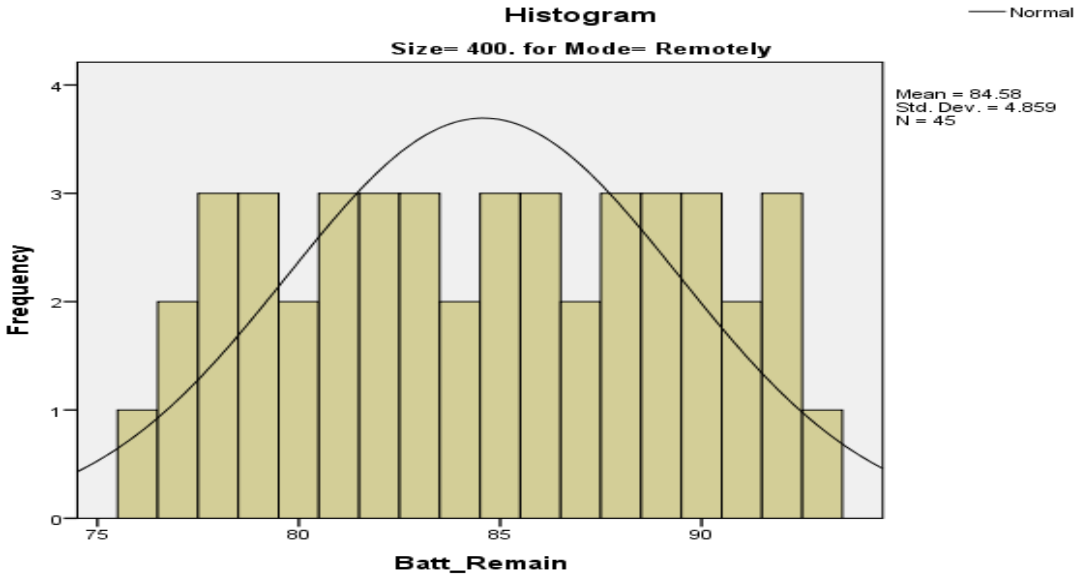
*. This is a lower bound of the true significance.

a. Size = 400

b. Lilliefors Significance Correction

In the table above, the Local Sig. value is just under 0.05 and the curve is non-normal in the Local Histogram. As with the previous different sizes the Mann-Whitney test must be performed. The **Local Mean** is 54.66 and the **Remote Mean** is 84.58





Test results for Exp3 v 4 Battery Remaining variable

Table 77

Ranks[a]

	Mode	N	Mean Rank	Sum of Ranks
Batt_Remain	Local	45	40.00	1800.00
	Remotely	45	51.00	2295.00
	Total	90		

a. Size = 50

Test Statistics[a,b]

	Batt_Remain
Mann-Whitney U	765.000
Wilcoxon W	1800.000
Z	-2.467
Asymp. Sig. (2-tailed)	.014

a. Size = 50

b. Grouping Variable: Mode

Table 78

Ranks[a]

	Mode	N	Mean Rank	Sum of Ranks
Batt_Remain	Local	45	44.34	1995.50
	Remotely	44	45.67	2009.50
	Total	89		

a. Size = 100

Test Statistics[a,b]

	Batt_Remain
Mann-Whitney U	960.500
Wilcoxon W	1995.500
Z	-.298
Asymp. Sig. (2-tailed)	.766

a. Size = 100

b. Grouping Variable: Mode

Table 79

Ranks[a]

	Mode	N	Mean Rank	Sum of Ranks
Batt_Remain	Local	47	42.93	2017.50
	Remotely	44	49.28	2168.50
	Total	91		

a. Size = 200

Test Statistics[a,b]

	Batt_Remain
Mann-Whitney U	889.500
Wilcoxon W	2017.500
Z	-1.172
Asymp. Sig. (2-tailed)	.241

a. Size = 200

b. Grouping Variable: Mode

Table 80

Ranks[a]

	Mode	N	Mean Rank	Sum of Ranks
Batt_Remain	Local	41	43.70	1791.50
	Remotely	45	43.32	1949.50
	Total	86		

a. Size = 400

Test Statistics[a,b]

	Batt_Remain
Mann-Whitney U	914.500
Wilcoxon W	1949.500
Z	-.069
Asymp. Sig. (2-tailed)	.945

a. Size = 400

b. Grouping Variable: Mode

In size 50 section of the experiment, the Remote Battery Remaining Mean is significantly larger than the Local Mean. In the rest of the sizes, there is very little difference between both groups.

6.4 Exp3 v 5 Output Results

Memory Variable Tests

Normality Tests for size 50

Table 81

Case Processing Summary[a]

		Cases					
		Valid		Missing		Total	
	Mode	N	Percent	N	Percent	N	Percent
Memory	Local	45	100.0%	0	0.0%	45	100.0%
	Remote	44	100.0%	0	0.0%	44	100.0%

a. Size = 50

Table 82

Descriptives[a]

	Mode			Statistic	Std. Error
Memory	Local	Mean		754238.49	958.222
		95% Confidence Interval for Mean	Lower Bound	752307.32	
			Upper Bound	756169.66	
		5% Trimmed Mean		753858.32	
		Median		750840.00	
		Variance		41318486.76	
		Std. Deviation		6427.946	
		Minimum		748568	
		Maximum		767160	
		Range		18592	
		Interquartile Range		8058	
		Skewness		1.201	.354
		Kurtosis		-.499	.695
	Remote	Mean		763701.34	120.709
		95% Confidence Interval for Mean	Lower Bound	763457.91	
			Upper Bound	763944.77	
		5% Trimmed Mean		763679.58	
		Median		763707.00	
		Variance		641106.276	
		Std. Deviation		800.691	
		Minimum		762185	
		Maximum		765639	
		Range		3454	
		Interquartile Range		1012	
		Skewness		.384	.357
		Kurtosis		-.244	.702

a. Size = 50

Table 83

Tests of Normality[a]

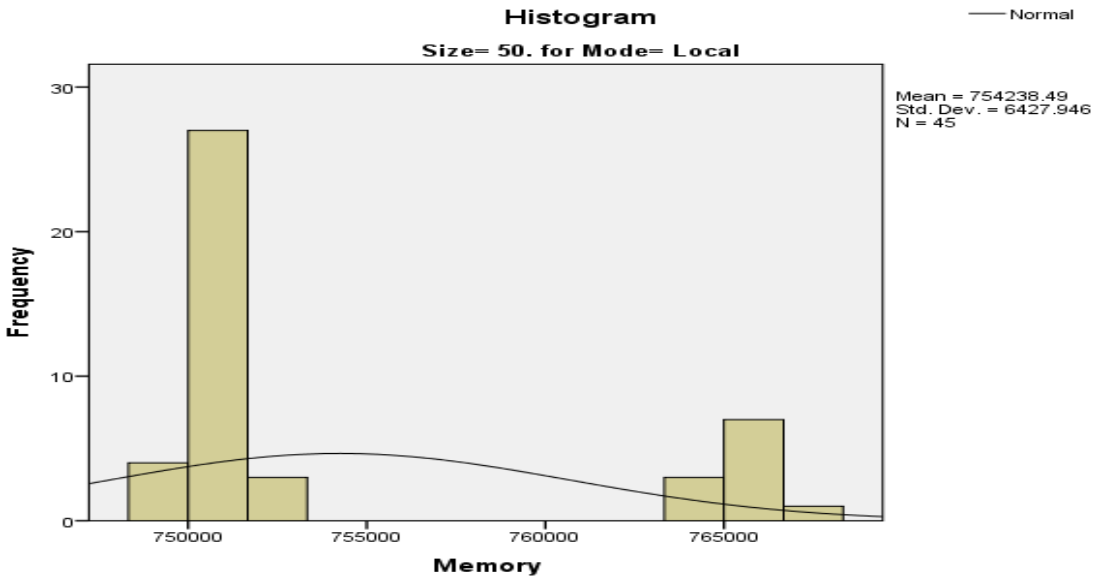
	Mode	Kolmogorov-Smirnov[b]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Memory	Local	.369	45	.000	.645	45	.000
	Remote	.090	44	.200*	.978	44	.552

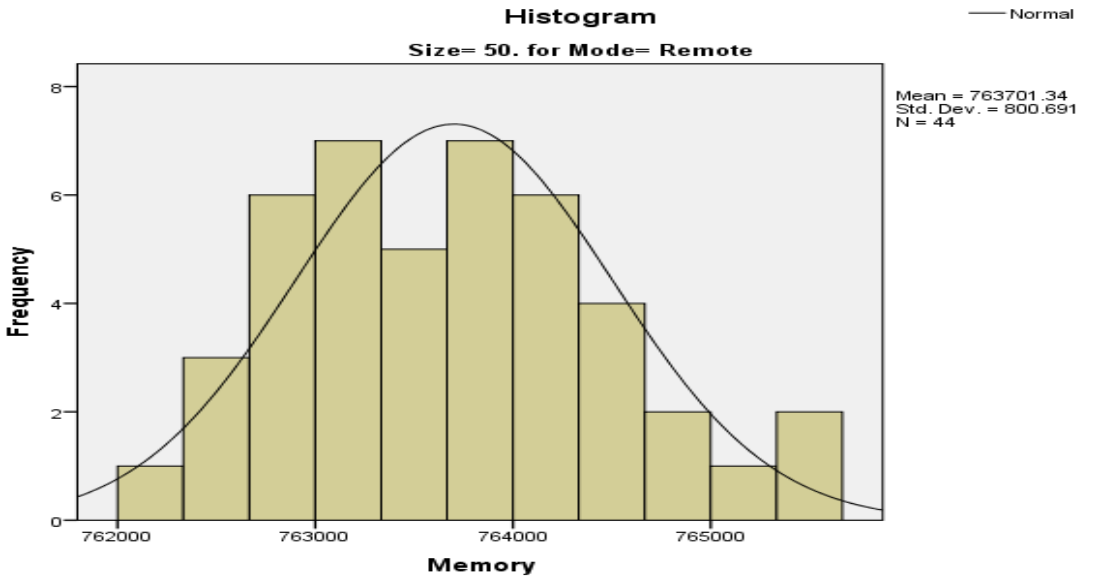
*. This is a lower bound of the true significance.

a. Size = 50

b. Lilliefors Significance Correction

The Local **Sig.** value is less than 0.05 and the curve on the Local Histogram is non-normal. This means a Mann-Whitney Test must be performed on the groups for this size. The **Local Mean** value is 753238.49 and the **Remote Mean** is 763701.34.





Normality Tests for Size 100

Table 84

Case Processing Summary[a]

		Cases					
		Valid		Missing		Total	
	Mode	N	Percent	N	Percent	N	Percent
Memory	Local	45	100.0%	0	0.0%	45	100.0%
	Remote	45	100.0%	0	0.0%	45	100.0%

a. Size = 100

Table 85

Descriptives[a]

	Mode			Statistic	Std. Error
Memory	Local	Mean		768288.71	82.248
		95% Confidence Interval for Mean	Lower Bound	768122.95	
			Upper Bound	768454.47	
		5% Trimmed Mean		768293.28	
		Median		768148.00	
		Variance		304409.665	
		Std. Deviation		551.733	
		Minimum		767120	
		Maximum		769300	
		Range		2180	
		Interquartile Range		880	
		Skewness		.038	.354
		Kurtosis		-.795	.695
	Remote	Mean		770288.53	187.413
		95% Confidence Interval for Mean	Lower Bound	769910.83	
			Upper Bound	770666.24	
		5% Trimmed Mean		770403.00	
		Median		770448.00	
		Variance		1580562.255	
		Std. Deviation		1257.204	
		Minimum		765432	
		Maximum		772503	
		Range		7071	
		Interquartile Range		1248	
		Skewness		-1.662	.354
		Kurtosis		5.150	.695

a. Size = 100

Table 86

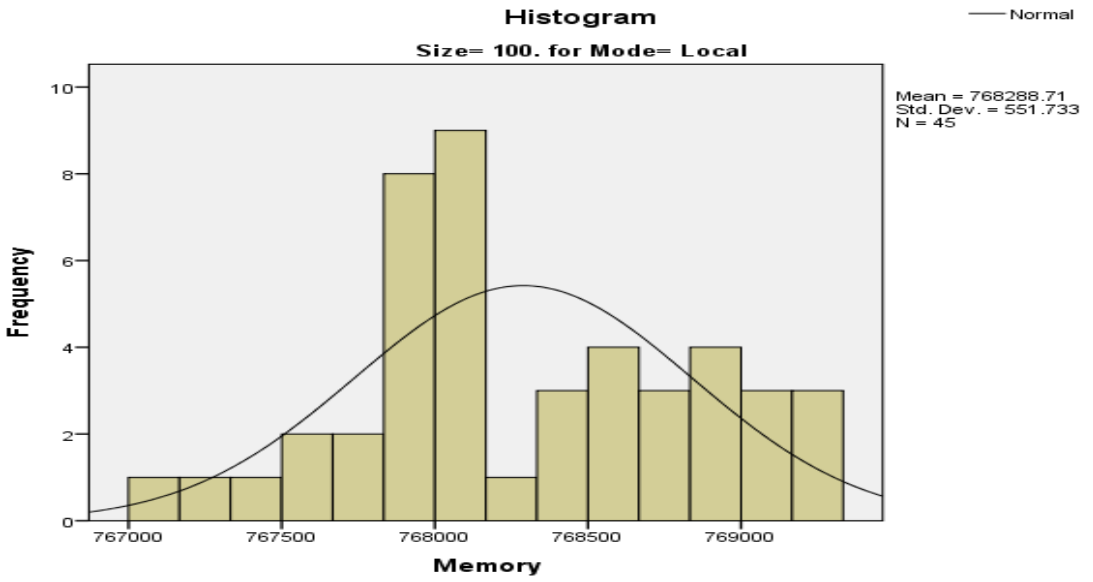
Tests of Normality[a]

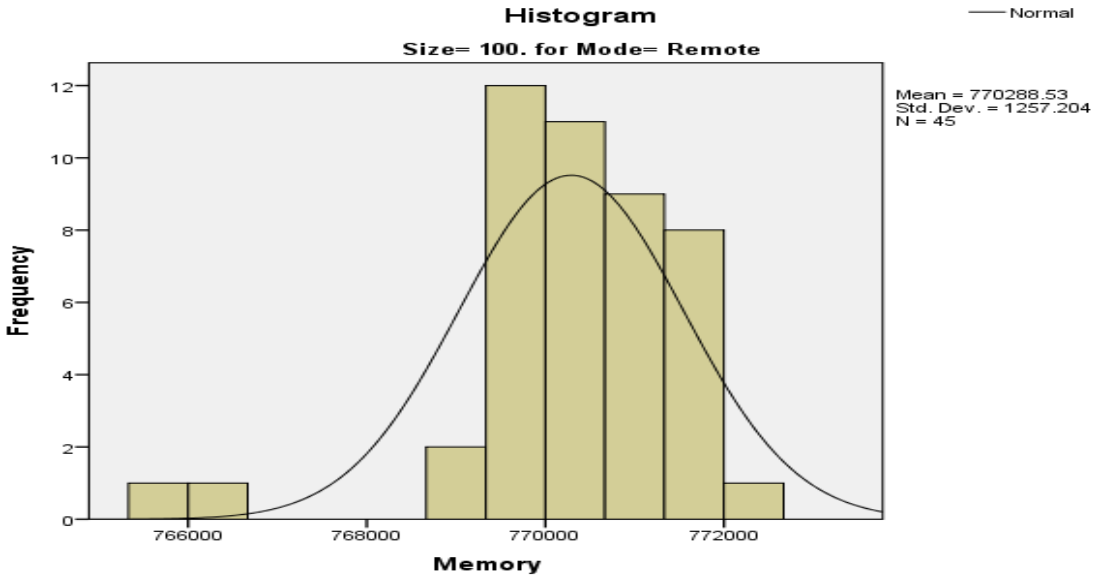
	Mode	Kolmogorov-Smirnov[b]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Memory	Local	.128	45	.061	.970	45	.301
	Remote	.141	45	.025	.870	45	.000

a. Size = 100

b. Lilliefors Significance Correction

The Sig. value for Remote group is less than 0.05 and its curve is non-normal. As with the previous size, a Mann-Whitney Test must be performed. The **Local Mean** value is 768288.71 and the **Remote Mean** is 770288.53.





Normality Tests for Size 200

Table 87

Case Processing Summary[a]

		Cases					
		Valid		Missing		Total	
	Mode	N	Percent	N	Percent	N	Percent
Memory	Local	47	100.0%	0	0.0%	47	100.0%
	Remote	46	100.0%	0	0.0%	46	100.0%

a. Size = 200

Table 88

Descriptives[a]

	Mode			Statistic	Std. Error
Memory	Local	Mean		765475.70	361.172
		95% Confidence Interval for Mean	Lower Bound	764748.70	
			Upper Bound	766202.70	
		5% Trimmed Mean		765682.78	
		Median		766708.00	
		Variance		6130915.866	
		Std. Deviation		2476.069	
		Minimum		755732	
		Maximum		768156	
		Range		12424	
		Interquartile Range		3732	
		Skewness		-1.529	.347
		Kurtosis		3.531	.681
	Remote	Mean		757753.09	1848.536
		95% Confidence Interval for Mean	Lower Bound	754029.94	
			Upper Bound	761476.23	
		5% Trimmed Mean		758402.10	
		Median		765069.50	
		Variance		157185913.3	
		Std. Deviation		12537.381	
		Minimum		735988	
		Maximum		769051	
		Range		33063	
		Interquartile Range		25703	
		Skewness		-1.059	.350
		Kurtosis		-.841	.688

a. Size = 200

Table 89

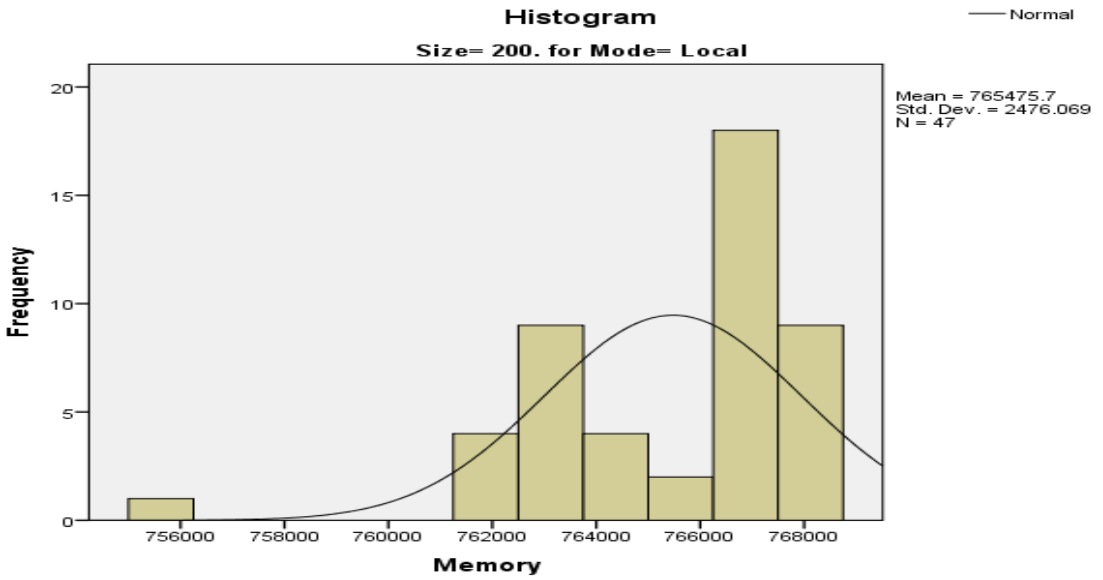
Tests of Normality[a]

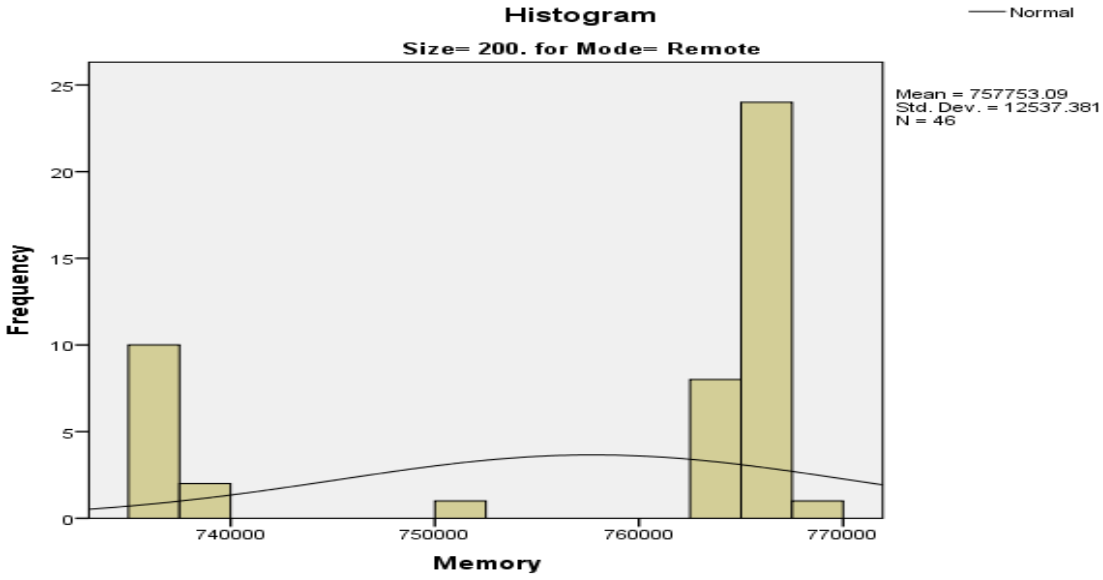
	Mode	Kolmogorov-Smirnov[b]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Memory	Local	.219	47	.000	.832	47	.000
	Remote	.398	46	.000	.638	46	.000

a. Size = 200

b. Lilliefors Significance Correction

From the table above, both groups produce Sig. values less than 0.05 and curves from both Histograms are both non-normal. A Mann-Witney Test must be performed. The **Local Mean** is 765475.7 and the **Remote Mean** is 757753.09





Normality Tests for Size 400

Table 90

Case Processing Summary[a]

		Cases					
		Valid		Missing		Total	
	Mode	N	Percent	N	Percent	N	Percent
Memory	Local	45	100.0%	0	0.0%	45	100.0%
	Remote	44	100.0%	0	0.0%	44	100.0%

a. Size = 400

Table 91

Descriptives[a]

	Mode			Statistic	Std. Error
Memory	Local	Mean		760267.40	850.234
		95% Confidence Interval for Mean	Lower Bound	758553.86	
			Upper Bound	761980.94	
		5% Trimmed Mean		760405.54	
		Median		761176.00	
		Variance		32530440.29	
		Std. Deviation		5703.546	
		Minimum		748680	
		Maximum		768920	
		Range		20240	
		Interquartile Range		8082	
		Skewness		-.290	.354
		Kurtosis		-.854	.695
	Remote	Mean		750935.45	963.590
		95% Confidence Interval for Mean	Lower Bound	748992.19	
			Upper Bound	752878.72	
		5% Trimmed Mean		750885.39	
		Median		752048.00	
		Variance		40854212.53	
		Std. Deviation		6391.730	
		Minimum		739484	
		Maximum		763425	
		Range		23941	
		Interquartile Range		9802	
		Skewness		-.220	.357
		Kurtosis		-.725	.702

a. Size = 400

Table 92

Tests of Normality[a]

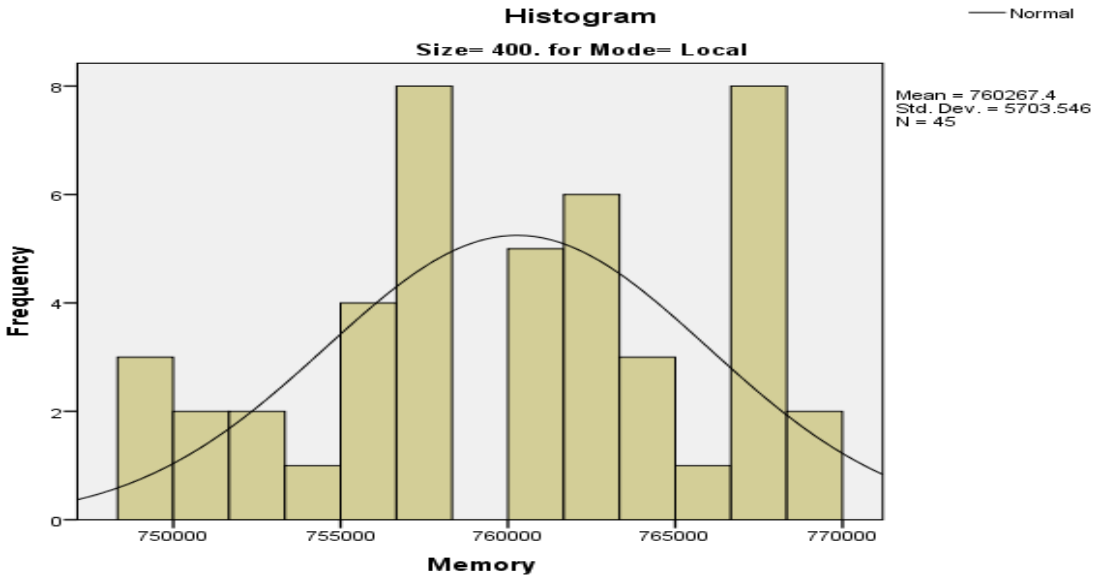
	Mode	Kolmogorov-Smirnov[b]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Memory	Local	.095	45	.200*	.951	45	.058
	Remote	.111	44	.200*	.955	44	.088

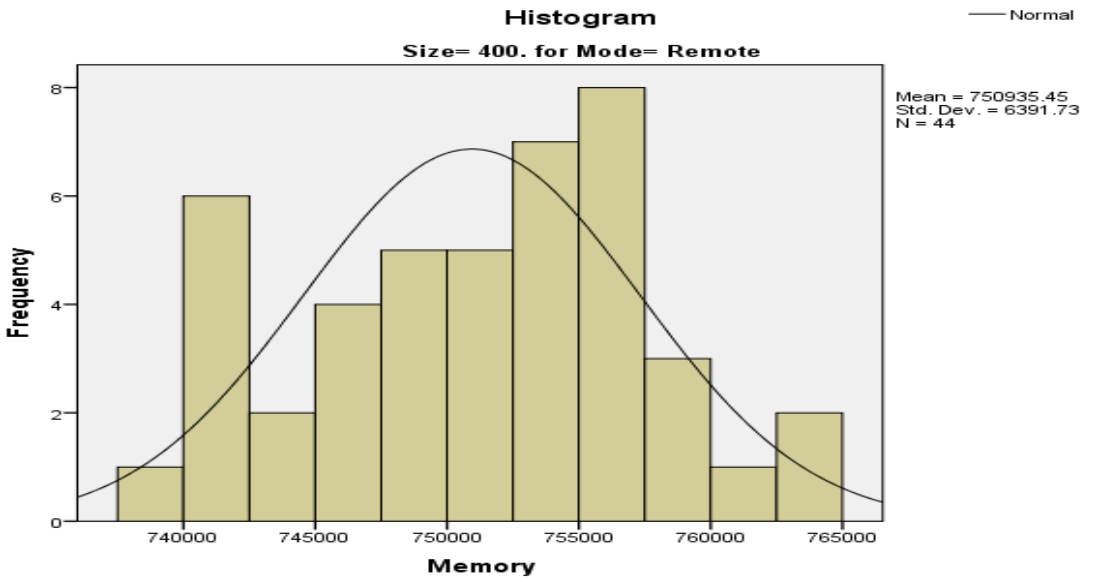
*. This is a lower bound of the true significance.

a. Size = 400

b. Lilliefors Significance Correction

Both groups have produced Sig. values that are greater than 0.05 and curves from both Histograms are normal. Therefore an Independent Sample T Test must be performed for this size. The **Local Mean** value is 760267.4 and **Remote Mean** is 750935.45





Test results for Exp3 v 5 Memory Variable

Table 93

Ranks[a]

	Mode	N	Mean Rank	Sum of Ranks
Memory	Local	45	33.14	1491.50
	Remote	44	57.13	2513.50
	Total	89		

a. Size = 50

Test Statistics[a,b]

	Memory
Mann-Whitney U	456.500
Wilcoxon W	1491.500
Z	-4.378
Asymp. Sig. (2-tailed)	.000

a. Size = 50

b. Grouping Variable: Mode

Table 94

Ranks[a]

	Mode	N	Mean Rank	Sum of Ranks
Memory	Local	45	25.22	1135.00
	Remote	45	65.78	2960.00
	Total	90		

a. Size = 100

Test Statistics[a,b]

	Memory
Mann-Whitney U	100.000
Wilcoxon W	1135.000
Z	-7.364
Asymp. Sig. (2-tailed)	.000

a. Size = 100

b. Grouping Variable: Mode

Table 95

Ranks[a]

	Mode	N	Mean Rank	Sum of Ranks
Memory	Local	47	56.31	2646.50
	Remote	46	37.49	1724.50
	Total	93		

a. Size = 200

Test Statistics[a,b]

	Memory
Mann-Whitney U	643.500
Wilcoxon W	1724.500
Z	-3.362
Asymp. Sig. (2-tailed)	.001

a. Size = 200

b. Grouping Variable: Mode

In the Mann-Whitney Test results above, the Local Mean is significantly better than the Remote Mean in the size 50 and 100 tests. The Independent T-Test results for size 400 are shown on the next page.

Table 96

Group Statistics[a]

	Mode	N	Mean	Std. Deviation	Std. Error Mean
Memory	Local	41	760926.07	5482.810	856.271
	Remotely	45	752902.31	4689.484	699.067

a. Size = 400

Independent Samples Test[a]

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Memory	Equal variances assumed	.328	.568	7.312	84	.000	8023.762	1097.356	5841.549	10205.975
	Equal variances not assumed			7.259	79.133	.000	8023.762	1105.393	5823.589	10223.935

a. Size = 400

The Mean for Memory used in remote group is significantly less than the Mean from the Local group in the size 400 test.

CPU Variable Tests

Normality Tests for Size 50

Table 97

Case Processing Summary[a]

		Cases					
		Valid		Missing		Total	
	Mode	N	Percent	N	Percent	N	Percent
CPU	Local	45	100.0%	0	0.0%	45	100.0%
	Remote	44	100.0%	0	0.0%	44	100.0%

a. Size = 50

Table 98

Descriptives[a]

	Mode			Statistic	Std. Error
CPU	Local	Mean		37.31	3.153
		95% Confidence Interval for Mean	Lower Bound	30.96	
			Upper Bound	43.67	
		5% Trimmed Mean		37.80	
		Median		50.00	
		Variance		447.401	
		Std. Deviation		21.152	
		Minimum		3	
		Maximum		65	
		Range		62	
		Interquartile Range		42	
		Skewness		-.543	.354
		Kurtosis		-1.407	.695
	Remote	Mean		13.66	.481
		95% Confidence Interval for Mean	Lower Bound	12.69	
			Upper Bound	14.63	
		5% Trimmed Mean		13.52	
		Median		13.00	
		Variance		10.183	
		Std. Deviation		3.191	
		Minimum		7	
		Maximum		23	
		Range		16	
		Interquartile Range		5	
		Skewness		.794	.357
		Kurtosis		.596	.702

a. Size = 50

Table 99

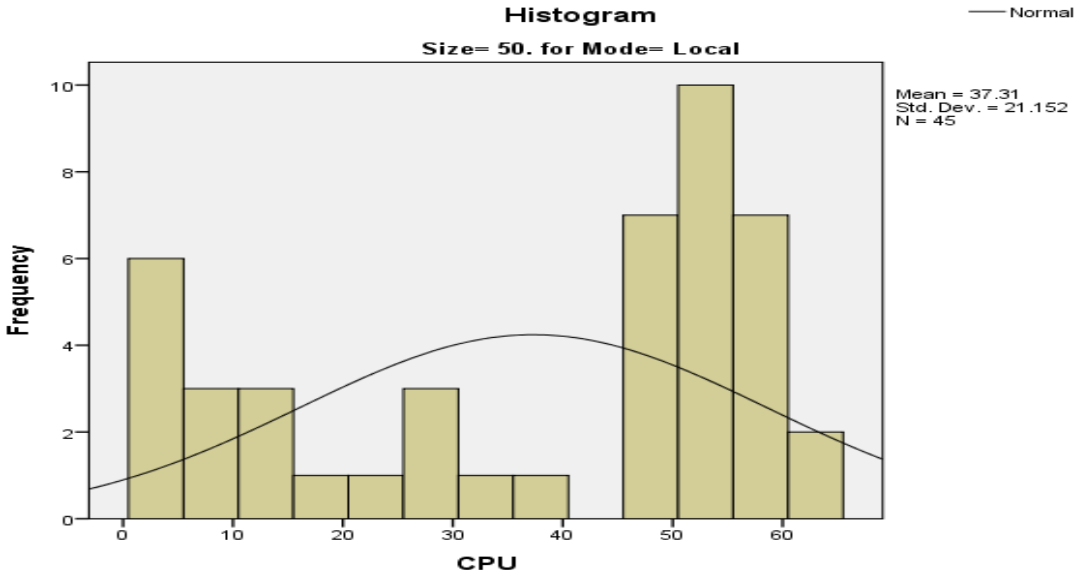
Tests of Normality[a]

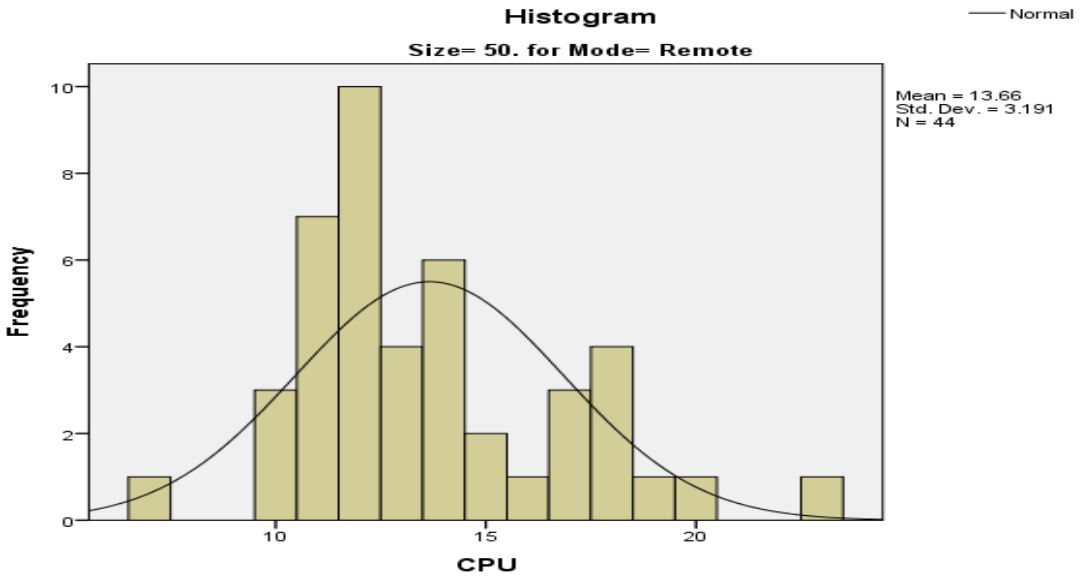
	Mode	Kolmogorov-Smirnov[b]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
CPU	Local	.259	45	.000	.836	45	.000
	Remote	.176	44	.002	.930	44	.010

a. Size = 50

b. Lilliefors Significance Correction

The **Local Mean** value is 37.31 and the **Remote Mean** is 13.66 as shown in the Descriptive table on previous page and Histograms below.





Normality Tests for Size 100

Table 100

Case Processing Summary[a]

		Cases					
		Valid		Missing		Total	
	Mode	N	Percent	N	Percent	N	Percent
CPU	Local	45	100.0%	0	0.0%	45	100.0%
	Remote	45	100.0%	0	0.0%	45	100.0%

a. Size = 100

Table 101

Descriptives[a]

	Mode			Statistic	Std. Error
CPU	Local	Mean		52.69	1.262
		95% Confidence Interval for Mean	Lower Bound	50.15	
			Upper Bound	55.23	
		5% Trimmed Mean		53.61	
		Median		53.00	
		Variance		71.674	
		Std. Deviation		8.466	
		Minimum		6	
		Maximum		64	
		Range		58	
		Interquartile Range		7	
		Skewness		-3.863	.354
		Kurtosis		21.224	.695
	Remote	Mean		53.00	.318
		95% Confidence Interval for Mean	Lower Bound	52.36	
			Upper Bound	53.64	
		5% Trimmed Mean		53.04	
		Median		53.00	
		Variance		4.545	
		Std. Deviation		2.132	
		Minimum		47	
		Maximum		59	
		Range		12	
		Interquartile Range		2	
		Skewness		-.383	.354
		Kurtosis		2.271	.695

a. Size = 100

Table 102

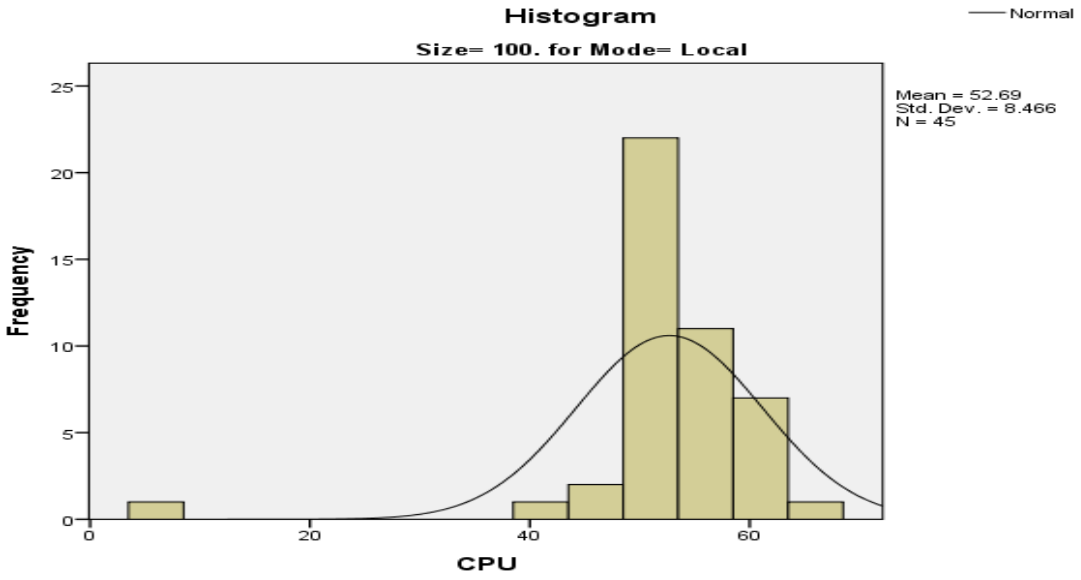
Tests of Normality[a]

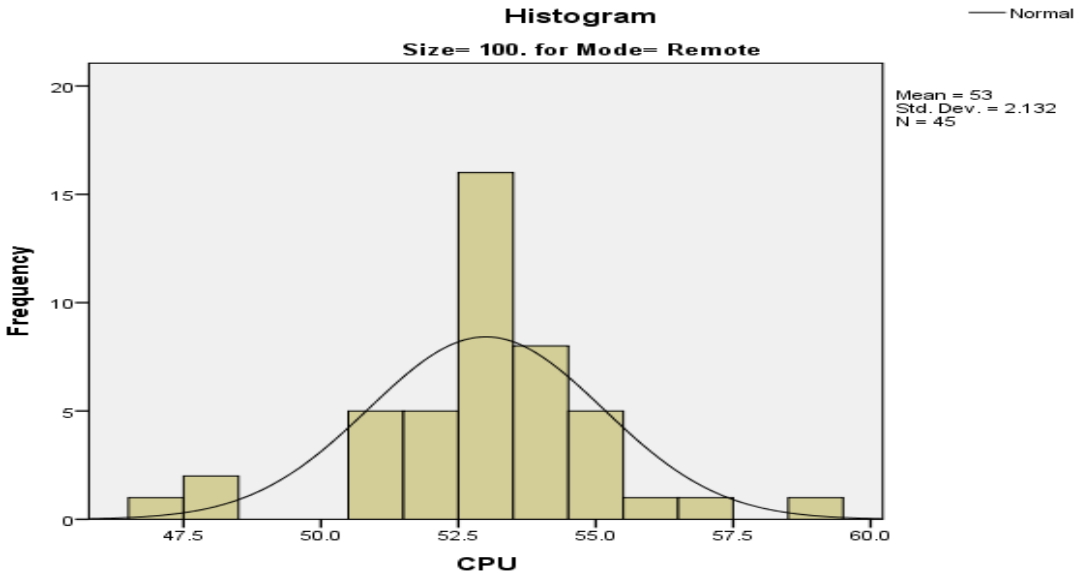
	Mode	Kolmogorov-Smirnov[b]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
CPU	Local	.264	45	.000	.641	45	.000
	Remote	.211	45	.000	.912	45	.002

a. Size = 100

b. Lilliefors Significance Correction

The **Local Mean** value is 52.69 and the **Remote Mean** is 53 as shown in the Descriptive table on previous page and Histograms below.





Normality for Size 200

Table 102

Case Processing Summary[a]

		Cases					
		Valid		Missing		Total	
	Mode	N	Percent	N	Percent	N	Percent
CPU	Local	47	100.0%	0	0.0%	47	100.0%
	Remote	46	100.0%	0	0.0%	46	100.0%

a. Size = 200

Table 103

Descriptives[a]

	Mode			Statistic	Std. Error
CPU	Local	Mean		52.49	.867
		95% Confidence Interval for Mean	Lower Bound	50.74	
			Upper Bound	54.23	
		5% Trimmed Mean		53.09	
		Median		53.00	
		Variance		35.342	
		Std. Deviation		5.945	
		Minimum		22	
		Maximum		61	
		Range		39	
		Interquartile Range		5	
		Skewness		-3.049	.347
		Kurtosis		14.803	.681
	Remote	Mean		55.00	.315
		95% Confidence Interval for Mean	Lower Bound	54.36	
			Upper Bound	55.64	
		5% Trimmed Mean		54.98	
		Median		55.00	
		Variance		4.578	
		Std. Deviation		2.140	
		Minimum		50	
		Maximum		61	
		Range		11	
		Interquartile Range		2	
		Skewness		-.014	.350
		Kurtosis		.601	.688

a. Size = 200

Table 104

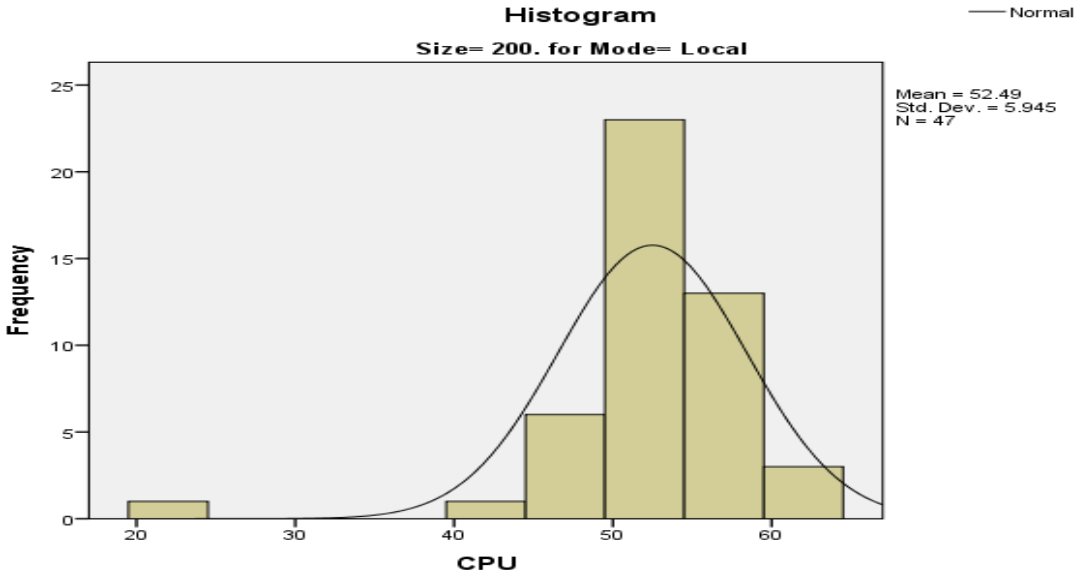
Tests of Normality[a]

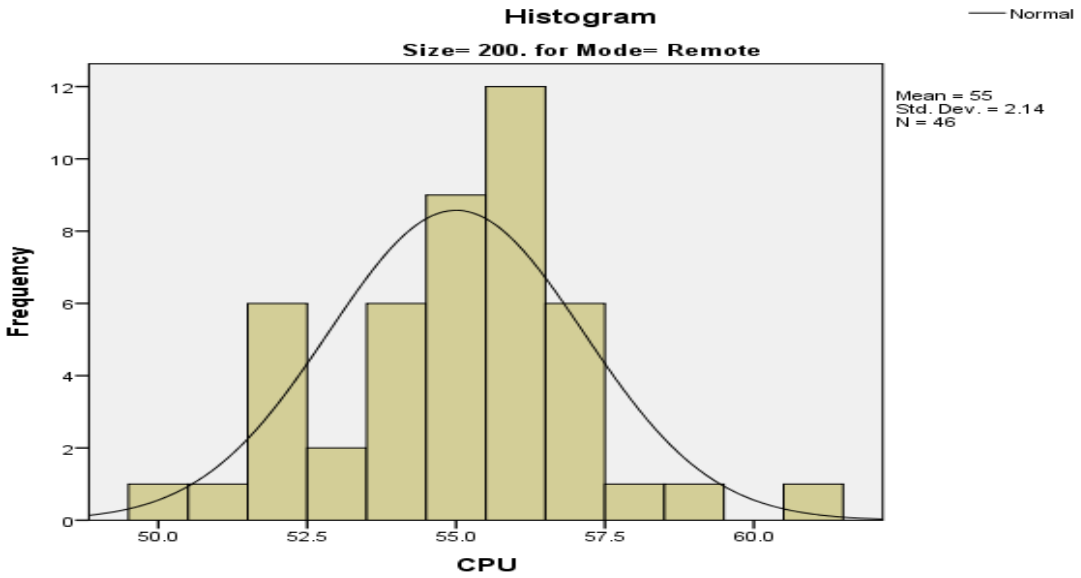
	Mode	Kolmogorov-Smirnov[b]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
CPU	Local	.194	47	.000	.735	47	.000
	Remote	.152	46	.009	.955	46	.075

a. Size = 200

b. Lilliefors Significance Correction

The **Local Mean** value is 52.49 and the **Remote Mean** is 55 as shown in the Descriptive table on previous page and Histograms below.





Normality Tests for Size 400

Table 105

Case Processing Summary[a]

		Cases					
		Valid		Missing		Total	
	Mode	N	Percent	N	Percent	N	Percent
CPU	Local	45	100.0%	0	0.0%	45	100.0%
	Remote	44	100.0%	0	0.0%	44	100.0%

a. Size = 400

Table 106

Descriptives[a]

	Mode			Statistic	Std. Error
CPU	Local	Mean		53.89	.494
		95% Confidence Interval for Mean	Lower Bound	52.89	
			Upper Bound	54.88	
		5% Trimmed Mean		53.59	
		Median		53.00	
		Variance		10.965	
		Std. Deviation		3.311	
		Minimum		48	
		Maximum		73	
		Range		25	
		Interquartile Range		2	
		Skewness		4.402	.354
		Kurtosis		26.020	.695
	Remote	Mean		54.11	.256
		95% Confidence Interval for Mean	Lower Bound	53.60	
			Upper Bound	54.63	
		5% Trimmed Mean		54.27	
		Median		54.00	
		Variance		2.894	
		Std. Deviation		1.701	
		Minimum		45	
		Maximum		56	
		Range		11	
		Interquartile Range		1	
		Skewness		-3.571	.357
		Kurtosis		19.117	.702

a. Size = 400

Table 107

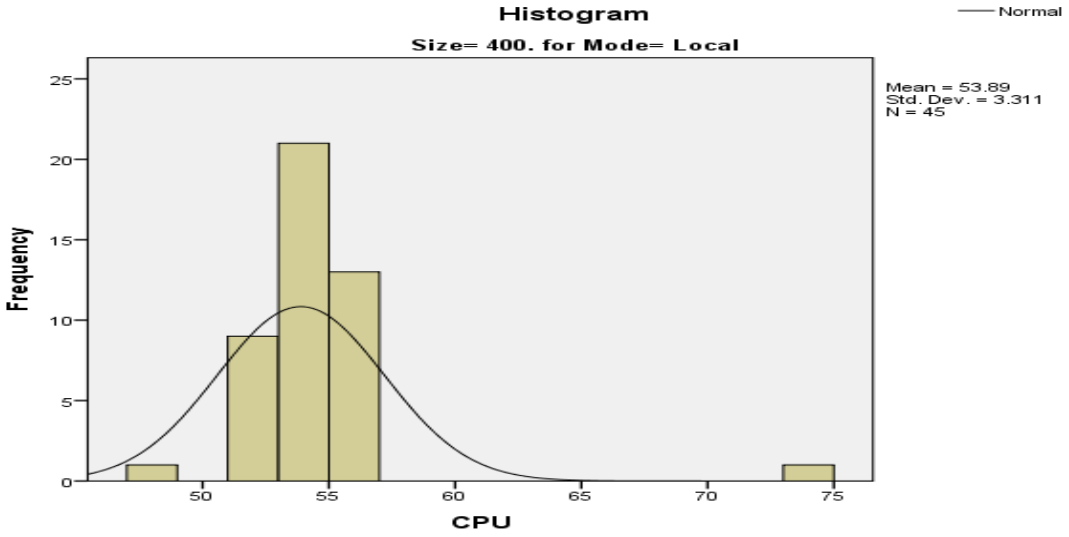
Tests of Normality[a]

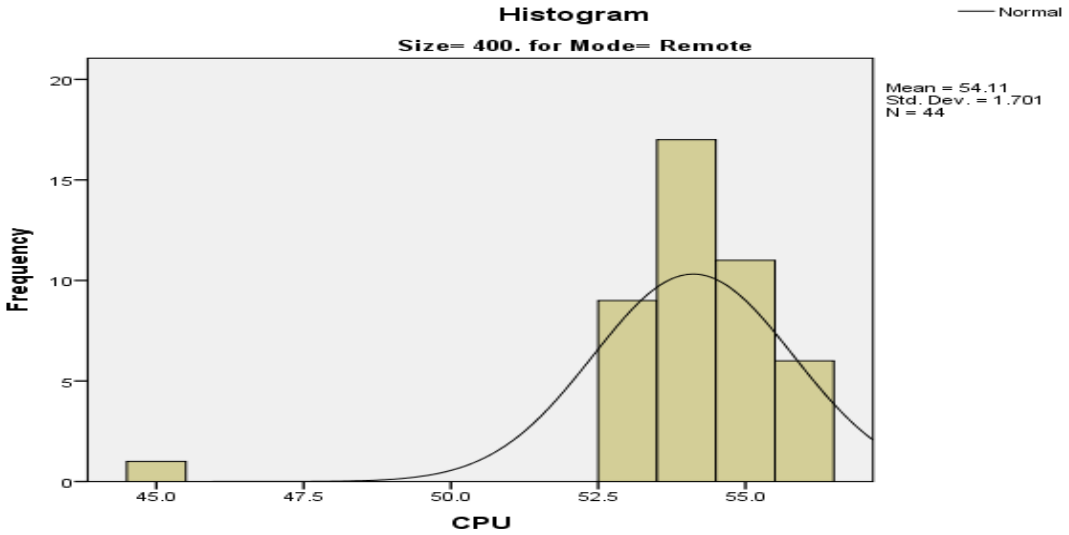
	Mode	Kolmogorov-Smirnov[b]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
CPU	Local	.257	45	.000	.560	45	.000
	Remote	.246	44	.000	.640	44	.000

a. Size = 400

b. Lilliefors Significance Correction

In all Normality Tests for CPU variable, all thee **Sig.** values were found to be under 0.05 and all curves from the Histograms are on non-normal. Only a Mann-Whitney Test can be performed for all sizes in this variable. The **Local Mean** value is 53.89 and the **Remote Mean** is 54.11 as shown in the Descriptive table on previous page and Histograms below.





Test results for Exp3 v 5 CPU Variable

Table 108

Ranks[a]

	Mode	N	Mean Rank	Sum of Ranks
CPU	Local	45	56.19	2528.50
	Remote	44	33.56	1476.50
	Total	89		

a. Size = 50

Test Statistics[a,b]

	CPU
Mann-Whitney U	486.500
Wilcoxon W	1476.500
Z	-4.139
Asymp. Sig. (2-tailed)	.000

a. Size = 50

b. Grouping Variable: Mode

Table 109

Ranks[a]

	Mode	N	Mean Rank	Sum of Ranks
CPU	Local	45	45.41	2043.50
	Remote	45	45.59	2051.50
	Total	90		

a. Size = 100

Test Statistics[a,b]

	CPU
Mann-Whitney U	1008.500
Wilcoxon W	2043.500
Z	-.033
Asymp. Sig. (2-tailed)	.974

a. Size = 100

b. Grouping Variable: Mode

Table 110

Ranks[a]

	Mode	N	Mean Rank	Sum of Ranks
CPU	Local	47	38.89	1828.00
	Remote	46	55.28	2543.00
	Total	93		

a. Size = 200

Test Statistics[a,b]

	CPU
Mann-Whitney U	700.000
Wilcoxon W	1828.000
Z	-2.949
Asymp. Sig. (2-tailed)	.003

a. Size = 200

b. Grouping Variable: Mode

Table 111

Ranks[a]

	Mode	N	Mean Rank	Sum of Ranks
CPU	Local	45	38.64	1739.00
	Remote	44	51.50	2266.00
	Total	89		

a. Size = 400

Test Statistics[a,b]

	CPU
Mann-Whitney U	704.000
Wilcoxon W	1739.000
Z	-2.408
Asymp. Sig. (2-tailed)	.016

a. Size = 400

b. Grouping Variable: Mode

From the above results, in the size 50 results the Remote Mean is significantly lower than the Local Mean. In size 100 results, there is no significant difference between the two groups. In the higher two sizes, the Local CPU Mean is significantly lower than the Remote Mean.

Computation Variable Tests

Normality Tests for size 50

Table 112

Case Processing Summary[a]

		Cases					
		Valid		Missing		Total	
	Mode	N	Percent	N	Percent	N	Percent
CompTime	Local	45	100.0%	0	0.0%	45	100.0%
	Remote	44	100.0%	0	0.0%	44	100.0%

a. Size = 50

Table 113

Descriptives[a]

	Mode			Statistic	Std. Error
CompTime	Local	Mean		12.20000	1.319856
		95% Confidence Interval for Mean	Lower Bound	9.54000	
			Upper Bound	14.86000	
		5% Trimmed Mean		11.34568	
		Median		8.00000	
		Variance		78.391	
		Std. Deviation		8.853864	
		Minimum		4.000	
		Maximum		37.000	
		Range		33.000	
		Interquartile Range		10.000	
		Skewness		1.320	.354
		Kurtosis		.915	.695
	Remote	Mean		.28655	.009855
		95% Confidence Interval for Mean	Lower Bound	.26667	
			Upper Bound	.30642	
		5% Trimmed Mean		.28288	
		Median		.29135	
		Variance		.004	
		Std. Deviation		.065369	
		Minimum		.208	
		Maximum		.444	
		Range		.236	
		Interquartile Range		.114	
		Skewness		.491	.357
		Kurtosis		-.486	.702

a. Size = 50

Table 114

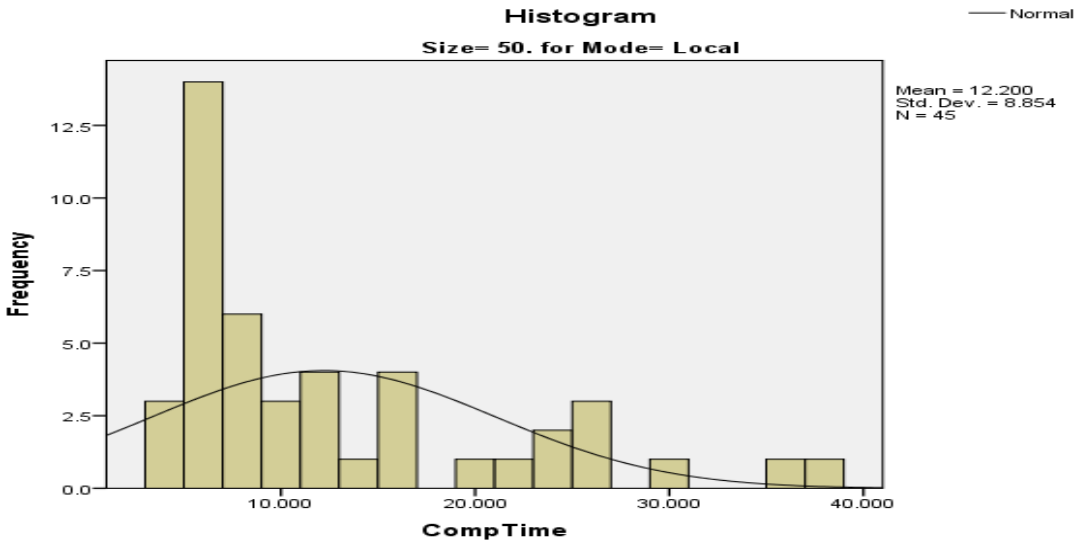
Tests of Normality[a]

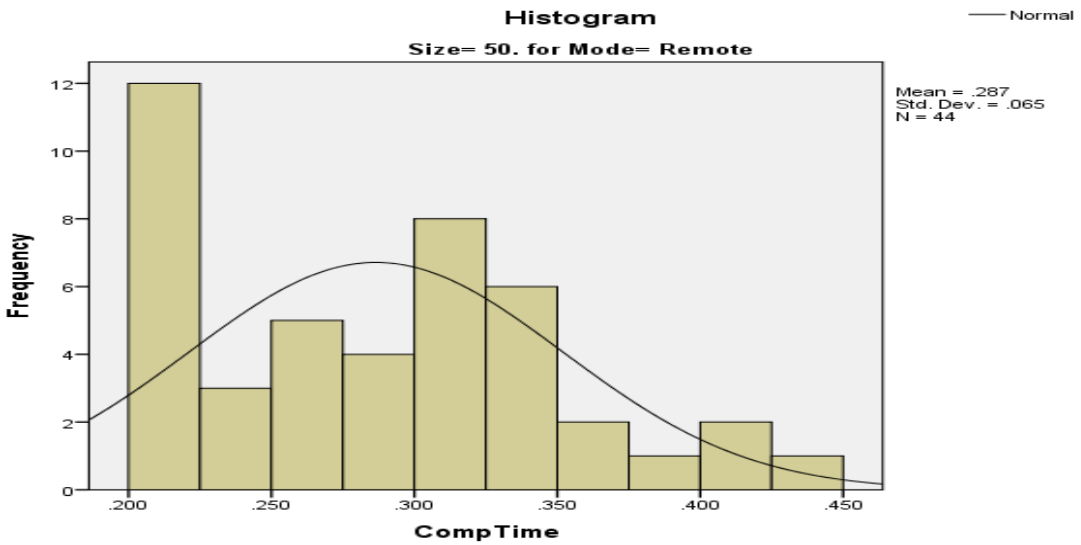
		Kolmogorov-Smirnov[b]			Shapiro-Wilk		
	Mode	Statistic	df	Sig.	Statistic	df	Sig.
CompTime	Local	.210	45	.000	.815	45	.000
	Remote	.113	44	.190	.923	44	.006

a. Size = 50

b. Lilliefors Significance Correction

Both **Sig.** values from the two groups are under 0.05 and the curves from both Histograms are non-normal. This means that a Mann-Whitney Test must be performed for size 50. The **Local Mean** value is 12.2 and the **Remote Mean** is 0.287 as shown in the Descriptive table on previous page and Histograms below.





Normality Tests for size 100

Table 115

Case Processing Summary[a]

		Cases					
		Valid		Missing		Total	
	Mode	N	Percent	N	Percent	N	Percent
CompTime	Local	45	100.0%	0	0.0%	45	100.0%
	Remote	45	100.0%	0	0.0%	45	100.0%

a. Size = 100

Table 116

Descriptives[a]

	Mode			Statistic	Std. Error
CompTime	Local	Mean		19.22222	.704164
		95% Confidence Interval for Mean	Lower Bound	17.80307	
			Upper Bound	20.64137	
		5% Trimmed Mean		18.59259	
		Median		17.00000	
		Variance		22.313	
		Std. Deviation		4.723678	
		Minimum		16.000	
		Maximum		35.000	
		Range		19.000	
		Interquartile Range		2.000	
		Skewness		2.109	.354
		Kurtosis		3.813	.695
	Remote	Mean		1.86667	.081650
		95% Confidence Interval for Mean	Lower Bound	1.70211	
			Upper Bound	2.03122	
		5% Trimmed Mean		1.85185	
		Median		2.00000	
		Variance		.300	
		Std. Deviation		.547723	
		Minimum		1.000	
		Maximum		3.000	
		Range		2.000	
		Interquartile Range		.000	
		Skewness		-.089	.354
		Kurtosis		.330	.695

a. Size = 100

Table 117

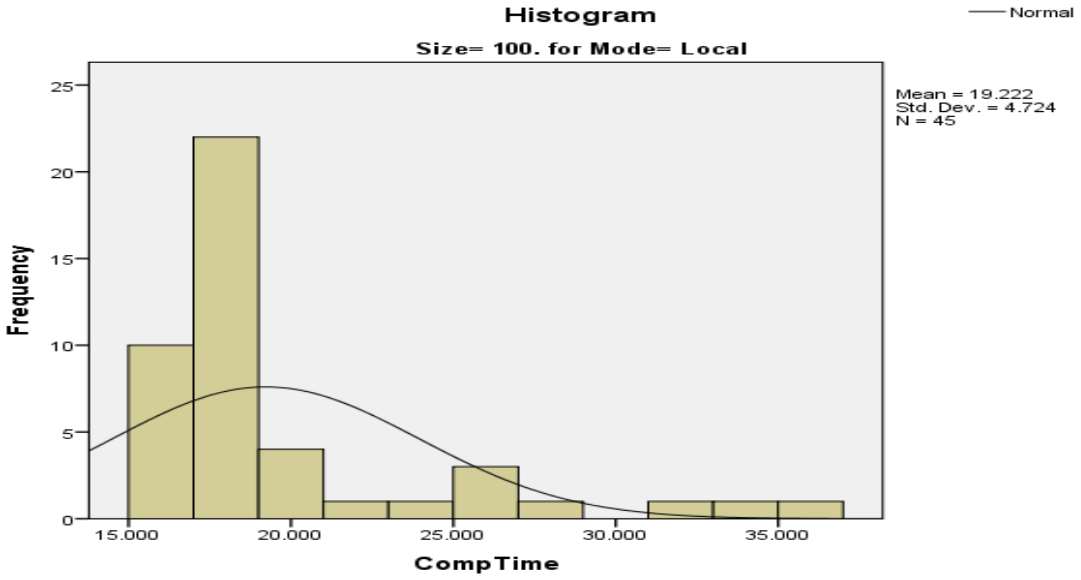
Tests of Normality[a]

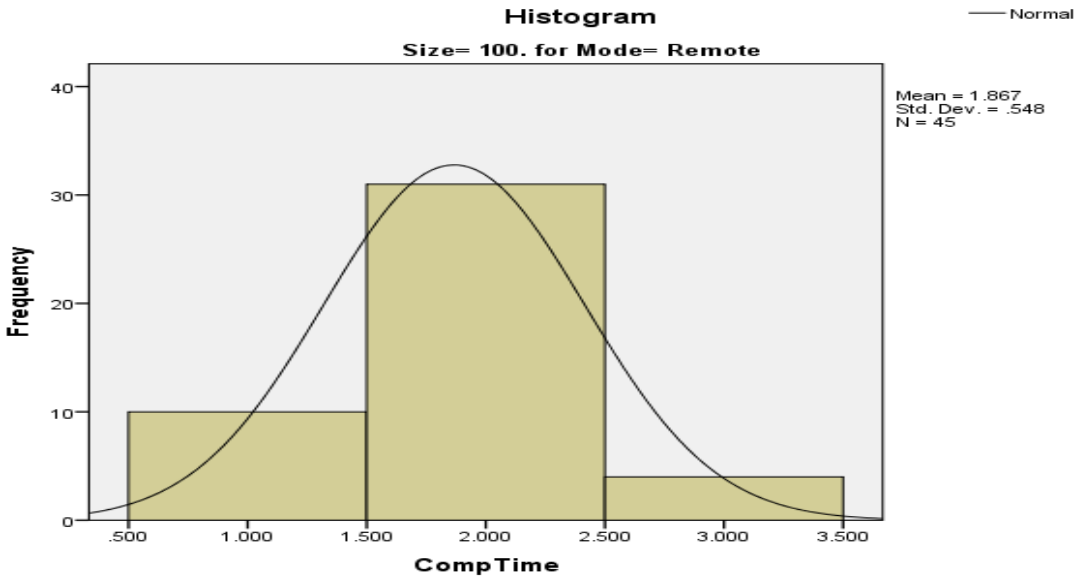
	Mode	Kolmogorov-Smirnov[b]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
CompTime	Local	.313	45	.000	.668	45	.000
	Remote	.374	45	.000	.720	45	.000

a. Size = 100

b. Lilliefors Significance Correction

As with the previous size, both **Sig.** values are under 0.05 and the curves from both Histograms are non-normal. The Mann-Whitney Test must be performed for size 100 as well as size 50. The **Local Mean** value is 19.222 and the **Remote Mean** is 1.867 as shown in the Descriptive table on previous page and Histograms below.





Normality Test for size 200

Table 118

Case Processing Summary[a]

		Cases					
		Valid		Missing		Total	
	Mode	N	Percent	N	Percent	N	Percent
CompTime	Local	47	100.0%	0	0.0%	47	100.0%
	Remote	46	100.0%	0	0.0%	46	100.0%

a. Size = 200

Table 119

Descriptives[a]

	Mode			Statistic	Std. Error
CompTime	Local	Mean		11.89362	.365276
		95% Confidence Interval for Mean	Lower Bound	11.15835	
			Upper Bound	12.62888	
		5% Trimmed Mean		11.64421	
		Median		11.00000	
		Variance		6.271	
		Std. Deviation		2.504206	
		Minimum		10.000	
		Maximum		20.000	
		Range		10.000	
		Interquartile Range		3.000	
		Skewness		1.393	.347
		Kurtosis		1.273	.681
	Remote	Mean		28.60870	1.175629
		95% Confidence Interval for Mean	Lower Bound	26.24086	
			Upper Bound	30.97653	
		5% Trimmed Mean		28.17150	
		Median		28.00000	
		Variance		63.577	
		Std. Deviation		7.973507	
		Minimum		14.000	
		Maximum		52.000	
		Range		38.000	
		Interquartile Range		11.000	
		Skewness		.701	.350
		Kurtosis		1.165	.688

a. Size = 200

Table 120

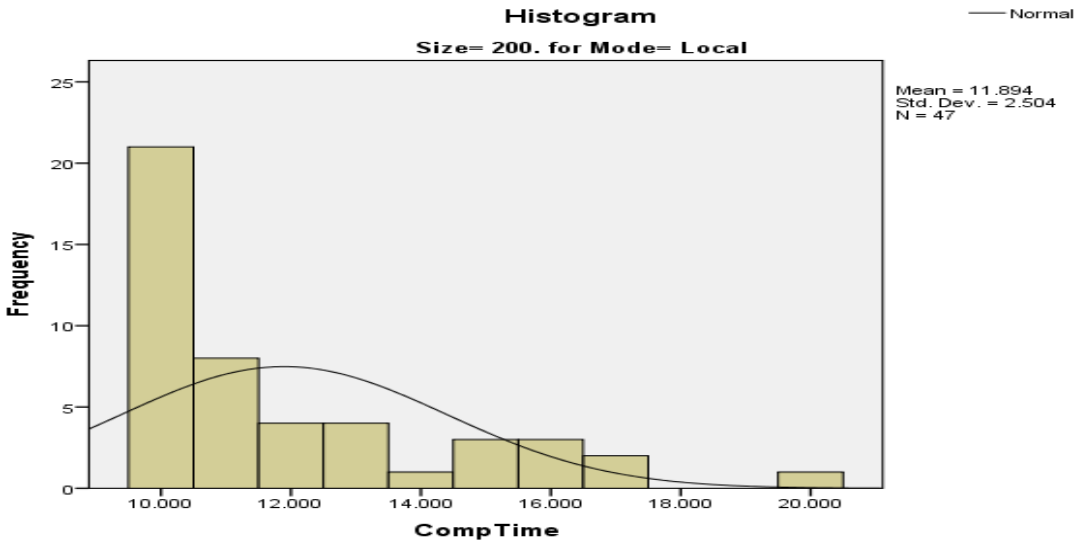
Tests of Normality[a]

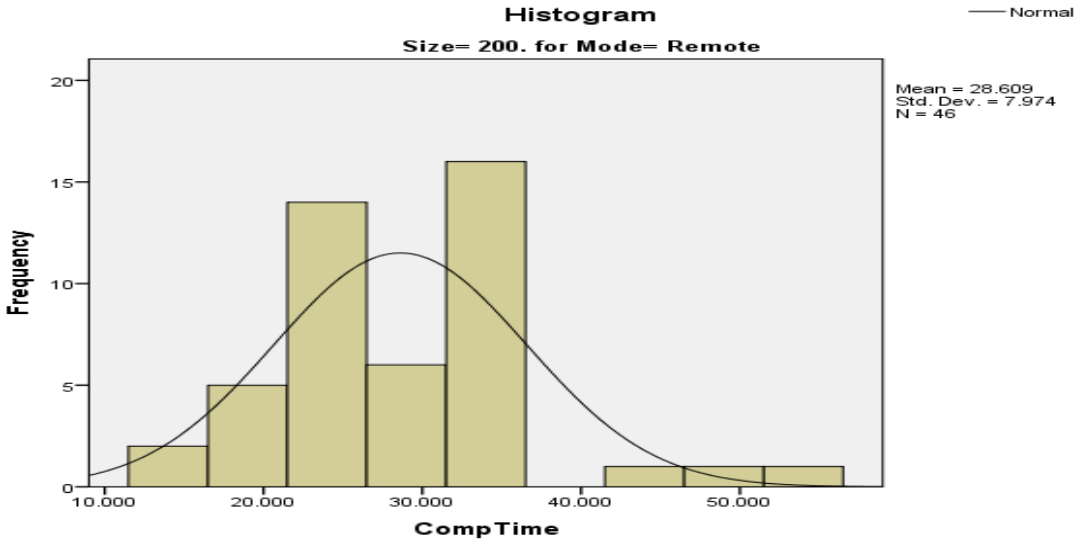
		Kolmogorov-Smirnov[b]			Shapiro-Wilk		
	Mode	Statistic	df	Sig.	Statistic	df	Sig.
CompTime	Local	.256	47	.000	.774	47	.000
	Remote	.112	46	.191	.950	46	.045

a. Size = 200

b. Lilliefors Significance Correction

Both Sig. values are under 0.05, the Remote Sig. value is only just under the threshold. The Remote Histogram also shows it is close to having a normal curve. However neither group reach the required target, so a Mann-Whitney Test has to be performed. The **Local Mean** value is 11.894 and the **Remote Mean** is 28.609 as shown in the Descriptive table on previous page and Histograms below.





Normality Tests for Size 400

Table 121

Case Processing Summary[a]

		Cases					
		Valid		Missing		Total	
	Mode	N	Percent	N	Percent	N	Percent
CompTime	Local	45	100.0%	0	0.0%	45	100.0%
	Remote	44	100.0%	0	0.0%	44	100.0%

a. Size = 400

Table 122

Descriptives[a]

	Mode			Statistic	Std. Error
CompTime	Local	Mean		41.75556	.695698
		95% Confidence Interval for Mean	Lower Bound	40.35347	
			Upper Bound	43.15764	
		5% Trimmed Mean		41.22222	
		Median		40.00000	
		Variance		21.780	
		Std. Deviation		4.666883	
		Minimum		37.000	
		Maximum		57.000	
		Range		20.000	
		Interquartile Range		6.000	
		Skewness		1.708	.354
		Kurtosis		3.245	.695
	Remote	Mean		325.95455	4.744303
		95% Confidence Interval for Mean	Lower Bound	316.38675	
			Upper Bound	335.52234	
		5% Trimmed Mean		322.86869	
		Median		320.00000	
		Variance		990.370	
		Std. Deviation		31.470144	
		Minimum		288.000	
		Maximum		461.000	
		Range		173.000	
		Interquartile Range		31.750	
		Skewness		2.126	.357
		Kurtosis		6.807	.702

a. Size = 400

Table 123

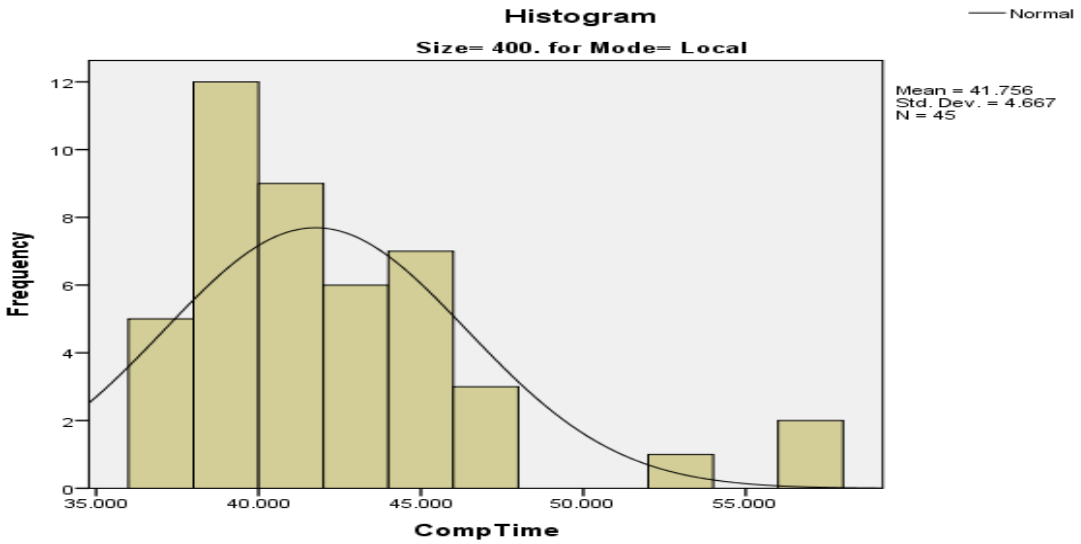
Tests of Normality[a]

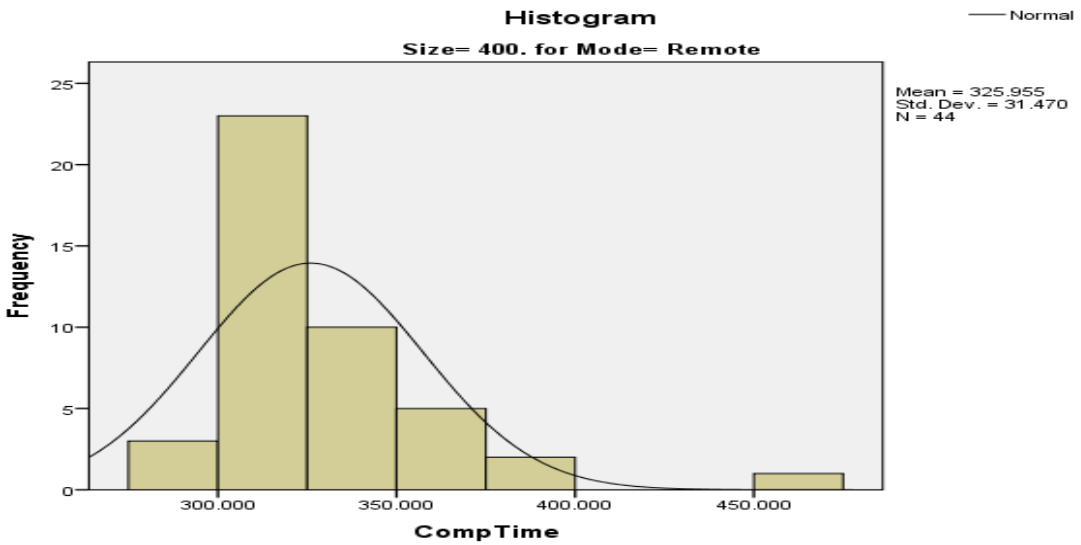
	Mode	Kolmogorov-Smirnov[b]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
CompTime	Local	.180	45	.001	.824	45	.000
	Remote	.181	44	.001	.822	44	.000

a. Size = 400

b. Lilliefors Significance Correction

Both groups **Sig.** values are under 0.05 and the curves from both Histograms show non-normal curves, therefore the Mann-Whitney Test has to be performed. The **Local Mean** value is 41.756 and the **Remote Mean** is 325.955 as shown in the Descriptive table on previous page and Histograms below.





Test Results for Exp3 v 5 Computation Times variable

Table 124

Ranks[a]

	Mode	N	Mean Rank	Sum of Ranks
CompTime	Local	45	67.00	3015.00
	Remote	44	22.50	990.00
	Total	89		

a. Size = 50

Test Statistics[a,b]

	CompTime
Mann-Whitney U	.000
Wilcoxon W	990.000
Z	-8.130
Asymp. Sig. (2-tailed)	.000

a. Size = 50

b. Grouping Variable: Mode

Table 125

Ranks[a]

	Mode	N	Mean Rank	Sum of Ranks
CompTime	Local	45	68.00	3060.00
	Remote	45	23.00	1035.00
	Total	90		

a. Size = 100

Test Statistics[a,b]

	CompTime
Mann-Whitney U	.000
Wilcoxon W	1035.000
Z	-8.377
Asymp. Sig. (2-tailed)	.000

a. Size = 100

b. Grouping Variable: Mode

Table 126

Ranks[a]

	Mode	N	Mean Rank	Sum of Ranks
CompTime	Local	47	24.44	1148.50
	Remote	46	70.05	3222.50
	Total	93		

a. Size = 200

Test Statistics[a,b]

	CompTime
Mann-Whitney U	20.500
Wilcoxon W	1148.500
Z	-8.202
Asymp. Sig. (2-tailed)	.000

a. Size = 200

b. Grouping Variable: Mode

Table 127

Ranks[a]

	Mode	N	Mean Rank	Sum of Ranks
CompTime	Local	45	23.00	1035.00
	Remote	44	67.50	2970.00
	Total	89		

a. Size = 400

Test Statistics[a,b]

	CompTime
Mann-Whitney U	.000
Wilcoxon W	1035.000
Z	-8.131
Asymp. Sig. (2-tailed)	.000

a. Size = 400

b. Grouping Variable: Mode

From the results above, size 50 and 100 show the Remote Mean value is significantly lower than the Local. In the bigger sizes, the trend reverses and the Local Mean shows a significantly lower time than the Remote Mean value.

Total Time Variable Tests

Normality Tests for Size 50

Table 128

Case Processing Summary[a]

		Cases					
		Valid		Missing		Total	
	Mode	N	Percent	N	Percent	N	Percent
TotalTime	Local	45	100.0%	0	0.0%	45	100.0%
	Remote	44	100.0%	0	0.0%	44	100.0%

a. Size = 50

Table 129

Descriptives[a]

	Mode			Statistic	Std. Error
TotalTime	Local	Mean		23.60	1.656
		95% Confidence Interval for Mean	Lower Bound	20.26	
			Upper Bound	26.94	
		5% Trimmed Mean		22.62	
		Median		19.00	
		Variance		123.427	
		Std. Deviation		11.110	
		Minimum		12	
		Maximum		58	
		Range		46	
		Interquartile Range		16	
		Skewness		1.271	.354
		Kurtosis		.992	.695
	Remote	Mean		3376.00	85.736
		95% Confidence Interval for Mean	Lower Bound	3203.10	
			Upper Bound	3548.90	
		5% Trimmed Mean		3398.11	
		Median		3387.50	
		Variance		323427.907	
		Std. Deviation		568.707	
		Minimum		1113	
		Maximum		4726	
		Range		3613	
		Interquartile Range		659	
		Skewness		-1.150	.357
		Kurtosis		5.005	.702

a. Size = 50

Table 130

Tests of Normality[a]

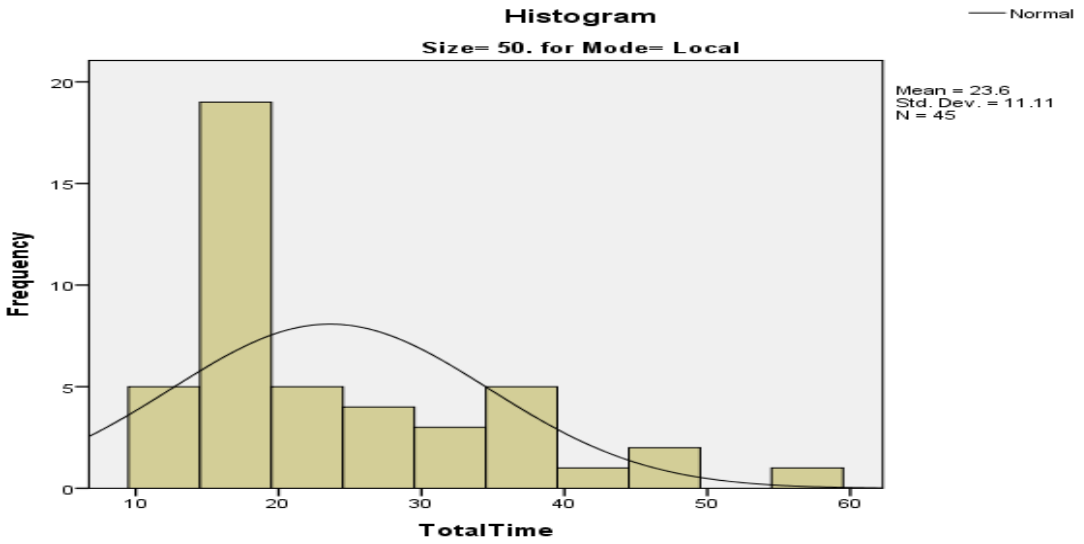
	Mode	Kolmogorov-Smirnov[b]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
TotalTime	Local	.215	45	.000	.842	45	.000
	Remote	.105	44	.200*	.916	44	.004

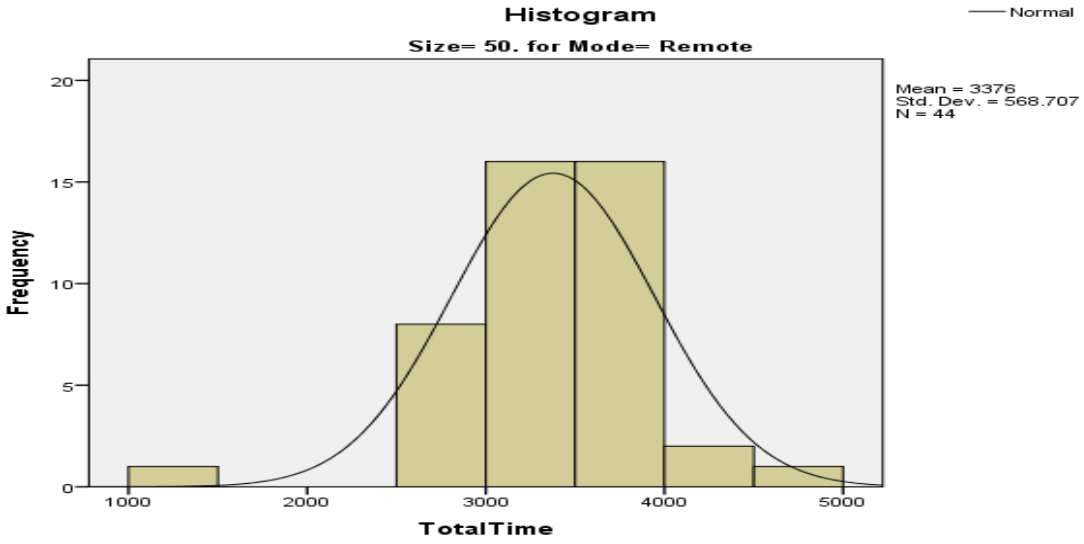
*. This is a lower bound of the true significance.

a. Size = 50

b. Lilliefors Significance Correction

From the table above, both Sig. values are under 0.05 and the curves from the Histograms below are non-normal. This means only a Mann-Whitney Test can be performed. The **Local Mean** value is 23.6 and the **Remote Mean** is 3376 as shown in the Descriptive table on previous page and Histograms below.





Normality Tests for Size 100

Table 131

Case Processing Summary[a]

		Cases					
		Valid		Missing		Total	
	Mode	N	Percent	N	Percent	N	Percent
TotalTime	Local	45	100.0%	0	0.0%	45	100.0%
	Remote	45	100.0%	0	0.0%	45	100.0%

a. Size = 100

Table 132

Descriptives[a]

	Mode			Statistic	Std. Error
TotalTime	Local	Mean		67.71	3.180
		95% Confidence Interval for Mean	Lower Bound	61.30	
			Upper Bound	74.12	
		5% Trimmed Mean		69.40	
		Median		72.00	
		Variance		455.028	
		Std. Deviation		21.331	
		Minimum		10	
		Maximum		99	
		Range		89	
		Interquartile Range		10	
		Skewness		-1.951	.354
		Kurtosis		3.218	.695
	Remote	Mean		3453.84	43.402
		95% Confidence Interval for Mean	Lower Bound	3366.37	
			Upper Bound	3541.32	
		5% Trimmed Mean		3456.24	
		Median		3404.00	
		Variance		84768.225	
		Std. Deviation		291.150	
		Minimum		2193	
		Maximum		4132	
		Range		1939	
		Interquartile Range		269	
		Skewness		-1.170	.354
		Kurtosis		7.840	.695

a. Size = 100

Table 133

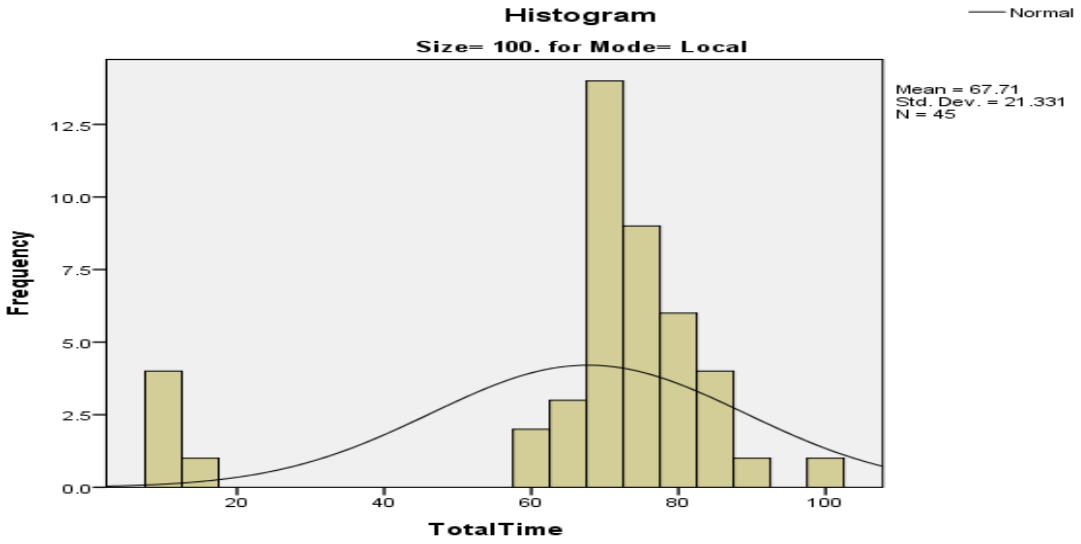
Tests of Normality[a]

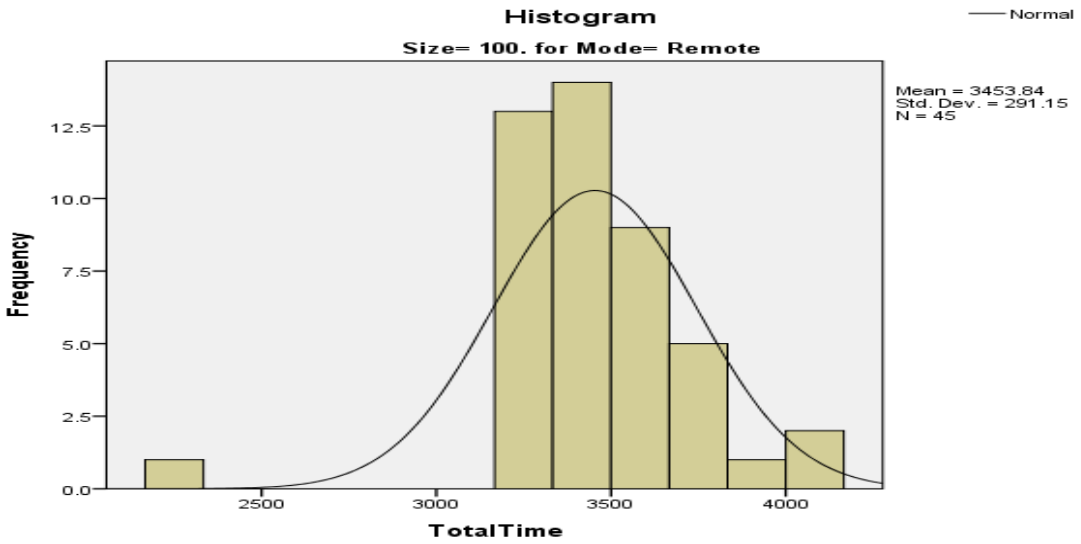
	Mode	Kolmogorov-Smirnov[b]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
TotalTime	Local	.290	45	.000	.702	45	.000
	Remote	.191	45	.000	.818	45	.000

a. Size = 100

b. Lilliefors Significance Correction

As in the last size, in the table above both groups have produced **Sig.** values under 0.05 and the curves from both Histograms are non-normal. As before, the Mann-Whitney Test has to be performed. The **Local Mean** value is 67.71 and the **Remote Mean** is 3453.84 as shown in the Descriptive table on previous page and Histograms below.





Normality Tests for Size 200

Table 134

Case Processing Summary[a]

		Cases					
		Valid		Missing		Total	
	Mode	N	Percent	N	Percent	N	Percent
TotalTime	Local	47	100.0%	0	0.0%	47	100.0%
	Remote	46	100.0%	0	0.0%	46	100.0%

a. Size = 200

Table 135

Descriptives[a]

	Mode			Statistic	Std. Error
TotalTime	Local	Mean		577.85	6.951
		95% Confidence Interval for Mean	Lower Bound	563.86	
			Upper Bound	591.84	
		5% Trimmed Mean		576.91	
		Median		570.00	
		Variance		2271.173	
		Std. Deviation		47.657	
		Minimum		502	
		Maximum		673	
		Range		171	
		Interquartile Range		80	
		Skewness		.301	.347
		Kurtosis		-1.087	.681
	Remote	Mean		5352.59	372.031
		95% Confidence Interval for Mean	Lower Bound	4603.28	
			Upper Bound	6101.90	
		5% Trimmed Mean		5194.82	
		Median		4824.50	
		Variance		6366740.159	
		Std. Deviation		2523.240	
		Minimum		2615	
		Maximum		10916	
		Range		8301	
		Interquartile Range		2574	
		Skewness		1.075	.350
		Kurtosis		-.005	.688

a. Size = 200

Table 136

Tests of Normality[a]

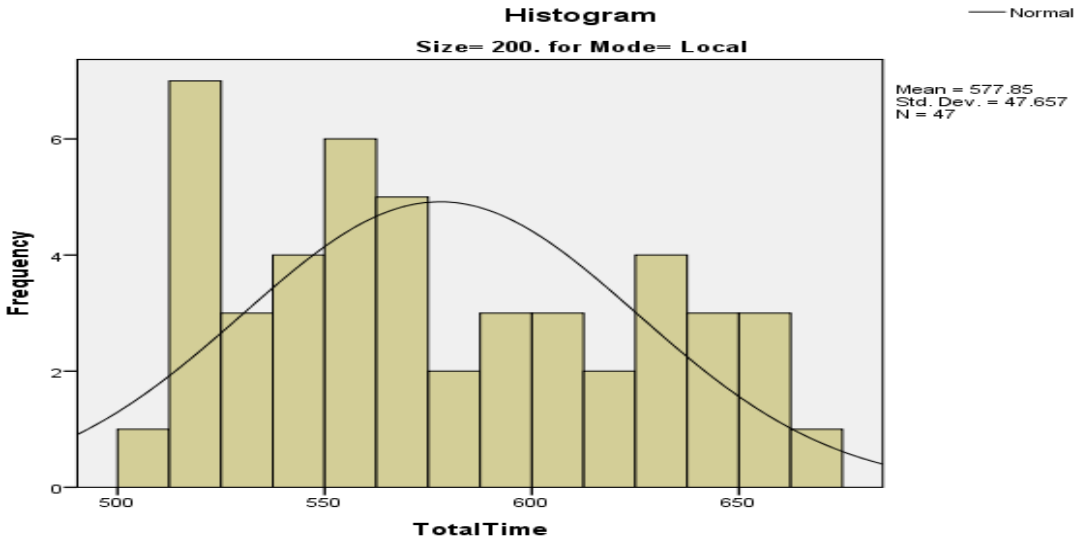
		Kolmogorov-Smirnov[b]			Shapiro-Wilk		
	Mode	Statistic	df	Sig.	Statistic	df	Sig.
TotalTime	Local	.096	47	.200*	.947	47	.033
	Remote	.245	46	.000	.838	46	.000

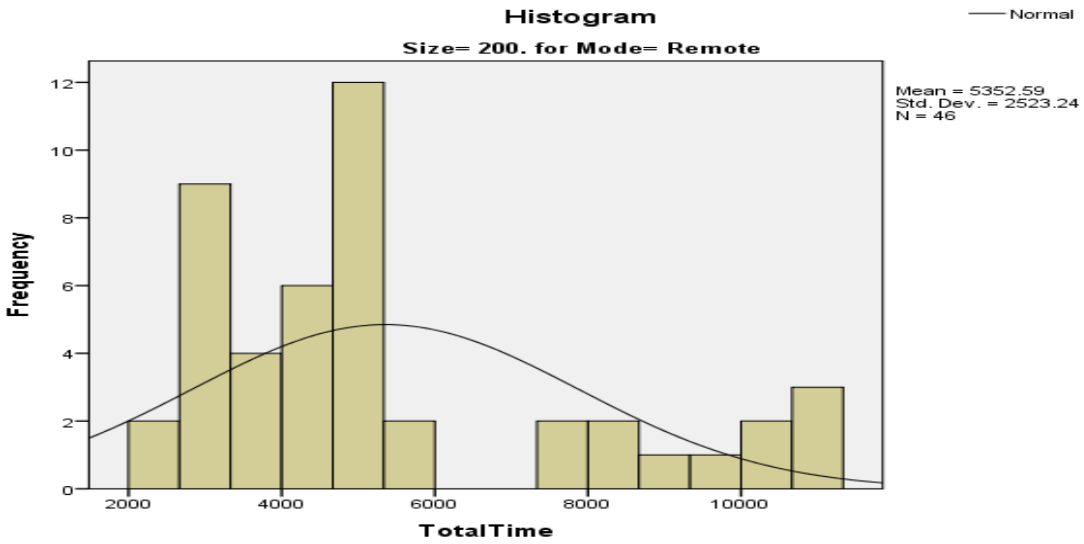
*. This is a lower bound of the true significance.

a. Size = 200

b. Lilliefors Significance Correction

As in size 50 and 100, both **Sig.** value shown in the table above are under 0.05 and both curves from the Histograms below are non-normal. Only the Mann-Whitney Test can be performed. The **Local Mean** value is 577.85 and the **Remote Mean** is 5332.59 as shown in the Descriptive table on previous page and Histograms below.





Normality Tests for Size 400

Table 137

Case Processing Summary[a]

		Cases					
		Valid		Missing		Total	
	Mode	N	Percent	N	Percent	N	Percent
TotalTime	Local	45	100.0%	0	0.0%	45	100.0%
	Remote	44	100.0%	0	0.0%	44	100.0%

a. Size = 400

Table 138

Descriptives[a]

	Mode			Statistic	Std. Error
TotalTime	Local	Mean		5094.80	43.970
		95% Confidence Interval for Mean	Lower Bound	5006.18	
			Upper Bound	5183.42	
		5% Trimmed Mean		5072.22	
		Median		5013.00	
		Variance		87001.482	
		Std. Deviation		294.960	
		Minimum		4737	
		Maximum		5914	
		Range		1177	
		Interquartile Range		385	
		Skewness		1.036	.354
		Kurtosis		.628	.695
	Remote	Mean		12617.23	619.425
		95% Confidence Interval for Mean	Lower Bound	11368.04	
			Upper Bound	13866.42	
		5% Trimmed Mean		12283.45	
		Median		10590.50	
		Variance		16882262.88	
		Std. Deviation		4108.803	
		Minimum		8383	
		Maximum		23303	
		Range		14920	
		Interquartile Range		5439	
		Skewness		1.116	.357
		Kurtosis		.376	.702

a. Size = 400

Table 139

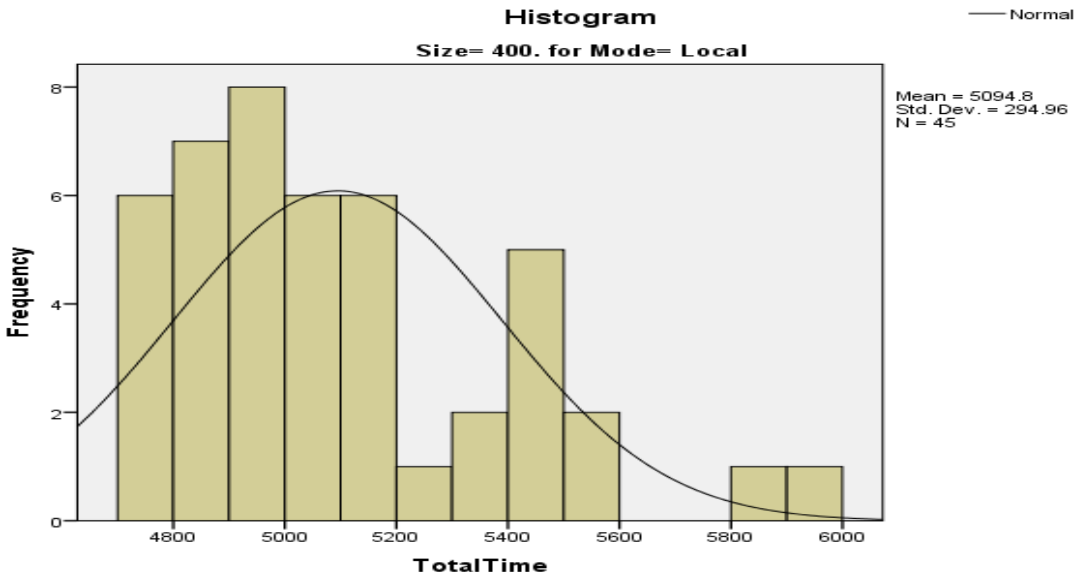
Tests of Normality[a]

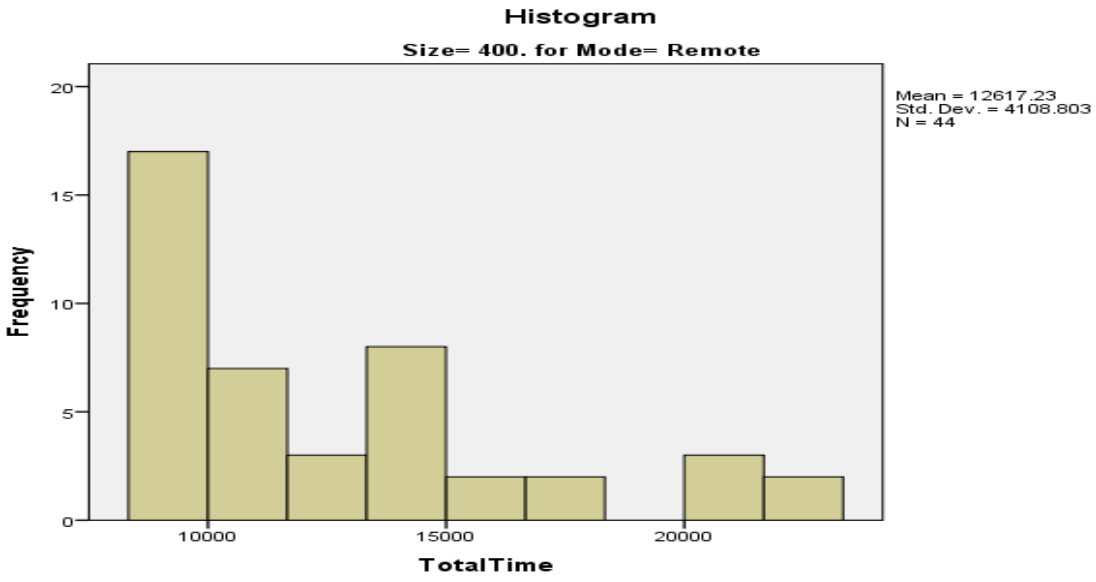
		Kolmogorov-Smirnov[b]			Shapiro-Wilk		
	Mode	Statistic	df	Sig.	Statistic	df	Sig.
TotalTime	Local	.133	45	.045	.904	45	.001
	Remote	.201	44	.000	.848	44	.000

a. Size = 400

b. Lilliefors Significance Correction

As found in all sizes so far for this variable, both groups Sig. value in the table above are under 0.05 and both have non-normal curves in their respective Histograms below. All sizes in this variable need to use the Mann-Whitney Test. The **Local Mean** value is 5094.8 and the **Remote Mean** is 12617.23as shown in the Descriptive table on previous page and Histograms below.





Test Results for Exp3 v 5 Total Time Variable

Table 140

Ranks[a]

	Mode	N	Mean Rank	Sum of Ranks
TotalTime	Local	45	23.00	1035.00
	Remote	44	67.50	2970.00
	Total	89		

a. Size = 50

Test Statistics[a,b]

	TotalTime
Mann-Whitney U	.000
Wilcoxon W	1035.000
Z	-8.129
Asymp. Sig. (2-tailed)	.000

a. Size = 50

b. Grouping Variable: Mode

Table 141

Ranks[a]

	Mode	N	Mean Rank	Sum of Ranks
TotalTime	Local	45	23.00	1035.00
	Remote	45	68.00	3060.00
	Total	90		

a. Size = 100

Test Statistics[a,b]

	TotalTime
Mann-Whitney U	.000
Wilcoxon W	1035.000
Z	-8.172
Asymp. Sig. (2-tailed)	.000

a. Size = 100

b. Grouping Variable: Mode

Table 142

Ranks[a]

	Mode	N	Mean Rank	Sum of Ranks
TotalTime	Local	47	24.00	1128.00
	Remote	46	70.50	3243.00
	Total	93		

a. Size = 200

Test Statistics[a,b]

	TotalTime
Mann-Whitney U	.000
Wilcoxon W	1128.000
Z	-8.307
Asymp. Sig. (2-tailed)	.000

a. Size = 200

b. Grouping Variable: Mode

Table 143

Ranks[a]

	Mode	N	Mean Rank	Sum of Ranks
TotalTime	Local	45	23.00	1035.00
	Remote	44	67.50	2970.00
	Total	89		

a. Size = 400

Test Statistics[a,b]

	TotalTime
Mann-Whitney U	.000
Wilcoxon W	1035.000
Z	-8.124
Asymp. Sig. (2-tailed)	.000

a. Size = 400

b. Grouping Variable: Mode

In all the sizes in this test, the Local Mean value is significantly lower than the Remote Mean value.

Tests for Battery Remaining Variable

Normality Tests for Size 50

Table 144

Case Processing Summary[a]

		Cases					
		Valid		Missing		Total	
	Mode	N	Percent	N	Percent	N	Percent
Batt_Remain	Local	45	100.0%	0	0.0%	45	100.0%
	Remote	44	100.0%	0	0.0%	44	100.0%

a. Size = 50

Table 145

Descriptives[a]

	Mode			Statistic	Std. Error
Batt_Remain	Local	Mean		99.20	.060
		95% Confidence Interval for Mean	Lower Bound	99.08	
			Upper Bound	99.32	
		5% Trimmed Mean		99.17	
		Median		99.00	
		Variance		.164	
		Std. Deviation		.405	
		Minimum		99	
		Maximum		100	
		Range		1	
		Interquartile Range		0	
		Skewness		1.552	.354
		Kurtosis		.426	.695
	Remote	Mean		98.89	.087
		95% Confidence Interval for Mean	Lower Bound	98.71	
			Upper Bound	99.06	
		5% Trimmed Mean		98.87	
		Median		99.00	
		Variance		.336	
		Std. Deviation		.579	
		Minimum		98	
		Maximum		100	
		Range		2	
		Interquartile Range		0	
		Skewness		-.002	.357
		Kurtosis		.071	.702

a. Size = 50

Table 146

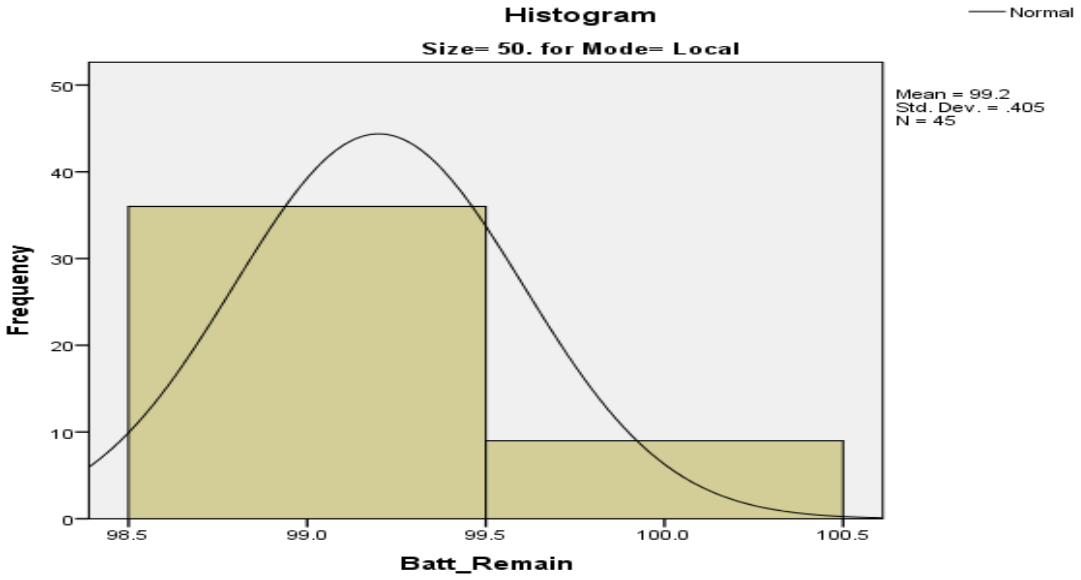
Tests of Normality[a]

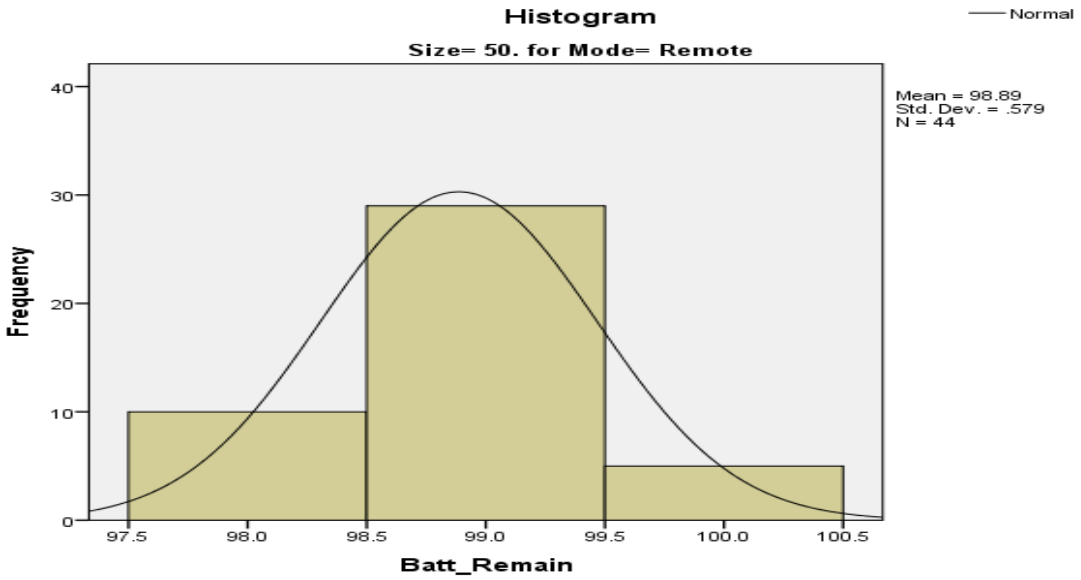
	Mode	Kolmogorov-Smirnov[b]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Batt_Remain	Local	.489	45	.000	.491	45	.000
	Remote	.350	44	.000	.746	44	.000

a. Size = 50

b. Lilliefors Significance Correction

As shown in the table above, both the **Sig.** values are under 0.05 and the curves in the respective Histograms are non-normal. Only the Mann-Whitney Test can be performed for this size. The **Local Mean** value is 99.2 and the **Remote Mean** is 98.89 as shown in the Descriptive table on previous page and Histograms below.





Normality Tests for Size 100

Table 147

Case Processing Summary[a]

		Cases					
		Valid		Missing		Total	
	Mode	N	Percent	N	Percent	N	Percent
Batt_Remain	Local	45	100.0%	0	0.0%	45	100.0%
	Remote	45	100.0%	0	0.0%	45	100.0%

a. Size = 100

Table 148

Descriptives[a]

	Mode			Statistic	Std. Error
Batt_Remain	Local	Mean		98.31	.070
		95% Confidence Interval for Mean	Lower Bound	98.17	
			Upper Bound	98.45	
		5% Trimmed Mean		98.29	
		Median		98.00	
		Variance		.219	
		Std. Deviation		.468	
		Minimum		98	
		Maximum		99	
		Range		1	
		Interquartile Range		1	
		Skewness		.844	.354
		Kurtosis		-1.349	.695
	Remote	Mean		96.84	.114
		95% Confidence Interval for Mean	Lower Bound	96.61	
			Upper Bound	97.07	
		5% Trimmed Mean		96.83	
		Median		97.00	
		Variance		.589	
		Std. Deviation		.767	
		Minimum		96	
		Maximum		98	
		Range		2	
		Interquartile Range		1	
		Skewness		.277	.354
		Kurtosis		-1.226	.695

a. Size = 100

Table 149

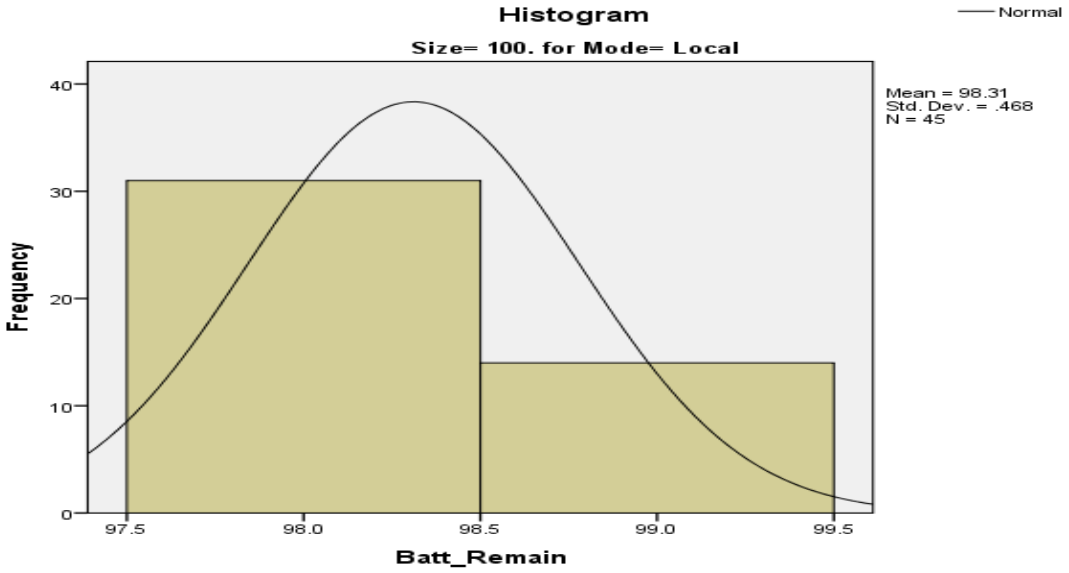
Tests of Normality[a]

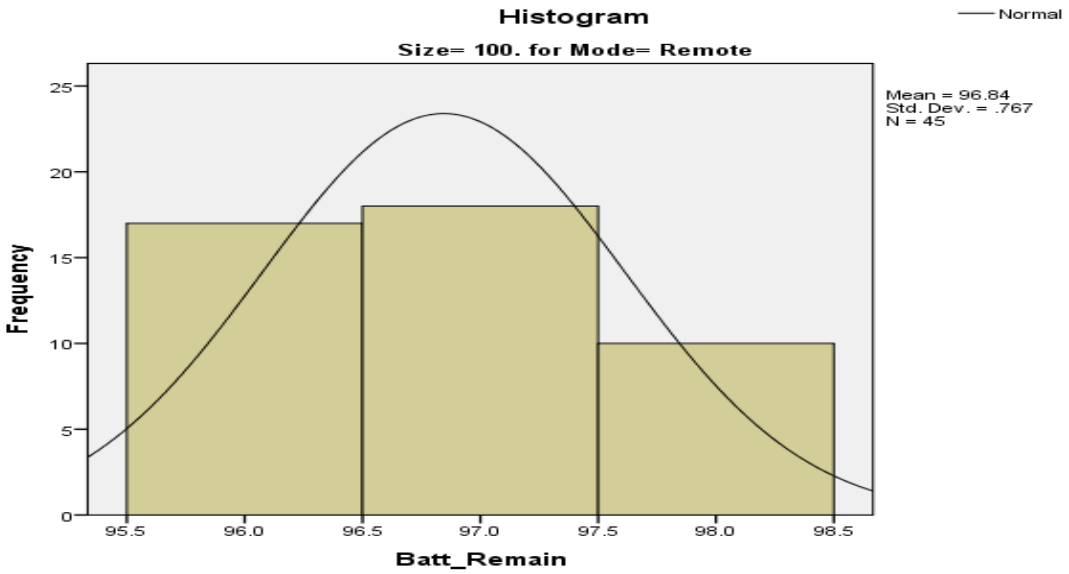
	Mode	Kolmogorov-Smirnov[b]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Batt_Remain	Local	.436	45	.000	.583	45	.000
	Remote	.242	45	.000	.799	45	.000

a. Size = 100

b. Lilliefors Significance Correction

As with the following size, both Sig. figures from the table above are under 0.05. Both curves from the Histograms are also non-normal. This means that the Mann-Whitney test has to be performed for sizes 50 and 100. The **Local Mean** value is 98.31 and the **Remote Mean** is 96.84 as shown in the Descriptive table on previous page and Histograms below.





Normality Tests for Size 200

Table 150

Case Processing Summary[a]

		Cases					
		Valid		Missing		Total	
	Mode	N	Percent	N	Percent	N	Percent
Batt_Remain	Local	47	100.0%	0	0.0%	47	100.0%
	Remote	46	100.0%	0	0.0%	46	100.0%

a. Size = 200

Table 151

Descriptives[a]

	Mode			Statistic	Std. Error
Batt_Remain	Local	Mean		95.17	.188
		95% Confidence Interval for Mean	Lower Bound	94.79	
			Upper Bound	95.55	
		5% Trimmed Mean		95.19	
		Median		95.00	
		Variance		1.666	
		Std. Deviation		1.291	
		Minimum		93	
		Maximum		97	
		Range		4	
		Interquartile Range		2	
		Skewness		-.078	.347
		Kurtosis		-1.085	.681
	Remote	Mean		92.17	.334
		95% Confidence Interval for Mean	Lower Bound	91.50	
			Upper Bound	92.85	
		5% Trimmed Mean		92.20	
		Median		92.00	
		Variance		5.125	
		Std. Deviation		2.264	
		Minimum		88	
		Maximum		96	
		Range		8	
		Interquartile Range		4	
		Skewness		-.189	.350
		Kurtosis		-.863	.688

a. Size = 200

Table 152

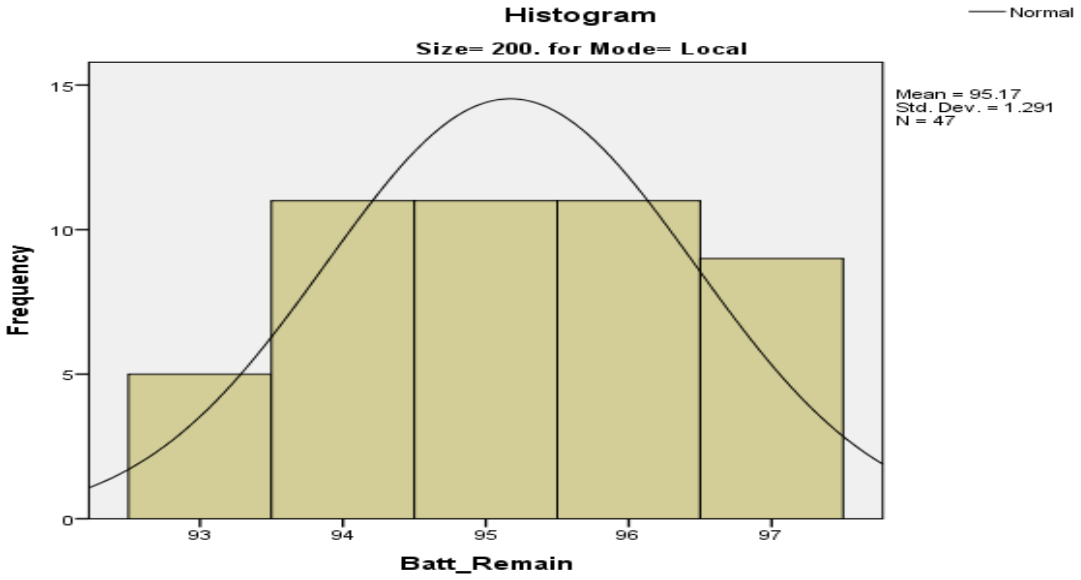
Tests of Normality[a]

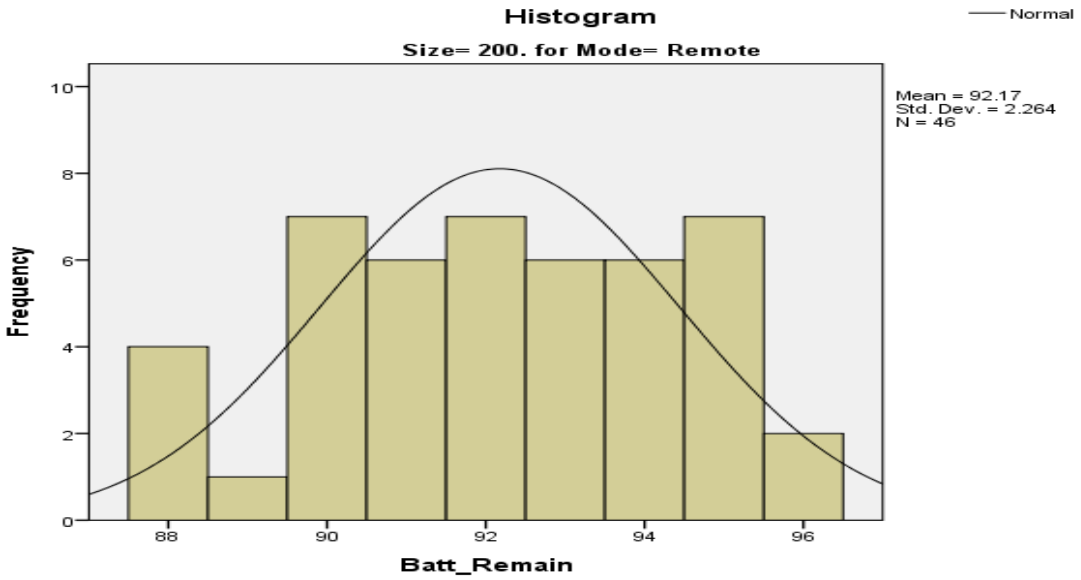
	Mode	Kolmogorov-Smirnov[b]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Batt_Remain	Local	.165	47	.002	.906	47	.001
	Remote	.116	46	.143	.950	46	.046

a. Size = 200

b. Lilliefors Significance Correction

As with the two previous sizes, the **Sig**. figures are under 0.05 and curves from the Histograms below are non-normal hence the Mann-Whitney Test must be performed for sizes 50, 100, and 200. The **Local Mean** value is 95.17 and the **Remote Mean** is 92.17 as shown in the Descriptive table on previous page and Histograms below.





Normality Tests for Size 400

Table 153

Case Processing Summary[a]

		Cases					
		Valid		Missing		Total	
	Mode	N	Percent	N	Percent	N	Percent
Batt_Remain	Local	45	100.0%	0	0.0%	45	100.0%
	Remote	44	100.0%	0	0.0%	44	100.0%

a. Size = 400

Table 154

Descriptives[a]

	Mode			Statistic	Std. Error
Batt_Remain	Local	Mean		83.84	.797
		95% Confidence Interval for Mean	Lower Bound	82.24	
			Upper Bound	85.45	
		5% Trimmed Mean		83.85	
		Median		84.00	
		Variance		28.589	
		Std. Deviation		5.347	
		Minimum		75	
		Maximum		93	
		Range		18	
		Interquartile Range		10	
		Skewness		.052	.354
		Kurtosis		-1.190	.695
	Remote	Mean		77.16	.967
		95% Confidence Interval for Mean	Lower Bound	75.21	
			Upper Bound	79.11	
		5% Trimmed Mean		77.18	
		Median		77.50	
		Variance		41.114	
		Std. Deviation		6.412	
		Minimum		66	
		Maximum		88	
		Range		22	
		Interquartile Range		12	
		Skewness		-.065	.357
		Kurtosis		-1.161	.702

a. Size = 400

Table 155

Tests of Normality[a]

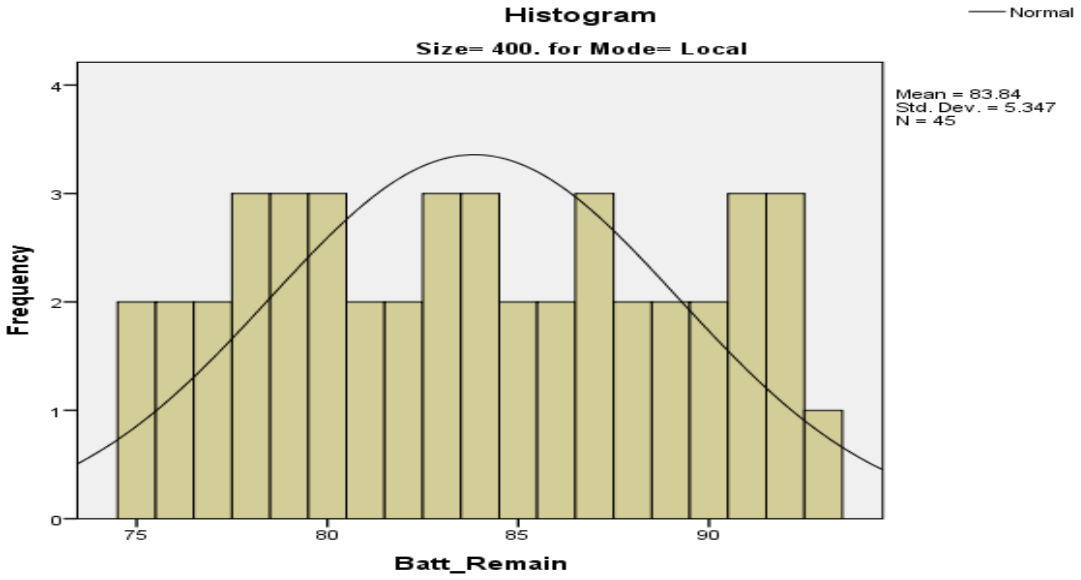
		Kolmogorov-Smirnov[b]			Shapiro-Wilk		
	Mode	Statistic	df	Sig.	Statistic	df	Sig.
Batt_Remain	Local	.097	45	.200*	.953	45	.064
	Remote	.082	44	.200*	.957	44	.102

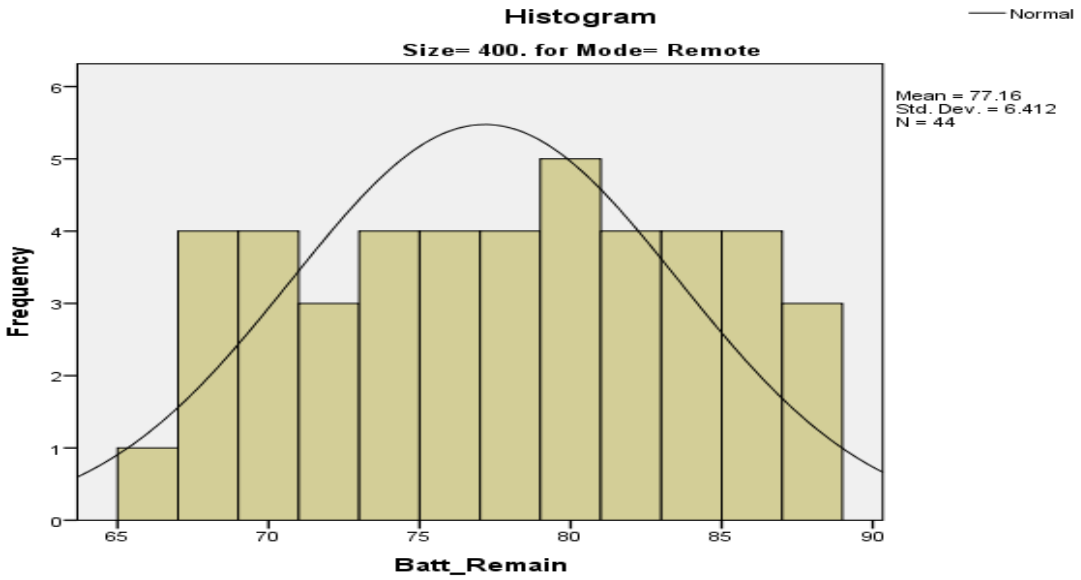
*. This is a lower bound of the true significance.

a. Size = 400

b. Lilliefors Significance Correction

Both groups show Sig. values over 0.05 and the curves on the Histograms below are normal. For size 400, an Independent T-Test needs to be performed. The **Local Mean** value is 83.84 and the **Remote Mean** is 77.16 as shown in the Descriptive table on previous page and Histograms below.





Test Results for Exp3 v 5 Battery Remaining Variable

Table 156

Ranks[a]

	Mode	N	Mean Rank	Sum of Ranks
Batt_Remain	Local	45	50.90	2290.50
	Remote	44	38.97	1714.50
	Total	89		

a. Size = 50

Test Statistics[a,b]

	Batt_Remain
Mann-Whitney U	724.500
Wilcoxon W	1714.500
Z	-2.801
Asymp. Sig. (2-tailed)	.005

a. Size = 50

b. Grouping Variable: Mode

Table 157

Ranks[a]

	Mode	N	Mean Rank	Sum of Ranks
Batt_Remain	Local	45	64.56	2905.00
	Remote	45	26.44	1190.00
	Total	90		

a. Size = 100

Test Statistics[a,b]

	Batt_Remain
Mann-Whitney U	155.000
Wilcoxon W	1190.000
Z	-7.347
Asymp. Sig. (2-tailed)	.000

a. Size = 100

b. Grouping Variable: Mode

Table 158

Ranks[a]

	Mode	N	Mean Rank	Sum of Ranks
Batt_Remain	Local	47	63.76	2996.50
	Remote	46	29.88	1374.50
	Total	93		

a. Size = 200

Test Statistics[a,b]

	Batt_Remain
Mann-Whitney U	293.500
Wilcoxon W	1374.500
Z	-6.112
Asymp. Sig. (2-tailed)	.000

a. Size = 200

b. Grouping Variable: Mode

In the Mann-Whiney results, the Local Mean value for Battery Remaining is significantly higher than the Remote Mean value. The Independent T-Test results are shown on the next page.

Table 159

Group Statistics[a]

	Mode	N	Mean	Std. Deviation	Std. Error Mean
Batt_Remain	Local	45	83.84	5.347	.797
	Remote	44	77.16	6.412	.967

a. Size = 400

Independent Samples Test[a]

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Batt_Remain	Equal variances assumed	2.118	.149	5.347	87	.000	6.685	1.250	4.200	9.171
	Equal variances not assumed			5.336	83.588	.000	6.685	1.253	4.194	9.177

a. Size = 400

The results above show that the Local Mean value for Battery Remaining is significantly higher than the Remote value.

6.5 Exp3 v 6 Test Results

Memory Variable Tests

Normality Test for Size 50

Table 160

Case Processing Summary[a]

		Cases					
		Valid		Missing		Total	
	Mode	N	Percent	N	Percent	N	Percent
Memory	Local	45	100.0%	0	0.0%	45	100.0%
	Remote	44	100.0%	0	0.0%	44	100.0%

a. Size = 50

Table 161

Descriptives[a]

	Mode			Statistic	Std. Error
Memory	Local	Mean		754238.49	958.222
		95% Confidence Interval for Mean	Lower Bound	752307.32	
			Upper Bound	756169.66	
		5% Trimmed Mean		753858.32	
		Median		750840.00	
		Variance		41318486.76	
		Std. Deviation		6427.946	
		Minimum		748568	
		Maximum		767160	
		Range		18592	
		Interquartile Range		8058	
		Skewness		1.201	.354
		Kurtosis		-.499	.695
	Remote	Mean		761651.43	153.410
		95% Confidence Interval for Mean	Lower Bound	761342.05	
			Upper Bound	761960.81	
		5% Trimmed Mean		761641.30	
		Median		761559.50	
		Variance		1035529.553	
		Std. Deviation		1017.610	
		Minimum		759809	
		Maximum		763634	
		Range		3825	
		Interquartile Range		1392	
		Skewness		.285	.357
		Kurtosis		-.698	.702

a. Size = 50

Table 162

Tests of Normality[a]

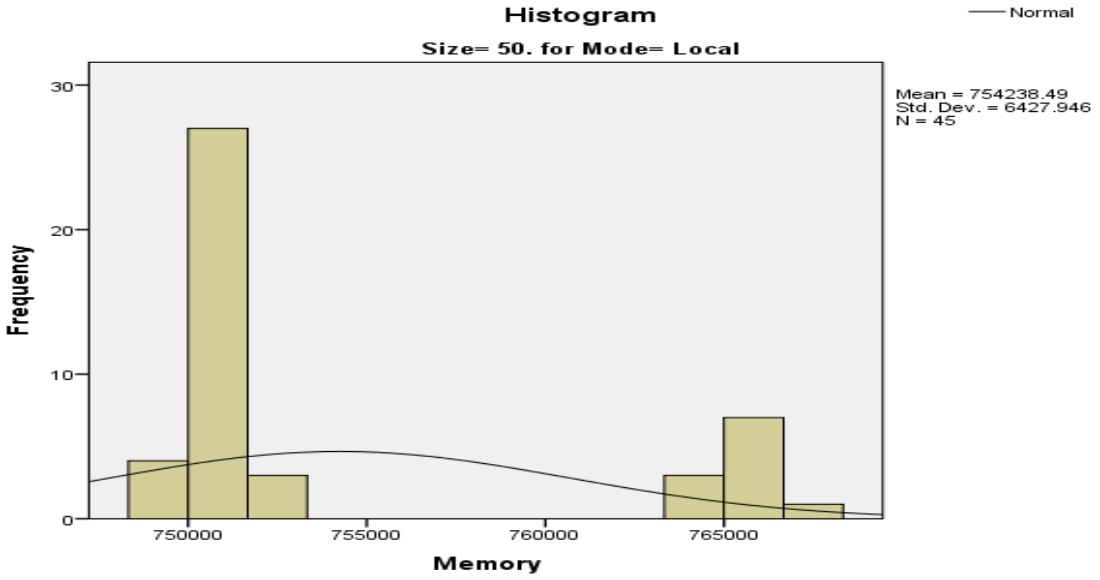
	Mode	Kolmogorov-Smirnov[b]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Memory	Local	.369	45	.000	.645	45	.000
	Remote	.089	44	.200*	.967	44	.245

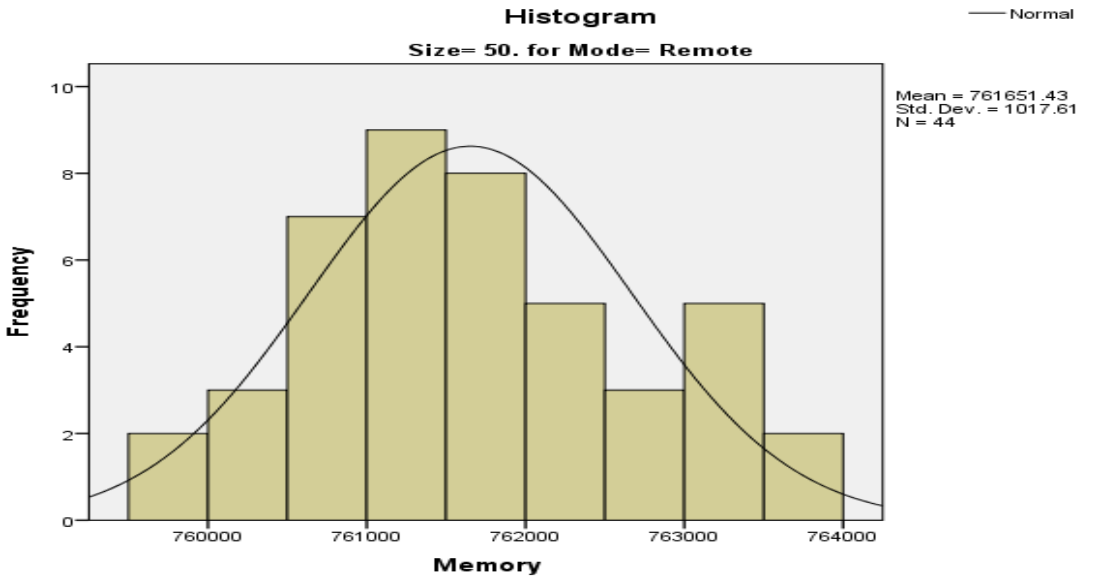
*. This is a lower bound of the true significance.

a. Size = 50

b. Lilliefors Significance Correction

The **Local Mean** value is 754238.49 and the **Remote Mean** is 761651.43 as shown in the Descriptive table on previous page and Histograms below.





Normality Tests for Size 100

Table 163

Case Processing Summary[a]

		Cases					
		Valid		Missing		Total	
	Mode	N	Percent	N	Percent	N	Percent
Memory	Local	45	100.0%	0	0.0%	45	100.0%
	Remote	43	100.0%	0	0.0%	43	100.0%

a. Size = 100

Table 164

Descriptives[a]

	Mode			Statistic	Std. Error
Memory	Local	Mean		768288.71	82.248
		95% Confidence Interval for Mean	Lower Bound	768122.95	
			Upper Bound	768454.47	
		5% Trimmed Mean		768293.28	
		Median		768148.00	
		Variance		304409.665	
		Std. Deviation		551.733	
		Minimum		767120	
		Maximum		769300	
		Range		2180	
		Interquartile Range		880	
		Skewness		.038	.354
		Kurtosis		-.795	.695
	Remote	Mean		767018.77	287.161
		95% Confidence Interval for Mean	Lower Bound	766439.25	
			Upper Bound	767598.28	
		5% Trimmed Mean		766977.00	
		Median		766634.00	
		Variance		3545840.754	
		Std. Deviation		1883.040	
		Minimum		764193	
		Maximum		770573	
		Range		6380	
		Interquartile Range		3341	
		Skewness		.413	.361
		Kurtosis		-1.110	.709

a. Size = 100

Table 165

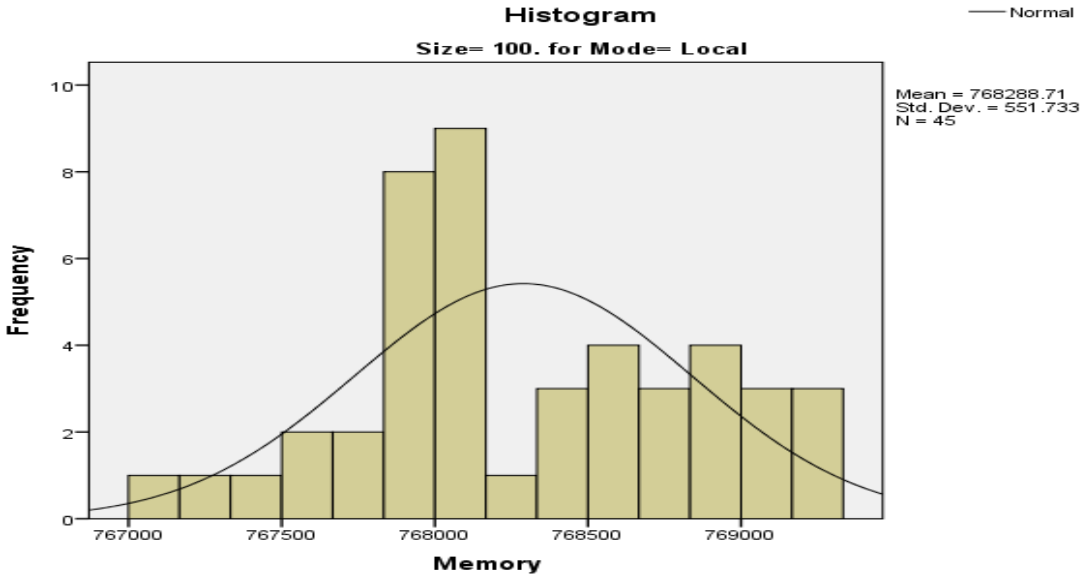
Tests of Normality[a]

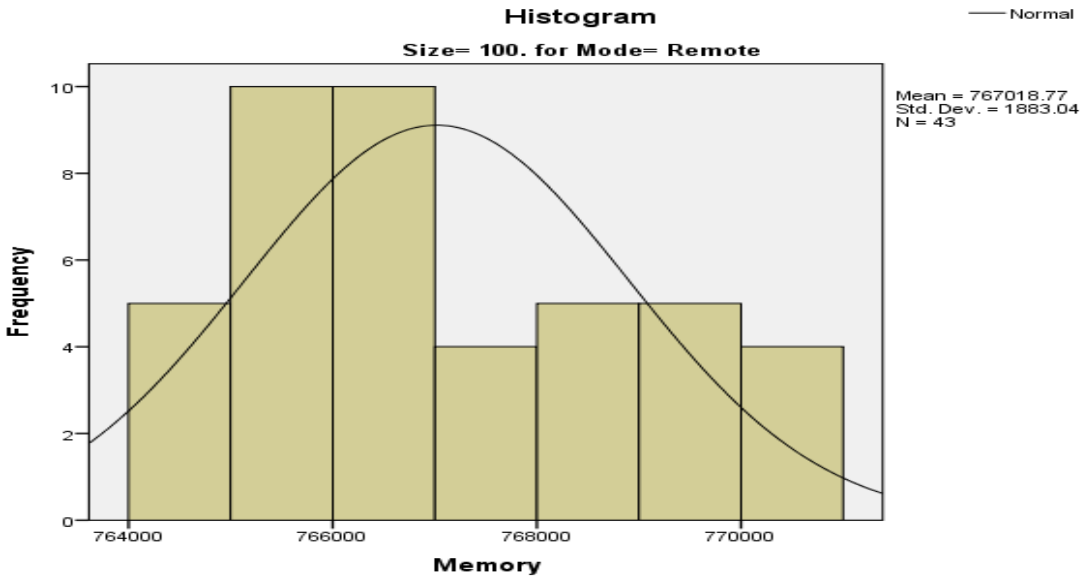
		Kolmogorov-Smirnov[b]			Shapiro-Wilk		
	Mode	Statistic	df	Sig.	Statistic	df	Sig.
Memory	Local	.128	45	.061	.970	45	.301
	Remote	.135	43	.046	.931	43	.013

a. Size = 100

b. Lilliefors Significance Correction

The **Local Mean** value is 768288.71 and the **Remote Mean** is 767018.77 as shown in the Descriptive table on previous page and Histograms below.





Normality Tests for Size 200

Table 166

Case Processing Summary[a]

		Cases					
		Valid		Missing		Total	
	Mode	N	Percent	N	Percent	N	Percent
Memory	Local	47	100.0%	0	0.0%	47	100.0%
	Remote	45	100.0%	0	0.0%	45	100.0%

a. Size = 200

Table 167

Descriptives[a]

	Mode			Statistic	Std. Error
Memory	Local	Mean		765475.70	361.172
		95% Confidence Interval for Mean	Lower Bound	764748.70	
			Upper Bound	766202.70	
		5% Trimmed Mean		765682.78	
		Median		766708.00	
		Variance		6130915.866	
		Std. Deviation		2476.069	
		Minimum		755732	
		Maximum		768156	
		Range		12424	
		Interquartile Range		3732	
		Skewness		-1.529	.347
		Kurtosis		3.531	.681
	Remote	Mean		761389.04	1317.000
		95% Confidence Interval for Mean	Lower Bound	758734.81	
			Upper Bound	764043.28	
		5% Trimmed Mean		761615.08	
		Median		763203.00	
		Variance		78051973.73	
		Std. Deviation		8834.703	
		Minimum		746352	
		Maximum		772034	
		Range		25682	
		Interquartile Range		18510	
		Skewness		-.474	.354
		Kurtosis		-1.387	.695

a. Size = 200

Table 168

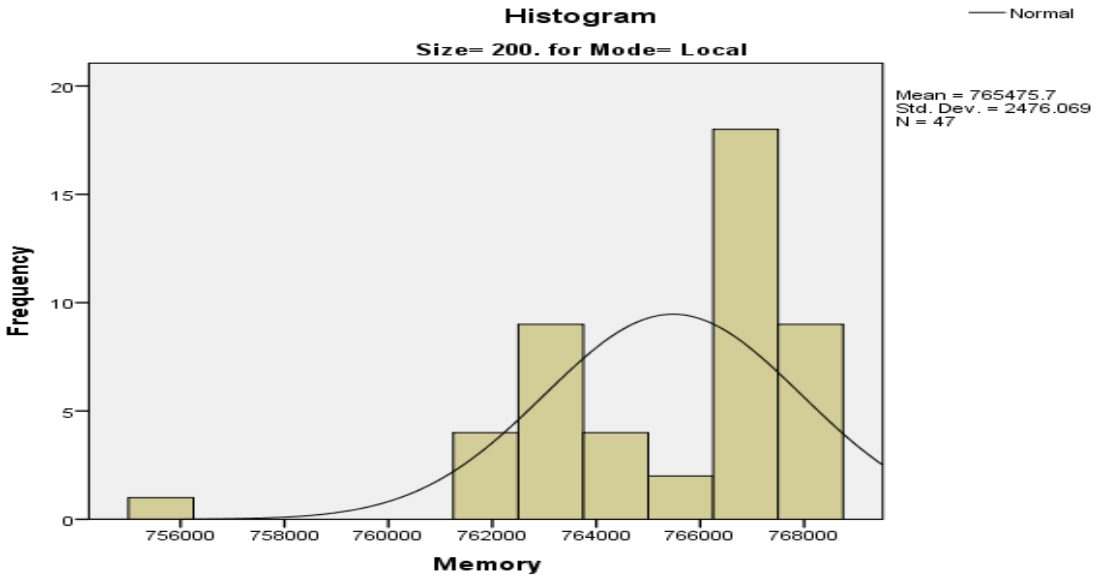
Tests of Normality[a]

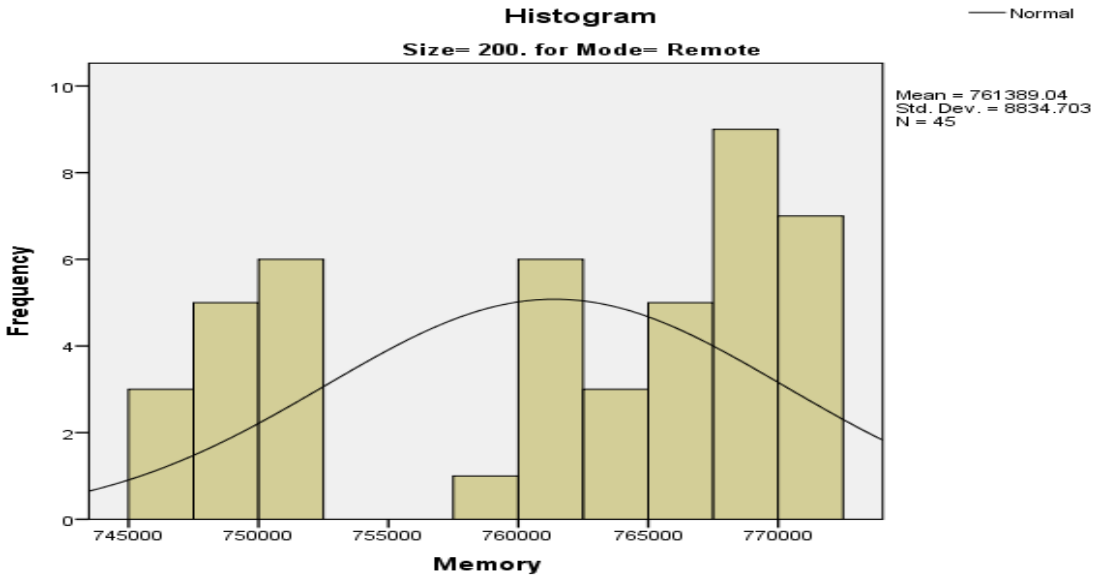
	Mode	Kolmogorov-Smirnov[b]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Memory	Local	.219	47	.000	.832	47	.000
	Remote	.170	45	.002	.859	45	.000

a. Size = 200

b. Lilliefors Significance Correction

The **Local Mean** value is 765475.7 and the **Remote Mean** is 761389.04 as shown in the Descriptive table on previous page and Histograms below.





Normality Tests for Size 400

Table 169

Case Processing Summary[a]

		Cases					
		Valid		Missing		Total	
	Mode	N	Percent	N	Percent	N	Percent
Memory	Local	45	100.0%	0	0.0%	45	100.0%
	Remote	47	100.0%	0	0.0%	47	100.0%

a. Size = 400

Table 170

Descriptives[a]

	Mode			Statistic	Std. Error
Memory	Local	Mean		760267.40	850.234
		95% Confidence Interval for Mean	Lower Bound	758553.86	
			Upper Bound	761980.94	
		5% Trimmed Mean		760405.54	
		Median		761176.00	
		Variance		32530440.29	
		Std. Deviation		5703.546	
		Minimum		748680	
		Maximum		768920	
		Range		20240	
		Interquartile Range		8082	
		Skewness		-.290	.354
		Kurtosis		-.854	.695
	Remote	Mean		750992.66	1081.916
		95% Confidence Interval for Mean	Lower Bound	748814.88	
			Upper Bound	753170.44	
		5% Trimmed Mean		751104.11	
		Median		752695.00	
		Variance		55015511.84	
		Std. Deviation		7417.244	
		Minimum		736653	
		Maximum		762809	
		Range		26156	
		Interquartile Range		11927	
		Skewness		-.422	.347
		Kurtosis		-.999	.681

a. Size = 400

Table 171

Tests of Normality[a]

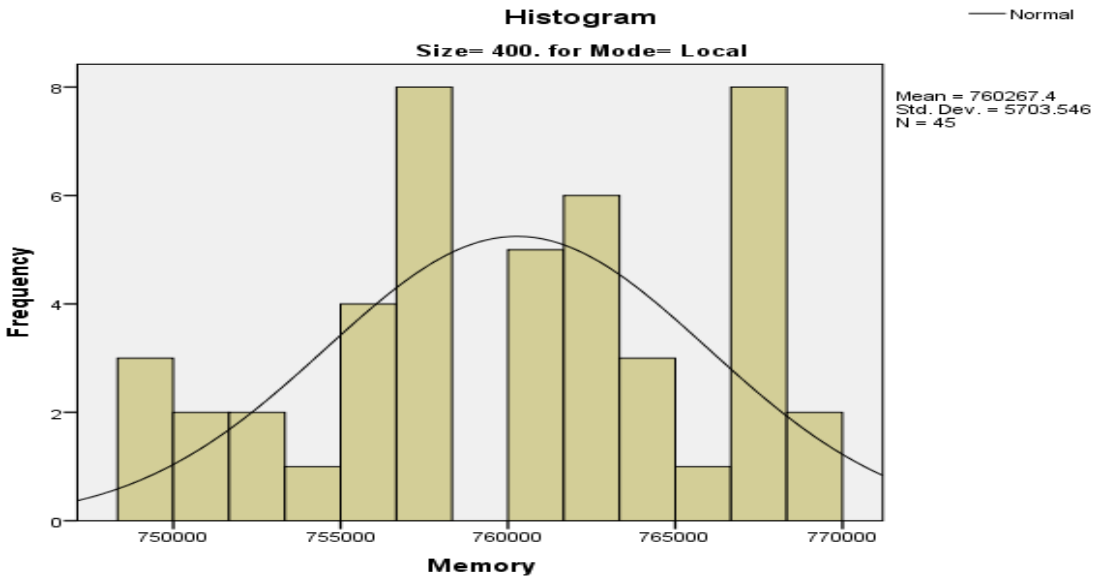
	Mode	Kolmogorov-Smirnov[b]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Memory	Local	.095	45	.200*	.951	45	.058
	Remote	.139	47	.023	.929	47	.007

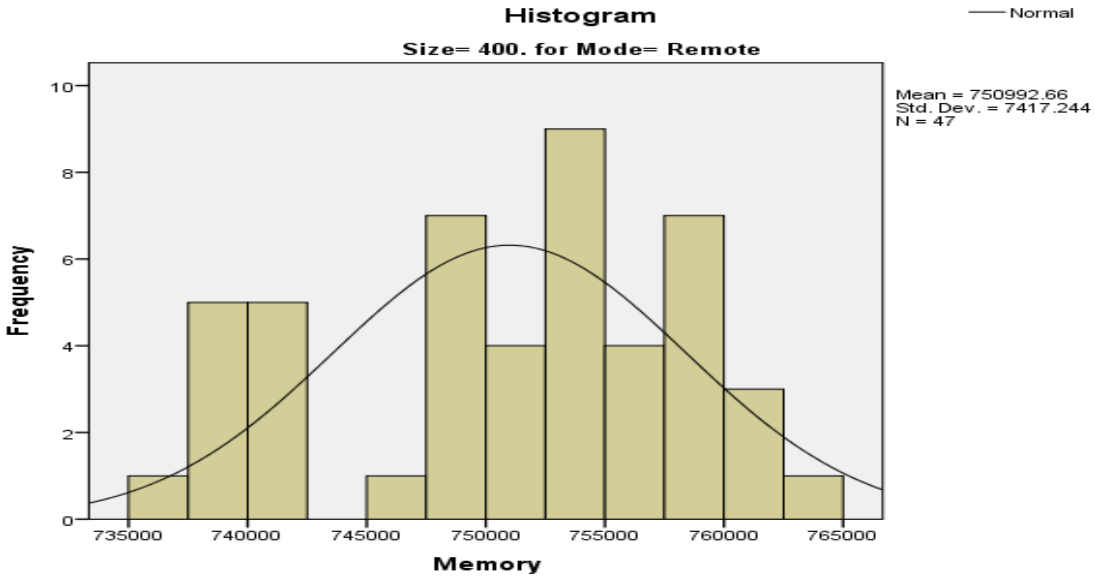
*. This is a lower bound of the true significance.

a. Size = 400

b. Lilliefors Significance Correction

At least one of the groups in each size had **Sig.** value under 0.05 which means only a Mann-Whitney Test could be performed. The **Local Mean** value is 760267.4 and the **Remote Mean** is 750992.66 as shown in the Descriptive table on previous page and Histograms below.





Test results for Exp3 v 6 Memory variable

Table 172

Ranks[a]

	Mode	N	Mean Rank	Sum of Ranks
Memory	Local	45	33.76	1519.00
	Remote	44	56.50	2486.00
	Total	89		

a. Size = 50

Test Statistics[a,b]

	Memory
Mann-Whitney U	484.000
Wilcoxon W	1519.000
Z	-4.152
Asymp. Sig. (2-tailed)	.000

a. Size = 50

b. Grouping Variable: Mode

Table 173

Ranks[a]

	Mode	N	Mean Rank	Sum of Ranks
Memory	Local	45	53.40	2403.00
	Remote	43	35.19	1513.00
	Total	88		

a. Size = 100

Test Statistics[a,b]

	Memory
Mann-Whitney U	567.000
Wilcoxon W	1513.000
Z	-3.343
Asymp. Sig. (2-tailed)	.001

a. Size = 100

b. Grouping Variable: Mode

Table 174

Ranks[a]

	Mode	N	Mean Rank	Sum of Ranks
Memory	Local	47	49.66	2334.00
	Remote	45	43.20	1944.00
	Total	92		

a. Size = 200

Test Statistics[a,b]

	Memory
Mann-Whitney U	909.000
Wilcoxon W	1944.000
Z	-1.160
Asymp. Sig. (2-tailed)	.246

a. Size = 200

b. Grouping Variable: Mode

Table 175

Ranks[a]

	Mode	N	Mean Rank	Sum of Ranks
Memory	Local	45	62.04	2792.00
	Remote	47	31.62	1486.00
	Total	92		

a. Size = 400

Test Statistics[a,b]

	Memory
Mann-Whitney U	358.000
Wilcoxon W	1486.000
Z	-5.464
Asymp. Sig. (2-tailed)	.000

a. Size = 400

b. Grouping Variable: Mode

From the results above, the Local Mean for Memory is significantly lower than the Remote Mean at size 50. The result reverses in the next size, where the Remote Mean is significantly lower. At size 200, there is no significant difference between either groups. When the size reaches 400, The Remote Mean significantly lowers compared to the Local Mean.

CPU Variable Tests

Normality Tests for Size 50

Table 176

Case Processing Summary[a]

		Cases					
		Valid		Missing		Total	
	Mode	N	Percent	N	Percent	N	Percent
CPU	Local	45	100.0%	0	0.0%	45	100.0%
	Remote	44	100.0%	0	0.0%	44	100.0%

a. Size = 50

Table 177

Descriptives[a]

	Mode			Statistic	Std. Error
CPU	Local	Mean		37.31	3.153
		95% Confidence Interval for Mean	Lower Bound	30.96	
			Upper Bound	43.67	
		5% Trimmed Mean		37.80	
		Median		50.00	
		Variance		447.401	
		Std. Deviation		21.152	
		Minimum		3	
		Maximum		65	
		Range		62	
		Interquartile Range		42	
		Skewness		-.543	.354
		Kurtosis		-1.407	.695
	Remote	Mean		7.70	.267
		95% Confidence Interval for Mean	Lower Bound	7.17	
			Upper Bound	8.24	
		5% Trimmed Mean		7.49	
		Median		7.00	
		Variance		3.143	
		Std. Deviation		1.773	
		Minimum		6	
		Maximum		14	
		Range		8	
		Interquartile Range		2	
		Skewness		1.836	.357
		Kurtosis		3.762	.702

a. Size = 50

Table 178

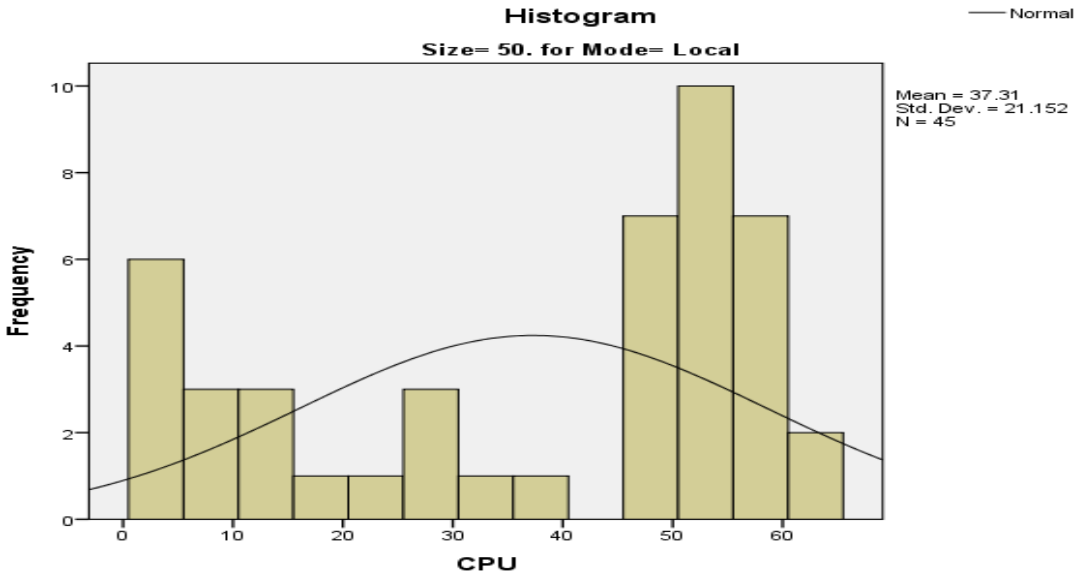
Tests of Normality[a]

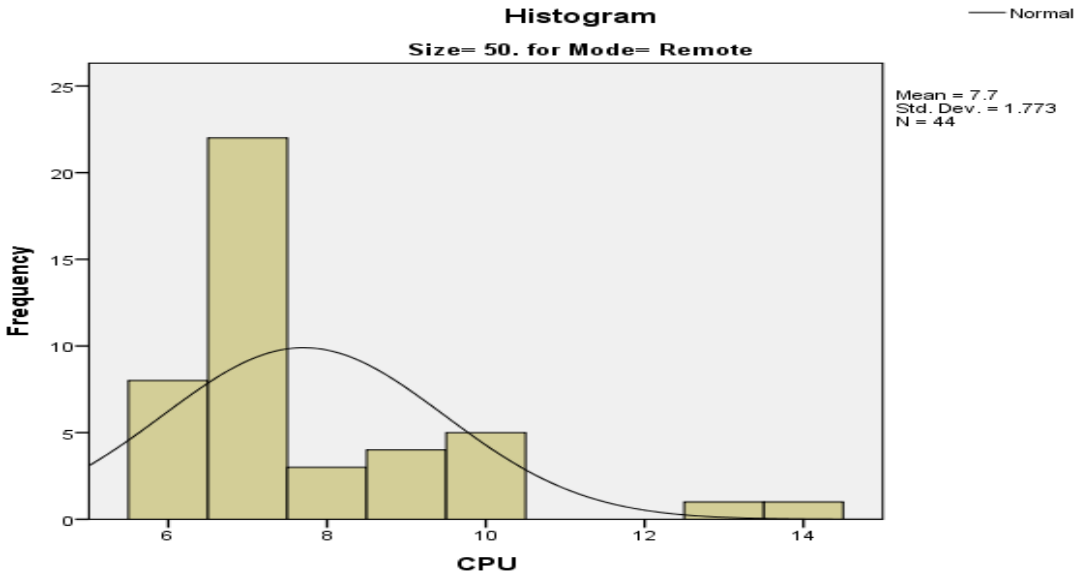
	Mode	Kolmogorov-Smirnov[b]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
CPU	Local	.259	45	.000	.836	45	.000
	Remote	.336	44	.000	.759	44	.000

a. Size = 50

b. Lilliefors Significance Correction

The **Local Mean** value is 37.31 and the **Remote Mean** is 7.7 as shown in the Descriptive table on previous page and Histograms below.





Normality tests for Size 100

Table 179

Case Processing Summary[a]

		Cases					
		Valid		Missing		Total	
	Mode	N	Percent	N	Percent	N	Percent
CPU	Local	45	100.0%	0	0.0%	45	100.0%
	Remote	43	100.0%	0	0.0%	43	100.0%

a. Size = 100

Table 180

Descriptives[a]

	Mode			Statistic	Std. Error
CPU	Local	Mean		52.69	1.262
		95% Confidence Interval for Mean	Lower Bound	50.15	
			Upper Bound	55.23	
		5% Trimmed Mean		53.61	
		Median		53.00	
		Variance		71.674	
		Std. Deviation		8.466	
		Minimum		6	
		Maximum		64	
		Range		58	
		Interquartile Range		7	
		Skewness		-3.863	.354
		Kurtosis		21.224	.695
	Remote	Mean		44.44	1.567
		95% Confidence Interval for Mean	Lower Bound	41.28	
			Upper Bound	47.60	
		5% Trimmed Mean		45.10	
		Median		47.00	
		Variance		105.633	
		Std. Deviation		10.278	
		Minimum		20	
		Maximum		57	
		Range		37	
		Interquartile Range		10	
		Skewness		-1.160	.361
		Kurtosis		.266	.709

a. Size = 100

Table 181

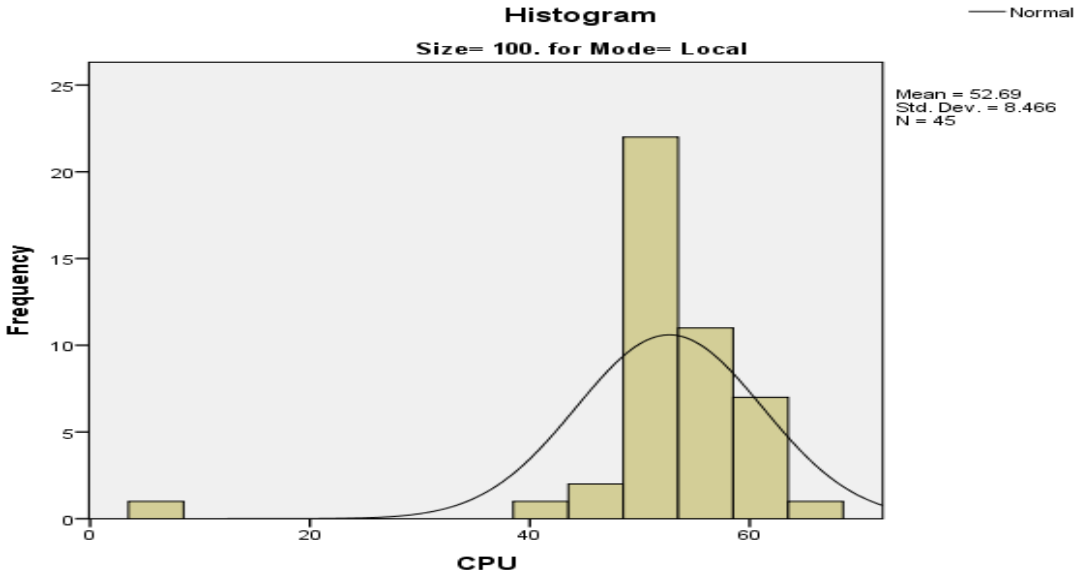
Tests of Normality[a]

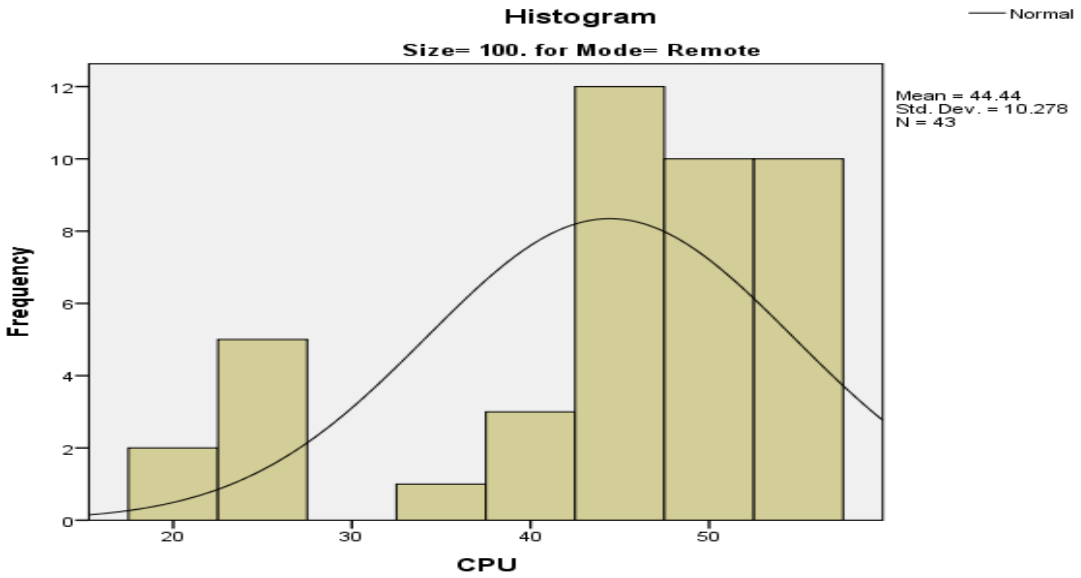
	Mode	Kolmogorov-Smirnov[b]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
CPU	Local	.264	45	.000	.641	45	.000
	Remote	.188	43	.001	.844	43	.000

a. Size = 100

b. Lilliefors Significance Correction

The **Local Mean** value is 52.69 and the **Remote Mean** is 44.44 as shown in the Descriptive table on previous page and Histograms below.





Normality Tests for Size 200

Table 182

Case Processing Summary[a]

		Cases					
		Valid		Missing		Total	
	Mode	N	Percent	N	Percent	N	Percent
CPU	Local	47	100.0%	0	0.0%	47	100.0%
	Remote	45	100.0%	0	0.0%	45	100.0%

a. Size = 200

Table 183

Descriptives[a]

	Mode			Statistic	Std. Error
CPU	Local	Mean		52.49	.867
		95% Confidence Interval for Mean	Lower Bound	50.74	
			Upper Bound	54.23	
		5% Trimmed Mean		53.09	
		Median		53.00	
		Variance		35.342	
		Std. Deviation		5.945	
		Minimum		22	
		Maximum		61	
		Range		39	
		Interquartile Range		5	
		Skewness		-3.049	.347
		Kurtosis		14.803	.681
	Remote	Mean		55.56	.394
		95% Confidence Interval for Mean	Lower Bound	54.76	
			Upper Bound	56.35	
		5% Trimmed Mean		55.67	
		Median		55.00	
		Variance		6.980	
		Std. Deviation		2.642	
		Minimum		48	
		Maximum		62	
		Range		14	
		Interquartile Range		4	
		Skewness		-.553	.354
		Kurtosis		2.016	.695

a. Size = 200

Table 184

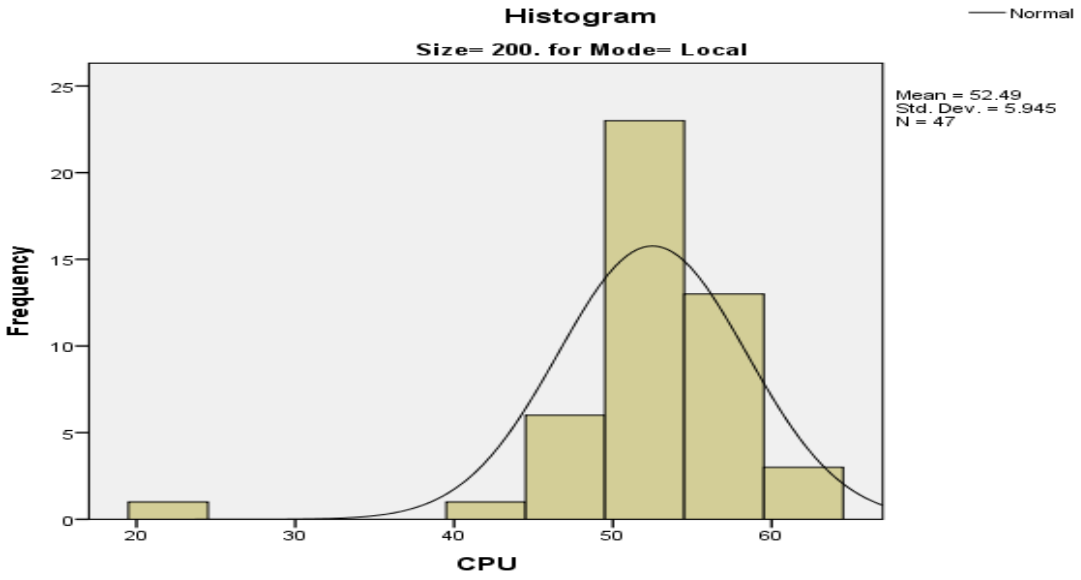
Tests of Normality[a]

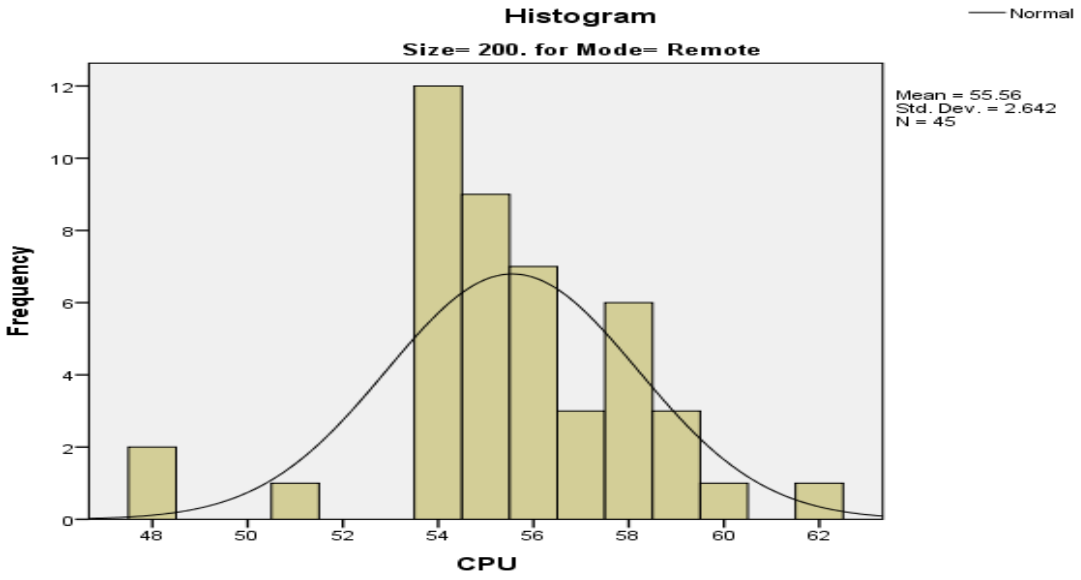
	Mode	Kolmogorov-Smirnov[b]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
CPU	Local	.194	47	.000	.735	47	.000
	Remote	.211	45	.000	.914	45	.003

a. Size = 200

b. Lilliefors Significance Correction

The **Local Mean** value is 52.49 and the **Remote Mean** is 55.56 as shown in the Descriptive table on previous page and Histograms below.





Normality Tests for Size 400

Table 185

Case Processing Summary[a]

		Cases					
		Valid		Missing		Total	
	Mode	N	Percent	N	Percent	N	Percent
CPU	Local	45	100.0%	0	0.0%	45	100.0%
	Remote	47	100.0%	0	0.0%	47	100.0%

a. Size = 400

Table 186

Descriptives[a]

	Mode			Statistic	Std. Error
CPU	Local	Mean		53.89	.494
		95% Confidence Interval for Mean	Lower Bound	52.89	
			Upper Bound	54.88	
		5% Trimmed Mean		53.59	
		Median		53.00	
		Variance		10.965	
		Std. Deviation		3.311	
		Minimum		48	
		Maximum		73	
		Range		25	
		Interquartile Range		2	
		Skewness		4.402	.354
		Kurtosis		26.020	.695
	Remote	Mean		47.17	1.214
		95% Confidence Interval for Mean	Lower Bound	44.73	
			Upper Bound	49.61	
		5% Trimmed Mean		47.58	
		Median		53.00	
		Variance		69.231	
		Std. Deviation		8.321	
		Minimum		30	
		Maximum		57	
		Range		27	
		Interquartile Range		15	
		Skewness		-.509	.347
		Kurtosis		-1.220	.681

a. Size = 400

Table 187

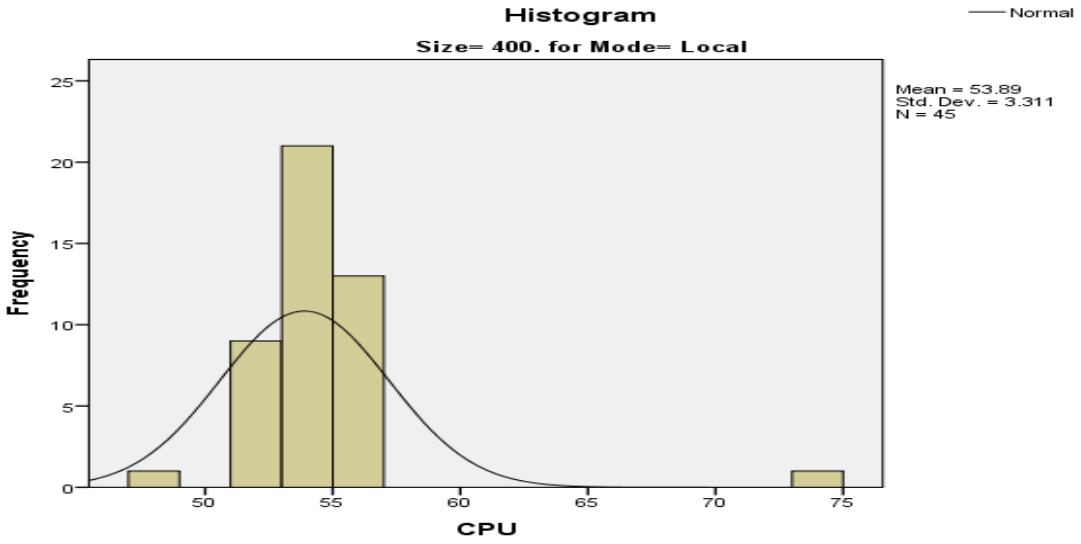
Tests of Normality[a]

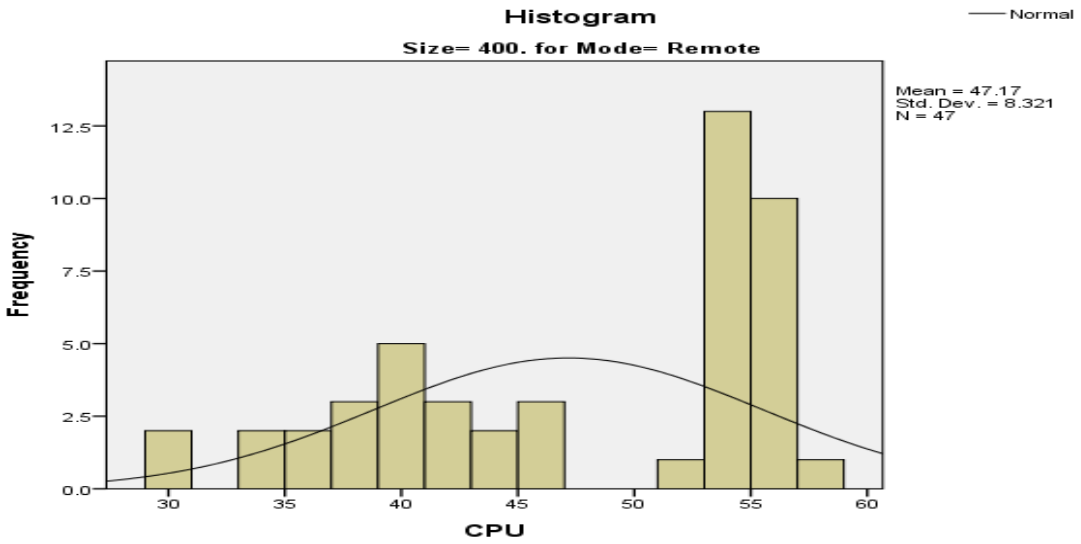
	Mode	Kolmogorov-Smirnov[b]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
CPU	Local	.257	45	.000	.560	45	.000
	Remote	.269	47	.000	.852	47	.000

a. Size = 400

b. Lilliefors Significance Correction

In all the Normality Tests performed for the different sizes in the CPU variable, all the **Sig.** values in Shapiro-Wilk section are under 0.05 and all the curves on the Histograms are non-normal. The Mann-Whitney Test has to be performed in all sizes for this variable. The **Local Mean** value is 53.89 and the **Remote Mean** is 47.47 as shown in the Descriptive table on previous page and Histograms below.





Test Results for Exp3 v 6 CPU variable

Table 188

Ranks[a]

	Mode	N	Mean Rank	Sum of Ranks
CPU	Local	45	60.08	2703.50
	Remote	44	29.58	1301.50
	Total	89		

a. Size = 50

Test Statistics[a,b]

	CPU
Mann-Whitney U	311.500
Wilcoxon W	1301.500
Z	-5.621
Asymp. Sig. (2-tailed)	.000

a. Size = 50

b. Grouping Variable: Mode

Table 189

Ranks[a]

	Mode	N	Mean Rank	Sum of Ranks
CPU	Local	45	56.46	2540.50
	Remote	43	31.99	1375.50
	Total	88		

a. Size = 100

Test Statistics[a,b]

	CPU
Mann-Whitney U	429.500
Wilcoxon W	1375.500
Z	-4.500
Asymp. Sig. (2-tailed)	.000

a. Size = 100

b. Grouping Variable: Mode

Table 190

Ranks[a]

	Mode	N	Mean Rank	Sum of Ranks
CPU	Local	47	36.82	1730.50
	Remote	45	56.61	2547.50
	Total	92		

a. Size = 200

Test Statistics[a,b]

	CPU
Mann-Whitney U	602.500
Wilcoxon W	1730.500
Z	-3.577
Asymp. Sig. (2-tailed)	.000

a. Size = 200

b. Grouping Variable: Mode

Table 191

Ranks[a]

	Mode	N	Mean Rank	Sum of Ranks
CPU	Local	45	53.64	2414.00
	Remote	47	39.66	1864.00
	Total	92		

a. Size = 400

Test Statistics[a,b]

	CPU
Mann-Whitney U	736.000
Wilcoxon W	1864.000
Z	-2.537
Asymp. Sig. (2-tailed)	.011

a. Size = 400

b. Grouping Variable: Mode

From the results shown above, the Remote Mean CPU value is significantly lower ate size 50, 100 and 400. The trend reverses at size 200, the Local Mean CPU value is significantly lower than the Remote Mean.

Computation Timing Variable Tests

Normality Tests for Size 50

Table 192

Case Processing Summary[a]

		Cases					
		Valid		Missing		Total	
	Mode	N	Percent	N	Percent	N	Percent
CompTime	Local	45	100.0%	0	0.0%	45	100.0%
	Remote	44	100.0%	0	0.0%	44	100.0%

a. Size = 50

Table 193

Descriptives[a]

	Mode			Statistic	Std. Error
CompTime	Local	Mean		12.20000	1.319856
		95% Confidence Interval for Mean	Lower Bound	9.54000	
			Upper Bound	14.86000	
		5% Trimmed Mean		11.34568	
		Median		8.00000	
		Variance		78.391	
		Std. Deviation		8.853864	
		Minimum		4.000	
		Maximum		37.000	
		Range		33.000	
		Interquartile Range		10.000	
		Skewness		1.320	.354
		Kurtosis		.915	.695
	Remote	Mean		.26126	.007629
		95% Confidence Interval for Mean	Lower Bound	.24588	
			Upper Bound	.27665	
		5% Trimmed Mean		.25870	
		Median		.25740	
		Variance		.003	
		Std. Deviation		.050602	
		Minimum		.206	
		Maximum		.369	
		Range		.162	
		Interquartile Range		.088	
		Skewness		.490	.357
		Kurtosis		-1.072	.702

a. Size = 50

Table 194

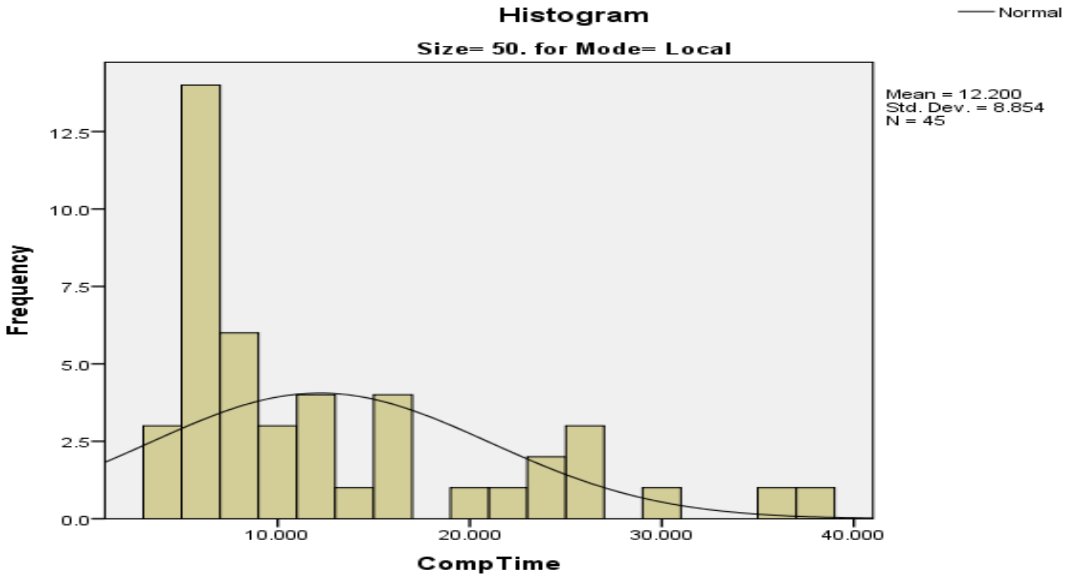
Tests of Normality[a]

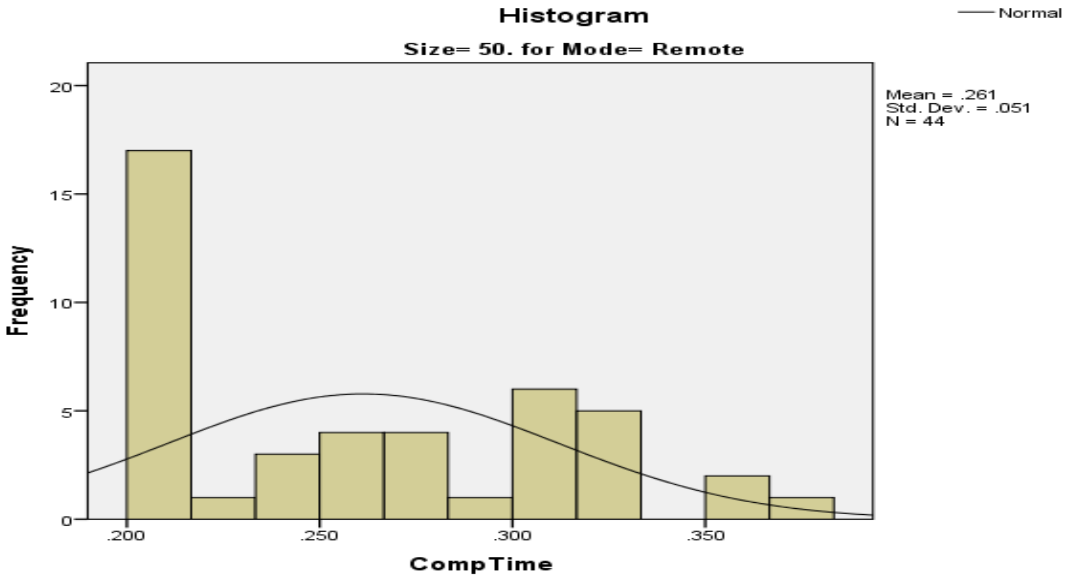
		Kolmogorov-Smirnov[b]			Shapiro-Wilk		
	Mode	Statistic	df	Sig.	Statistic	df	Sig.
CompTime	Local	.210	45	.000	.815	45	.000
	Remote	.215	44	.000	.884	44	.000

a. Size = 50

b. Lilliefors Significance Correction

The **Local Mean** value is 12.2 and the **Remote Mean** is 0.261 as shown in the Descriptive table on previous page and Histograms below.





Normality Tests for Size 100

Table 195

Case Processing Summary[a]

		Cases					
		Valid		Missing		Total	
	Mode	N	Percent	N	Percent	N	Percent
CompTime	Local	45	100.0%	0	0.0%	45	100.0%
	Remote	43	100.0%	0	0.0%	43	100.0%

a. Size = 100

Table 196

Descriptives[a]

	Mode			Statistic	Std. Error
CompTime	Local	Mean		19.22222	.704164
		95% Confidence Interval for Mean	Lower Bound	17.80307	
			Upper Bound	20.64137	
		5% Trimmed Mean		18.59259	
		Median		17.00000	
		Variance		22.313	
		Std. Deviation		4.723678	
		Minimum		16.000	
		Maximum		35.000	
		Range		19.000	
		Interquartile Range		2.000	
		Skewness		2.109	.354
		Kurtosis		3.813	.695
	Remote	Mean		1.97674	.122218
		95% Confidence Interval for Mean	Lower Bound	1.73010	
			Upper Bound	2.22339	
		5% Trimmed Mean		1.89664	
		Median		2.00000	
		Variance		.642	
		Std. Deviation		.801438	
		Minimum		1.000	
		Maximum		6.000	
		Range		5.000	
		Interquartile Range		.000	
		Skewness		2.953	.361
		Kurtosis		14.921	.709

a. Size = 100

Table 197

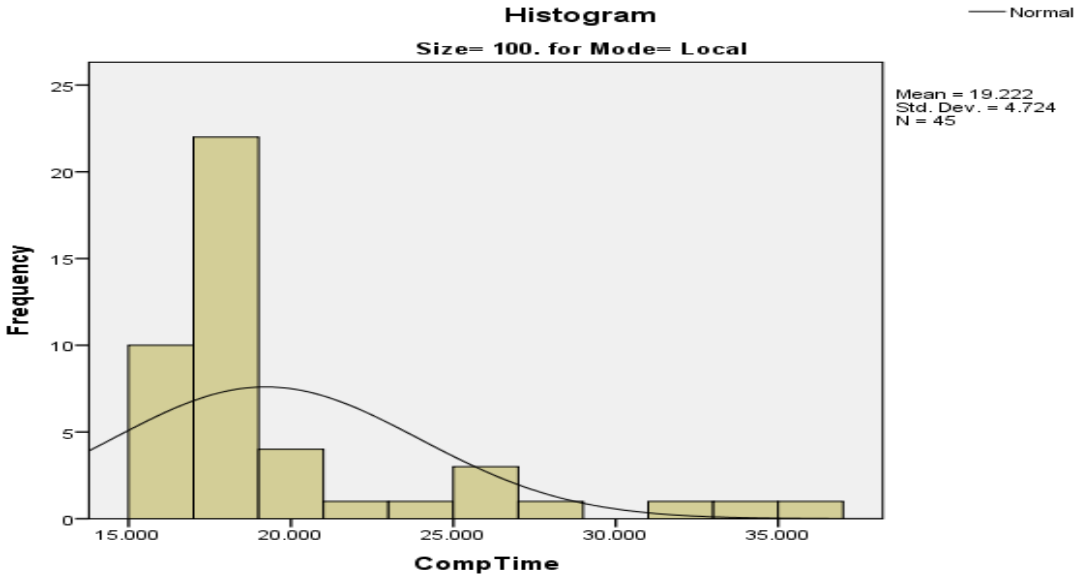
Tests of Normality[a]

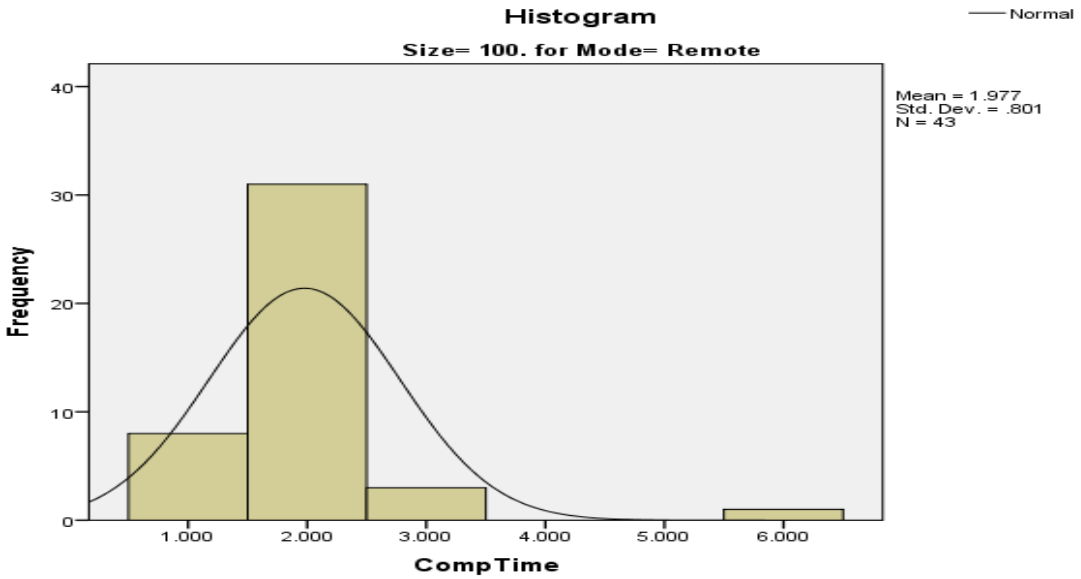
		Kolmogorov-Smirnov[b]			Shapiro-Wilk		
	Mode	Statistic	df	Sig.	Statistic	df	Sig.
CompTime	Local	.313	45	.000	.668	45	.000
	Remote	.395	43	.000	.582	43	.000

a. Size = 100

b. Lilliefors Significance Correction

The **Local Mean** value is 19.222 and the **Remote Mean** is 1.977 as shown in the Descriptive table on previous page and Histograms below.





Normality Tests for Size 200

Table 198

Case Processing Summary[a]

		Cases					
		Valid		Missing		Total	
	Mode	N	Percent	N	Percent	N	Percent
CompTime	Local	47	100.0%	0	0.0%	47	100.0%
	Remote	45	100.0%	0	0.0%	45	100.0%

a. Size = 200

Table 199

Descriptives[a]

	Mode			Statistic	Std. Error
CompTime	Local	Mean		11.89362	.365276
		95% Confidence Interval for Mean	Lower Bound	11.15835	
			Upper Bound	12.62888	
		5% Trimmed Mean		11.64421	
		Median		11.00000	
		Variance		6.271	
		Std. Deviation		2.504206	
		Minimum		10.000	
		Maximum		20.000	
		Range		10.000	
		Interquartile Range		3.000	
		Skewness		1.393	.347
		Kurtosis		1.273	.681
	Remote	Mean		24.91111	.965476
		95% Confidence Interval for Mean	Lower Bound	22.96532	
			Upper Bound	26.85690	
		5% Trimmed Mean		24.64198	
		Median		25.00000	
		Variance		41.946	
		Std. Deviation		6.476609	
		Minimum		16.000	
		Maximum		40.000	
		Range		24.000	
		Interquartile Range		9.000	
		Skewness		.517	.354
		Kurtosis		-.500	.695

a. Size = 200

Table 200

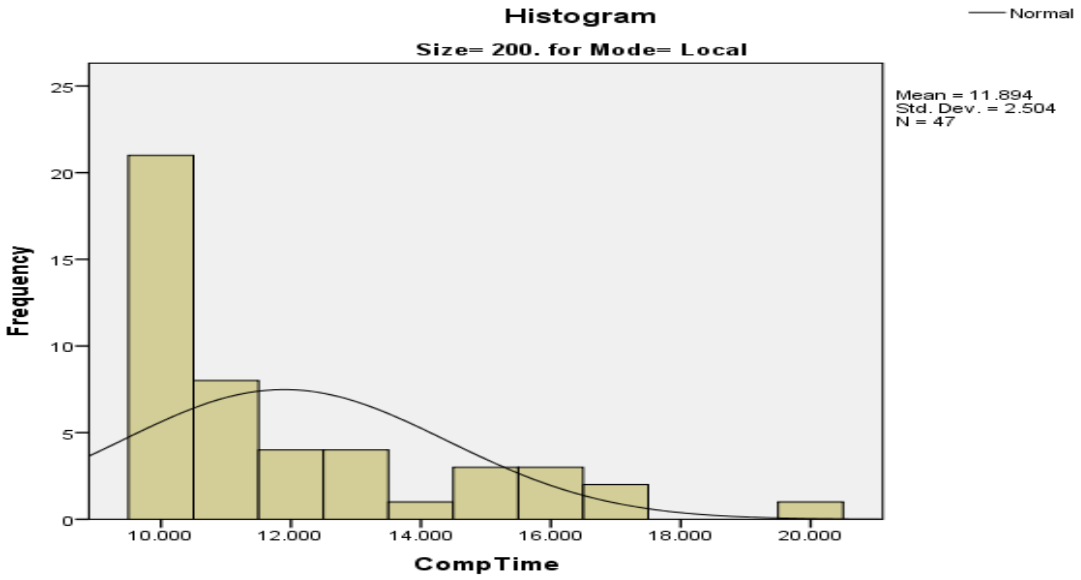
Tests of Normality[a]

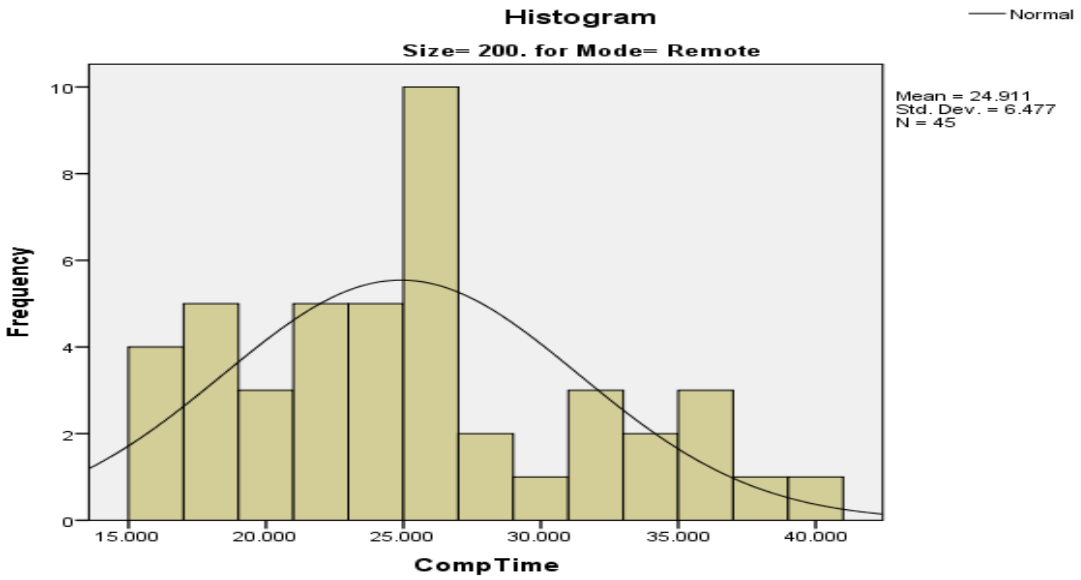
	Mode	Kolmogorov-Smirnov[b]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
CompTime	Local	.256	47	.000	.774	47	.000
	Remote	.144	45	.020	.944	45	.029

a. Size = 200

b. Lilliefors Significance Correction

The **Local Mean** value is 11.894 and the **Remote Mean** is 24.911 as shown in the Descriptive table on previous page and Histograms below.





Normality Tests for Size 400

Table 201

Case Processing Summary[a]

		Cases					
		Valid		Missing		Total	
	Mode	N	Percent	N	Percent	N	Percent
CompTime	Local	45	100.0%	0	0.0%	45	100.0%
	Remote	46	97.9%	1	2.1%	47	100.0%

a. Size = 400

Table 202

Descriptives[a]

	Mode			Statistic	Std. Error
CompTime	Local	Mean		41.75556	.695698
		95% Confidence Interval for Mean	Lower Bound	40.35347	
			Upper Bound	43.15764	
		5% Trimmed Mean		41.22222	
		Median		40.00000	
		Variance		21.780	
		Std. Deviation		4.666883	
		Minimum		37.000	
		Maximum		57.000	
		Range		20.000	
		Interquartile Range		6.000	
		Skewness		1.708	.354
		Kurtosis		3.245	.695
	Remote	Mean		326.30435	4.250362
		95% Confidence Interval for Mean	Lower Bound	317.74368	
			Upper Bound	334.86502	
		5% Trimmed Mean		324.53865	
		Median		317.50000	
		Variance		831.016	
		Std. Deviation		28.827355	
		Minimum		287.000	
		Maximum		404.000	
		Range		117.000	
		Interquartile Range		38.250	
		Skewness		.946	.350
		Kurtosis		.085	.688

a. Size = 400

Table 203

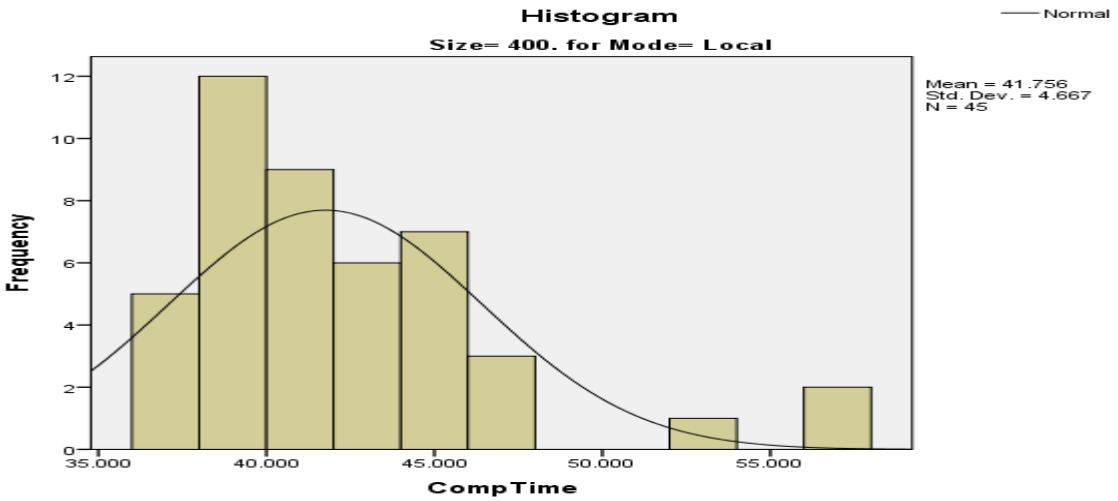
Tests of Normality[a]

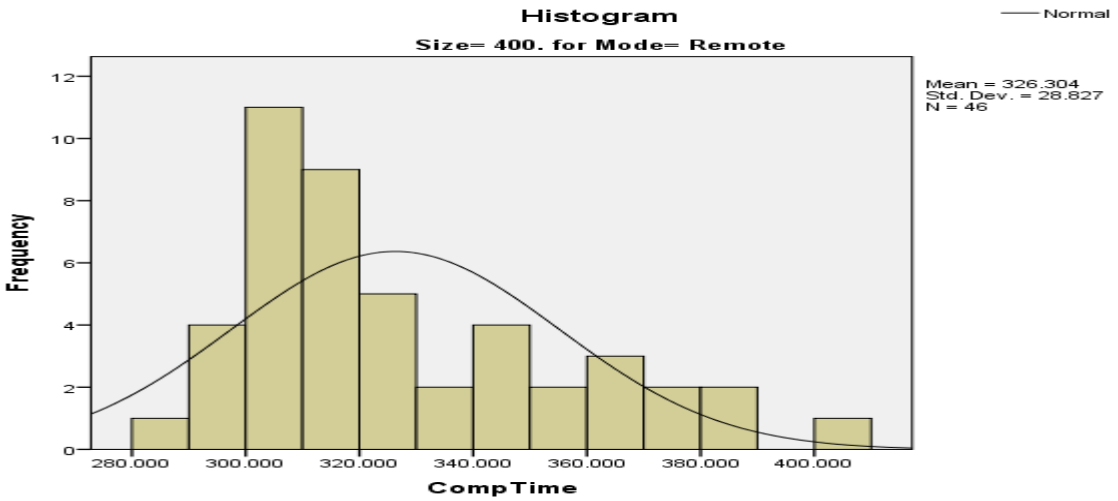
		Kolmogorov-Smirnov[b]			Shapiro-Wilk		
	Mode	Statistic	df	Sig.	Statistic	df	Sig.
CompTime	Local	.180	45	.001	.824	45	.000
	Remote	.152	46	.010	.909	46	.002

a. Size = 400

b. Lilliefors Significance Correction

All the Normality Tests for all sizes for the Computation Timing variable have shown the Sig. value of the Shapiro-Wilk section to be under 0.05. Also all the curves on each Histogram has a non-normal curve. This means a Mann-Whitney Test has to be carried out for all sizes for this variable. The **Local Mean** value is 41.756 and the **Remote Mean** is 326.304 as shown in the Descriptive table on previous page and Histograms below.





Test Results for Exp3 v 6 Computation Timing variable

Table 204

Ranks[a]

	Mode	N	Mean Rank	Sum of Ranks
CompTime	Local	45	67.00	3015.00
	Remote	44	22.50	990.00
	Total	89		

a. Size = 50

Test Statistics[a,b]

	CompTime
Mann-Whitney U	.000
Wilcoxon W	990.000
Z	-8.129
Asymp. Sig. (2-tailed)	.000

a. Size = 50

b. Grouping Variable: Mode

Table 205

Ranks[a]

	Mode	N	Mean Rank	Sum of Ranks
CompTime	Local	45	66.00	2970.00
	Remote	43	22.00	946.00
	Total	88		

a. Size = 100

Test Statistics[a,b]

	CompTime
Mann-Whitney U	.000
Wilcoxon W	946.000
Z	-8.292
Asymp. Sig. (2-tailed)	.000

a. Size = 100

b. Grouping Variable: Mode

Table 206

Ranks[a]

	Mode	N	Mean Rank	Sum of Ranks
CompTime	Local	47	24.61	1156.50
	Remote	45	69.37	3121.50
	Total	92		

a. Size = 200

Test Statistics[a,b]

	CompTime
Mann-Whitney U	28.500
Wilcoxon W	1156.500
Z	-8.094
Asymp. Sig. (2-tailed)	.000

a. Size = 200

b. Grouping Variable: Mode

Table 207

Ranks[a]

	Mode	N	Mean Rank	Sum of Ranks
CompTime	Local	45	23.00	1035.00
	Remote	46	68.50	3151.00
	Total	91		

a. Size = 400

Test Statistics[a,b]

	CompTime
Mann-Whitney U	.000
Wilcoxon W	1035.000
Z	-8.222
Asymp. Sig. (2-tailed)	.000

a. Size = 400

b. Grouping Variable: Mode

From the results shown above, the Remote Mean value is significantly lower than the Local Mean in sizes 50 and 100. However the trend reverses in sizes 200 and 400, the Local Mean is significantly lower than the Remote Mean value.

Total Timing Variable

Normality Tests for Size 50

Table 208

Case Processing Summary[a]

		Cases					
		Valid		Missing		Total	
	Mode	N	Percent	N	Percent	N	Percent
TotalTime	Local	45	100.0%	0	0.0%	45	100.0%
	Remote	44	100.0%	0	0.0%	44	100.0%

a. Size = 50

Table 209

Descriptives[a]

	Mode			Statistic	Std. Error
TotalTime	Local	Mean		23.60	1.656
		95% Confidence Interval for Mean	Lower Bound	20.26	
			Upper Bound	26.94	
		5% Trimmed Mean		22.62	
		Median		19.00	
		Variance		123.427	
		Std. Deviation		11.110	
		Minimum		12	
		Maximum		58	
		Range		46	
		Interquartile Range		16	
		Skewness		1.271	.354
		Kurtosis		.992	.695
	Remote	Mean		4180.48	128.487
		95% Confidence Interval for Mean	Lower Bound	3921.36	
			Upper Bound	4439.60	
		5% Trimmed Mean		4101.61	
		Median		4153.50	
		Variance		726394.674	
		Std. Deviation		852.288	
		Minimum		3011	
		Maximum		7863	
		Range		4852	
		Interquartile Range		1014	
		Skewness		1.969	.357
		Kurtosis		6.854	.702

a. Size = 50

Table 210

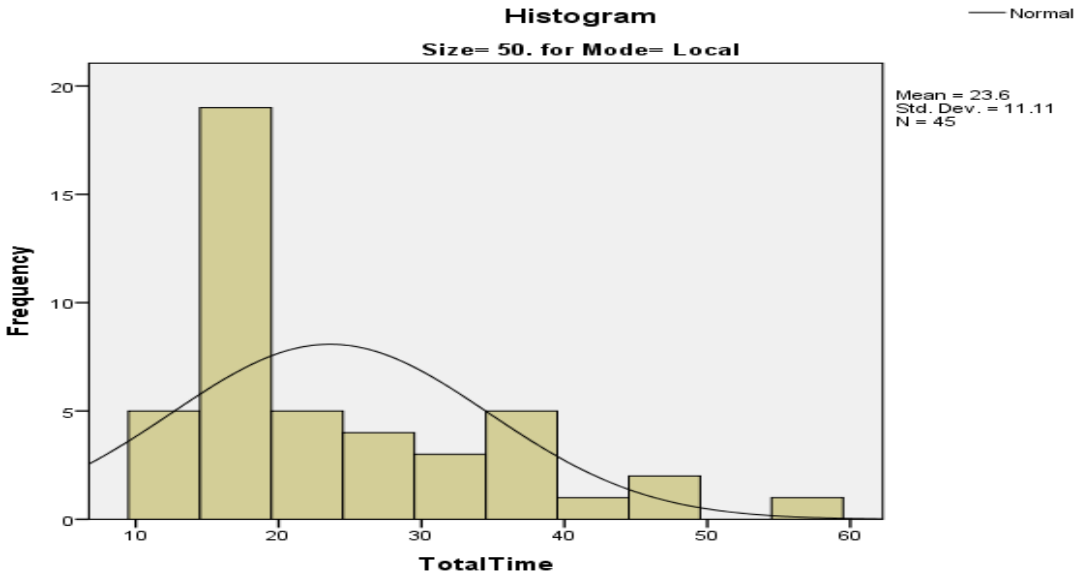
Tests of Normality[a]

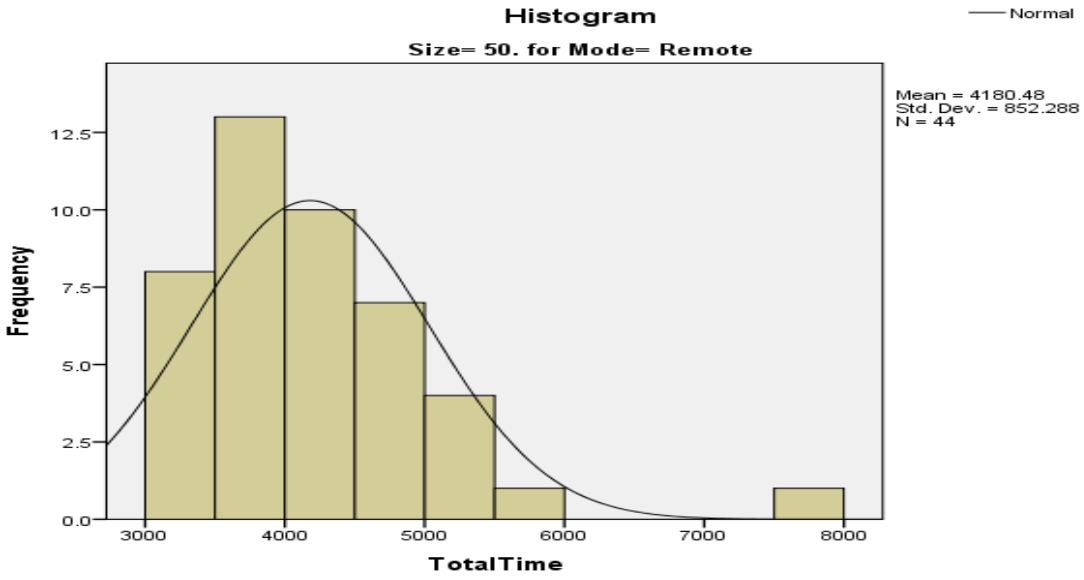
		Kolmogorov-Smirnov[b]			Shapiro-Wilk		
	Mode	Statistic	df	Sig.	Statistic	df	Sig.
TotalTime	Local	.215	45	.000	.842	45	.000
	Remote	.144	44	.022	.844	44	.000

a. Size = 50

b. Lilliefors Significance Correction

The **Local Mean** value is 23.6 and the **Remote Mean** is 4180.48 as shown in the Descriptive table on previous page and Histograms below.





Normality Tests for Size 100

Table 211

Case Processing Summary[a]

		Cases					
		Valid		Missing		Total	
	Mode	N	Percent	N	Percent	N	Percent
TotalTime	Local	45	100.0%	0	0.0%	45	100.0%
	Remote	43	100.0%	0	0.0%	43	100.0%

a. Size = 100

Table 212

Descriptives[a]

	Mode			Statistic	Std. Error
TotalTime	Local	Mean		67.71	3.180
		95% Confidence Interval for Mean	Lower Bound	61.30	
			Upper Bound	74.12	
		5% Trimmed Mean		69.40	
		Median		72.00	
		Variance		455.028	
		Std. Deviation		21.331	
		Minimum		10	
		Maximum		99	
		Range		89	
		Interquartile Range		10	
		Skewness		-1.951	.354
		Kurtosis		3.218	.695
	Remote	Mean		4842.12	567.335
		95% Confidence Interval for Mean	Lower Bound	3697.19	
			Upper Bound	5987.05	
		5% Trimmed Mean		4228.35	
		Median		3686.00	
		Variance		13840376.11	
		Std. Deviation		3720.266	
		Minimum		2132	
		Maximum		25894	
		Range		23762	
		Interquartile Range		808	
		Skewness		4.683	.361
		Kurtosis		25.309	.709

a. Size = 100

Table 213

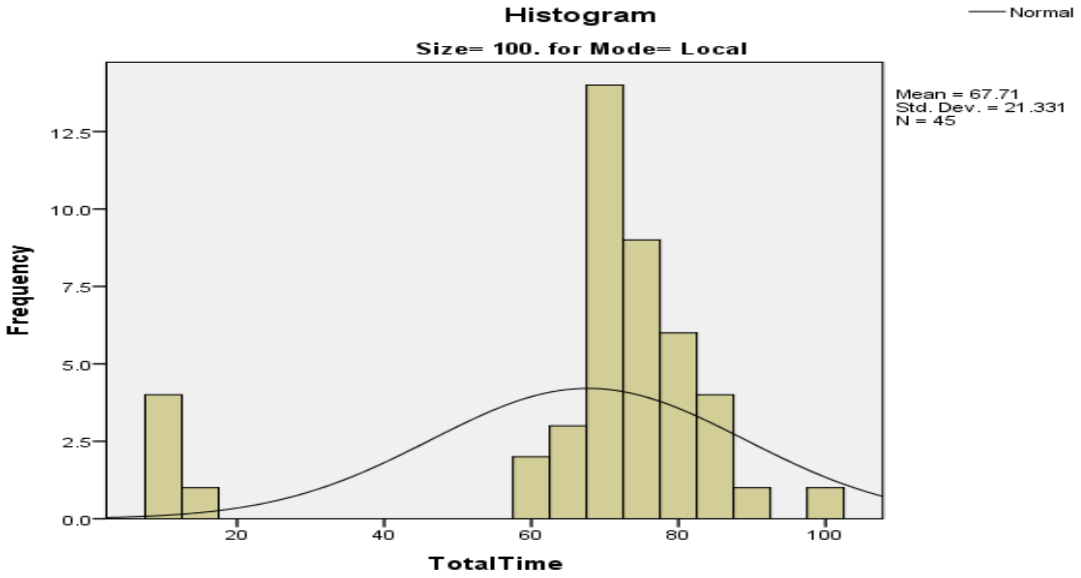
Tests of Normality[a]

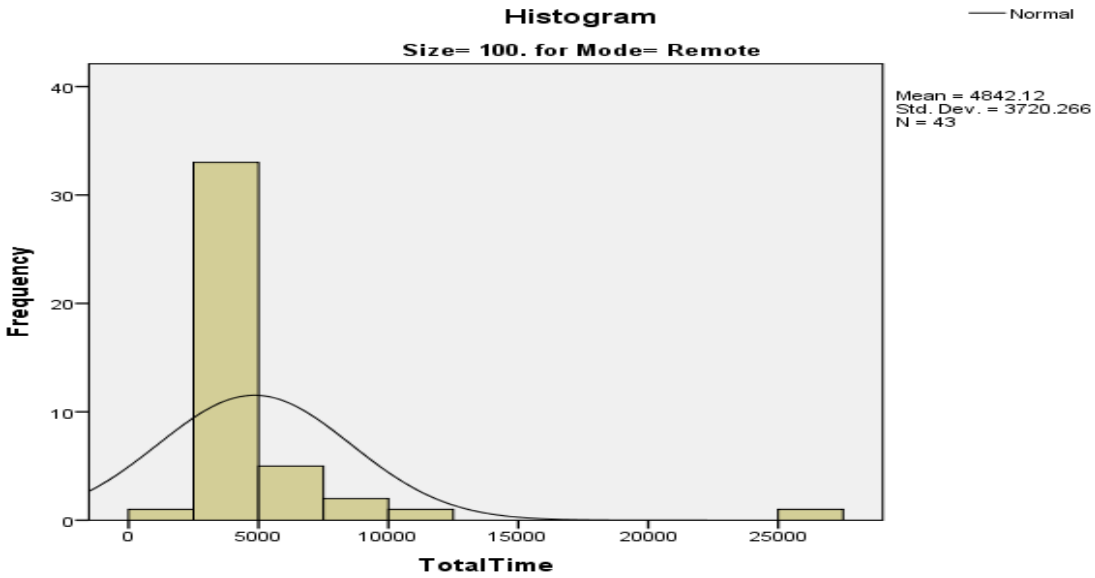
	Mode	Kolmogorov-Smirnov[b]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
TotalTime	Local	.290	45	.000	.702	45	.000
	Remote	.330	43	.000	.447	43	.000

a. Size = 100

b. Lilliefors Significance Correction

The **Local Mean** value is 67.71 and the **Remote Mean** is 4842.12 as shown in the Descriptive table on previous page and Histograms below.





Normality Tests for Size 200

Table 214

Case Processing Summary[a]

		Cases					
		Valid		Missing		Total	
	Mode	N	Percent	N	Percent	N	Percent
TotalTime	Local	47	100.0%	0	0.0%	47	100.0%
	Remote	45	100.0%	0	0.0%	45	100.0%

a. Size = 200

Table 215

Descriptives[a]

	Mode			Statistic	Std. Error
TotalTime	Local	Mean		577.85	6.951
		95% Confidence Interval for Mean	Lower Bound	563.86	
			Upper Bound	591.84	
		5% Trimmed Mean		576.91	
		Median		570.00	
		Variance		2271.173	
		Std. Deviation		47.657	
		Minimum		502	
		Maximum		673	
		Range		171	
		Interquartile Range		80	
		Skewness		.301	.347
		Kurtosis		-1.087	.681
	Remote	Mean		3876.02	395.408
		95% Confidence Interval for Mean	Lower Bound	3079.13	
			Upper Bound	4672.91	
		5% Trimmed Mean		3553.17	
		Median		2829.00	
		Variance		7035637.340	
		Std. Deviation		2652.478	
		Minimum		1629	
		Maximum		13865	
		Range		12236	
		Interquartile Range		1273	
		Skewness		2.142	.354
		Kurtosis		4.278	.695

a. Size = 200

Table 216

Tests of Normality[a]

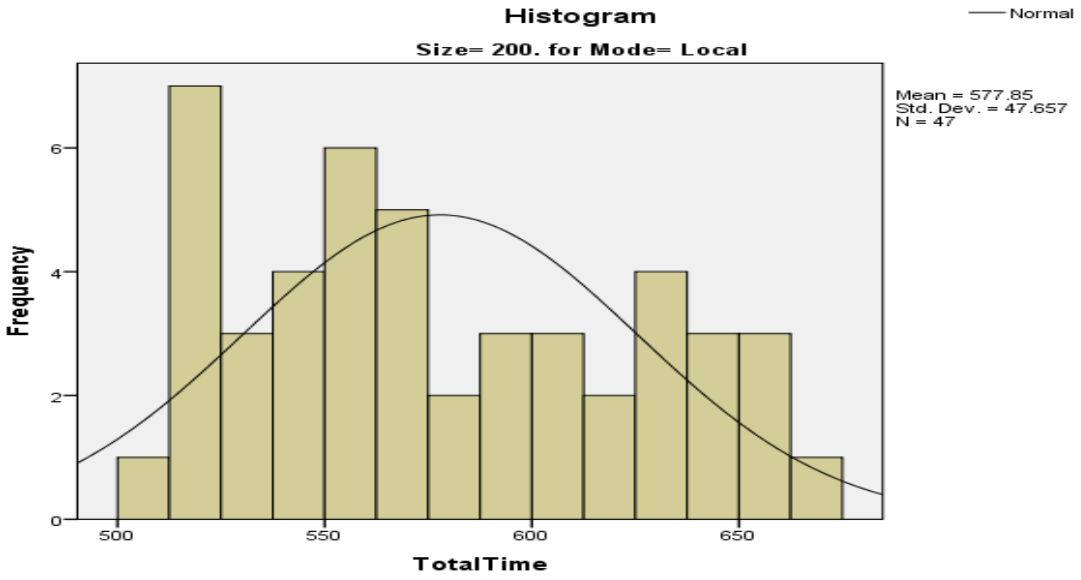
	Mode	Kolmogorov-Smirnov[b]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
TotalTime	Local	.096	47	.200*	.947	47	.033
	Remote	.328	45	.000	.674	45	.000

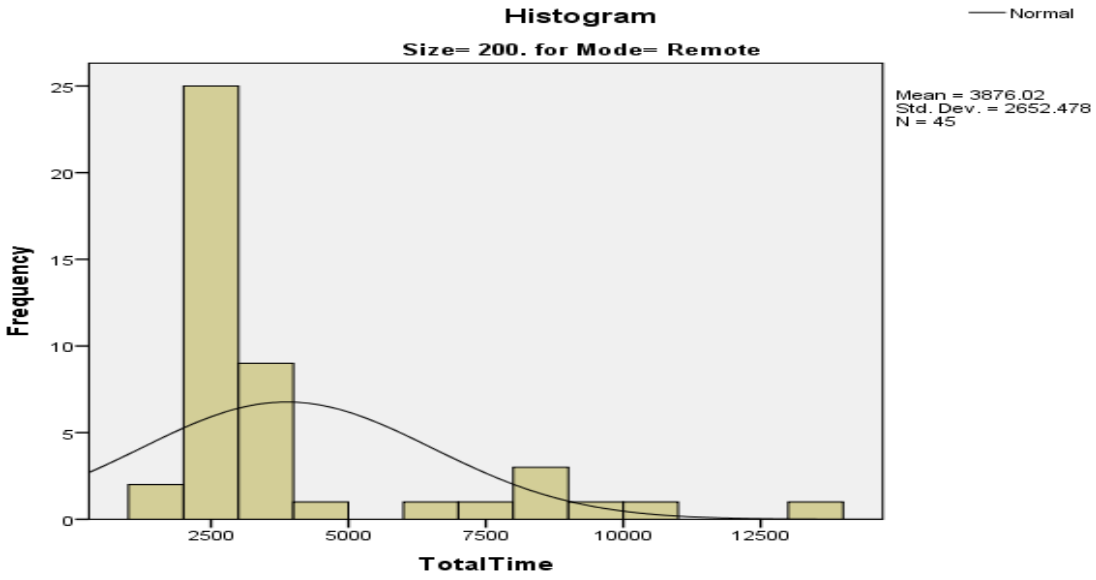
*. This is a lower bound of the true significance.

a. Size = 200

b. Lilliefors Significance Correction

The **Local Mean** value is 577.85 and the **Remote Mean** is 3876.02 as shown in the Descriptive table on previous page and Histograms below.





Normality Tests for Size 400

Table 217

Case Processing Summary[a]

		Cases					
		Valid		Missing		Total	
	Mode	N	Percent	N	Percent	N	Percent
TotalTime	Local	45	100.0%	0	0.0%	45	100.0%
	Remote	47	100.0%	0	0.0%	47	100.0%

a. Size = 400

Table 218

Descriptives[a]

	Mode			Statistic	Std. Error
TotalTime	Local	Mean		5094.80	43.970
		95% Confidence Interval for Mean	Lower Bound	5006.18	
			Upper Bound	5183.42	
		5% Trimmed Mean		5072.22	
		Median		5013.00	
		Variance		87001.482	
		Std. Deviation		294.960	
		Minimum		4737	
		Maximum		5914	
		Range		1177	
		Interquartile Range		385	
		Skewness		1.036	.354
		Kurtosis		.628	.695
	Remote	Mean		51392.96	6177.602
		95% Confidence Interval for Mean	Lower Bound	38958.09	
			Upper Bound	63827.83	
		5% Trimmed Mean		49905.15	
		Median		30278.00	
		Variance		1793650313	
		Std. Deviation		42351.509	
		Minimum		8011	
		Maximum		131979	
		Range		123968	
		Interquartile Range		84772	
		Skewness		.282	.347
		Kurtosis		-1.724	.681

a. Size = 400

Table 219

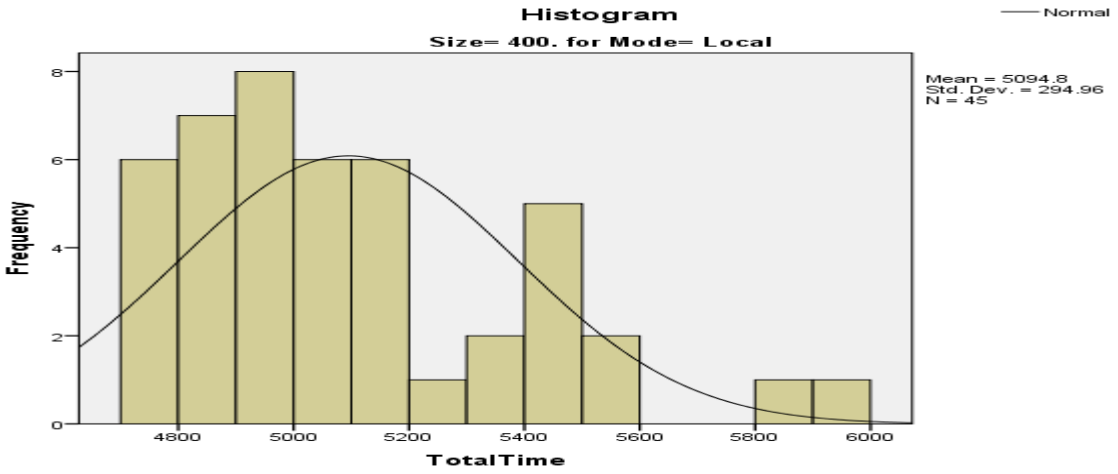
Tests of Normality[a]

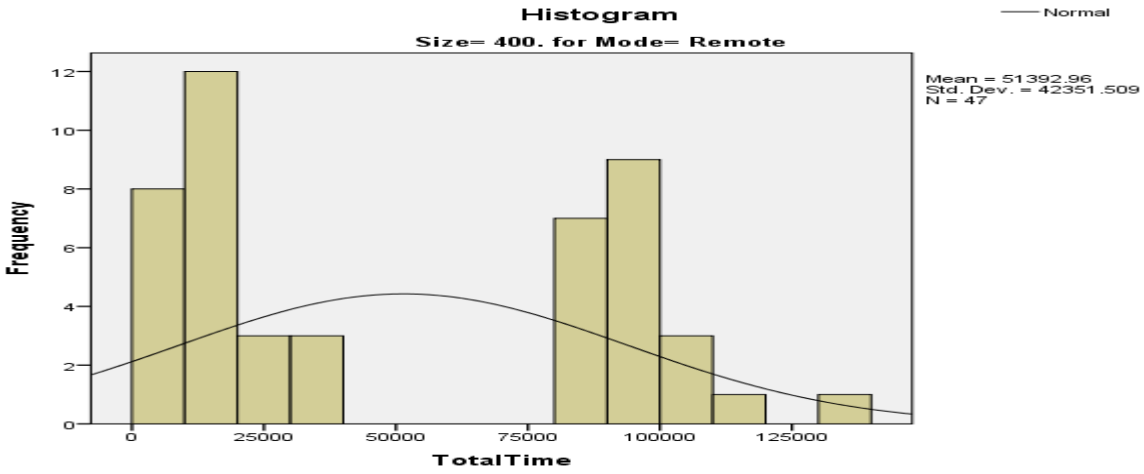
	Mode	Kolmogorov-Smirnov[b]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
TotalTime	Local	.133	45	.045	.904	45	.001
	Remote	.233	47	.000	.803	47	.000

a. Size = 400

b. Lilliefors Significance Correction

In all the Normality Tests carried out for the Total Timing Variable, all the **Sig.** values in the Shapiro-Wilk section like in the table above are under 0.05. All the curves from each Histogram in this variable are non-normal. This means a Mann-Whitney Test will be carried out for all of the sizes in this variable. The **Local Mean** value is 5094.5 and the **Remote Mean** is 51392.96 as shown in the Descriptive table on previous page and Histograms below.





Test Results from Exp3 v 6 Total Timing variable

Table 220

Ranks[a]

	Mode	N	Mean Rank	Sum of Ranks
TotalTime	Local	45	23.00	1035.00
	Remote	44	67.50	2970.00
	Total	89		

a. Size = 50

Test Statistics[a,b]

	TotalTime
Mann-Whitney U	.000
Wilcoxon W	1035.000
Z	-8.129
Asymp. Sig. (2-tailed)	.000

a. Size = 50

b. Grouping Variable: Mode

Table 221

Ranks[a]

	Mode	N	Mean Rank	Sum of Ranks
TotalTime	Local	45	23.00	1035.00
	Remote	43	67.00	2881.00
	Total	88		

a. Size = 100

Test Statistics[a,b]

	TotalTime
Mann-Whitney U	.000
Wilcoxon W	1035.000
Z	-8.078
Asymp. Sig. (2-tailed)	.000

a. Size = 100

b. Grouping Variable: Mode

Table 222

Ranks[a]

	Mode	N	Mean Rank	Sum of Ranks
TotalTime	Local	47	24.00	1128.00
	Remote	45	70.00	3150.00
	Total	92		

a. Size = 200

Test Statistics[a,b]

	TotalTime
Mann-Whitney U	.000
Wilcoxon W	1128.000
Z	-8.260
Asymp. Sig. (2-tailed)	.000

a. Size = 200

b. Grouping Variable: Mode

Table 223

Ranks[a]

	Mode	N	Mean Rank	Sum of Ranks
TotalTime	Local	45	23.00	1035.00
	Remote	47	69.00	3243.00
	Total	92		

a. Size = 400

Test Statistics[a,b]

	TotalTime
Mann-Whitney U	.000
Wilcoxon W	1035.000
Z	-8.260
Asymp. Sig. (2-tailed)	.000

a. Size = 400

b. Grouping Variable: Mode

From the results above, the Local Mean for Total Timing is significantly lower than the Remote Mean in all the sizes.

Battery Remaining Variable Tests

Normality Tests for Size 50

Table 224

Case Processing Summary[a]

		Cases					
		Valid		Missing		Total	
	Mode	N	Percent	N	Percent	N	Percent
Batt_Remain	Local	45	100.0%	0	0.0%	45	100.0%
	Remote	44	100.0%	0	0.0%	44	100.0%

a. Size = 50

Table 225

Descriptives[a]

	Mode			Statistic	Std. Error
Batt_Remain	Local	Mean		99.20	.060
		95% Confidence Interval for Mean	Lower Bound	99.08	
			Upper Bound	99.32	
		5% Trimmed Mean		99.17	
		Median		99.00	
		Variance		.164	
		Std. Deviation		.405	
		Minimum		99	
		Maximum		100	
		Range		1	
		Interquartile Range		0	
		Skewness		1.552	.354
		Kurtosis		.426	.695
	Remote	Mean		99.66	.072
		95% Confidence Interval for Mean	Lower Bound	99.51	
			Upper Bound	99.80	
		5% Trimmed Mean		99.68	
		Median		100.00	
		Variance		.230	
		Std. Deviation		.479	
		Minimum		99	
		Maximum		100	
		Range		1	
		Interquartile Range		1	
		Skewness		-.695	.357
		Kurtosis		-1.591	.702

a. Size = 50

Table 226

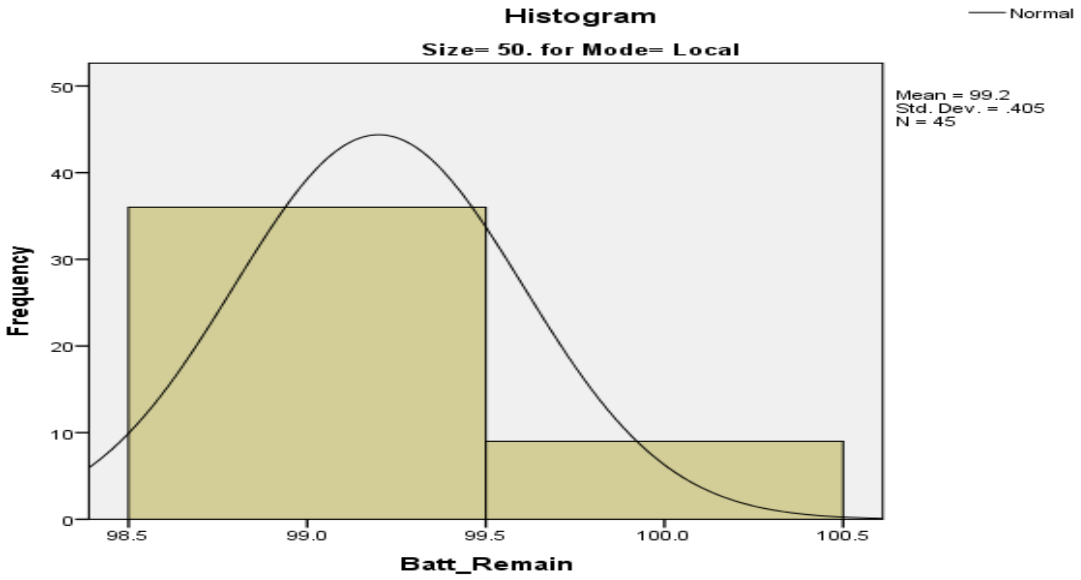
Tests of Normality[a]

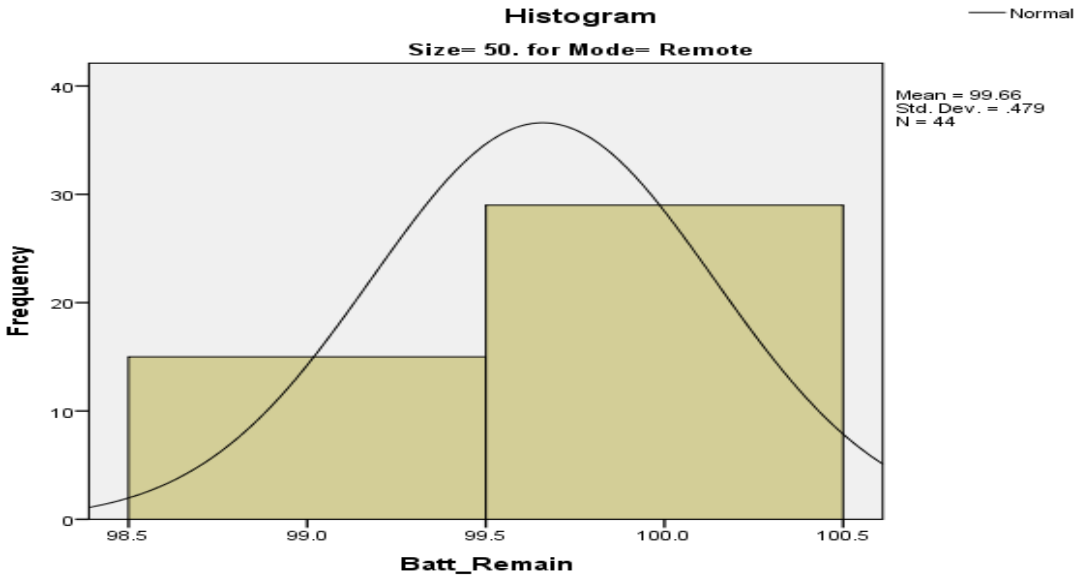
		Kolmogorov-Smirnov[b]			Shapiro-Wilk		
	Mode	Statistic	df	Sig.	Statistic	df	Sig.
Batt_Remain	Local	.489	45	.000	.491	45	.000
	Remote	.421	44	.000	.599	44	.000

a. Size = 50

b. Lilliefors Significance Correction

The **Local Mean** value is 99.2 and the **Remote Mean** is 99.66 as shown in the Descriptive table on previous page and Histograms below.





Normality Tests for Size 100

Table 227

Case Processing Summary[a]

		Cases					
		Valid		Missing		Total	
	Mode	N	Percent	N	Percent	N	Percent
Batt_Remain	Local	45	100.0%	0	0.0%	45	100.0%
	Remote	43	100.0%	0	0.0%	43	100.0%

a. Size = 100

Table 228

Descriptives[a]

	Mode			Statistic	Std. Error
Batt_Remain	Local	Mean		98.31	.070
		95% Confidence Interval for Mean	Lower Bound	98.17	
			Upper Bound	98.45	
		5% Trimmed Mean		98.29	
		Median		98.00	
		Variance		.219	
		Std. Deviation		.468	
		Minimum		98	
		Maximum		99	
		Range		1	
		Interquartile Range		1	
		Skewness		.844	.354
		Kurtosis		-1.349	.695
	Remote	Mean		97.33	.148
		95% Confidence Interval for Mean	Lower Bound	97.03	
			Upper Bound	97.62	
		5% Trimmed Mean		97.31	
		Median		97.00	
		Variance		.939	
		Std. Deviation		.969	
		Minimum		96	
		Maximum		99	
		Range		3	
		Interquartile Range		1	
		Skewness		.274	.361
		Kurtosis		-.815	.709

a. Size = 100

Table 229

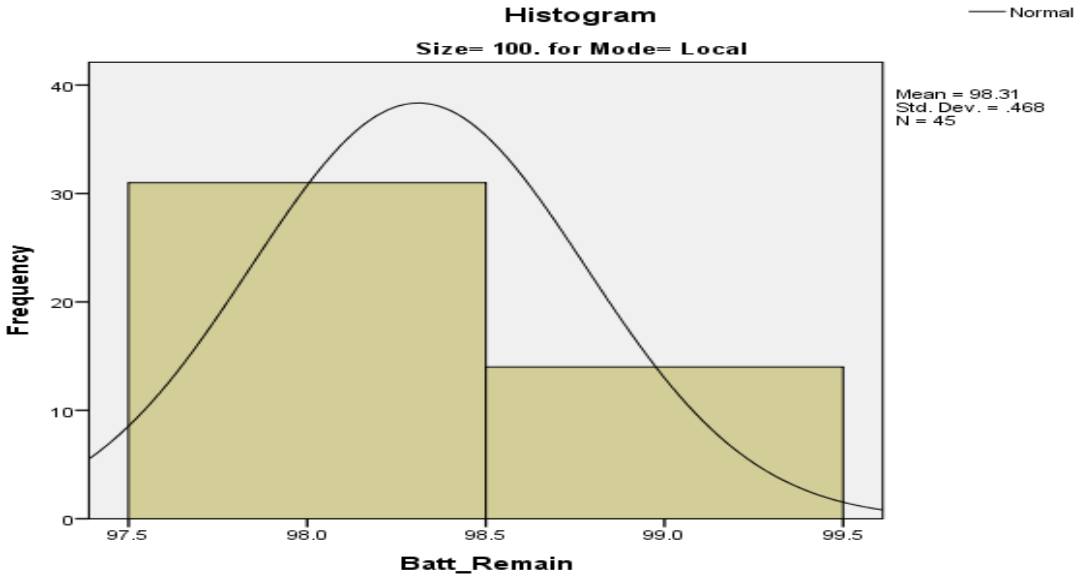
Tests of Normality[a]

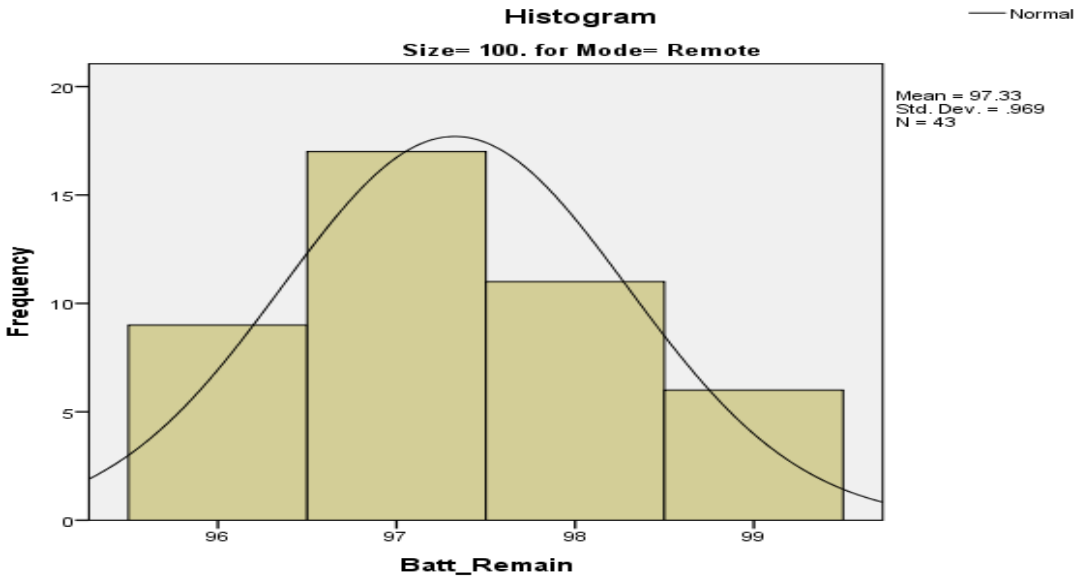
	Mode	Kolmogorov-Smirnov[b]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Batt_Remain	Local	.436	45	.000	.583	45	.000
	Remote	.236	43	.000	.874	43	.000

a. Size = 100

b. Lilliefors Significance Correction

The **Local Mean** value is 98.31 and the **Remote Mean** is 97.33 as shown in the Descriptive table on previous page and Histograms below.





Normality Tests for Size 200

Table 230

Case Processing Summary[a]

		Cases					
		Valid		Missing		Total	
	Mode	N	Percent	N	Percent	N	Percent
Batt_Remain	Local	47	100.0%	0	0.0%	47	100.0%
	Remote	45	100.0%	0	0.0%	45	100.0%

a. Size = 200

Table 231

Descriptives[a]

	Mode			Statistic	Std. Error
Batt_Remain	Local	Mean		95.17	.188
		95% Confidence Interval for Mean	Lower Bound	94.79	
			Upper Bound	95.55	
		5% Trimmed Mean		95.19	
		Median		95.00	
		Variance		1.666	
		Std. Deviation		1.291	
		Minimum		93	
		Maximum		97	
		Range		4	
		Interquartile Range		2	
		Skewness		-.078	.347
		Kurtosis		-1.085	.681
	Remote	Mean		92.53	.307
		95% Confidence Interval for Mean	Lower Bound	91.91	
			Upper Bound	93.15	
		5% Trimmed Mean		92.53	
		Median		92.00	
		Variance		4.255	
		Std. Deviation		2.063	
		Minimum		89	
		Maximum		96	
		Range		7	
		Interquartile Range		3	
		Skewness		.032	.354
		Kurtosis		-1.201	.695

a. Size = 200

Table 232

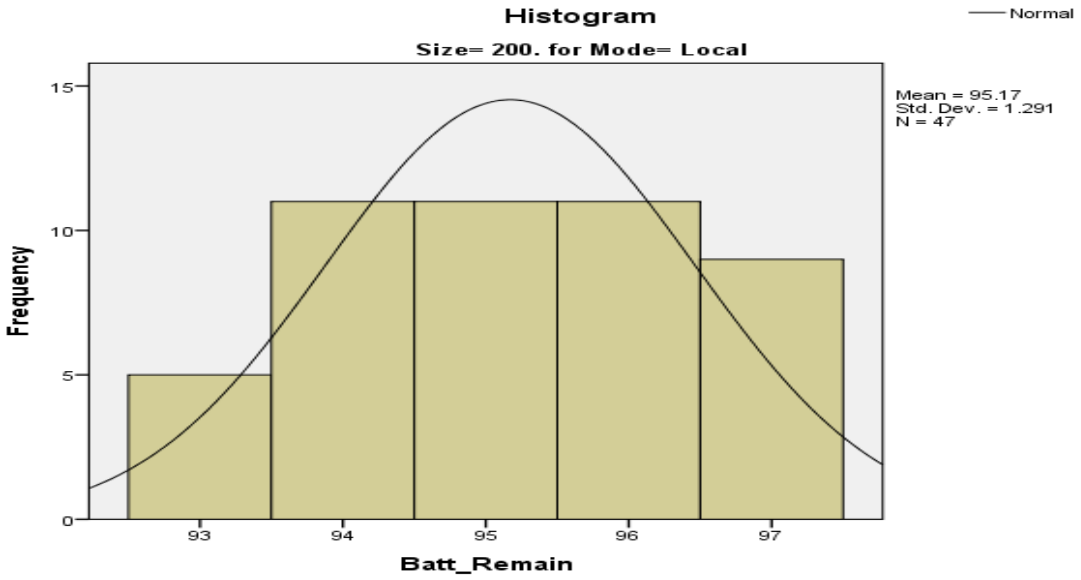
Tests of Normality[a]

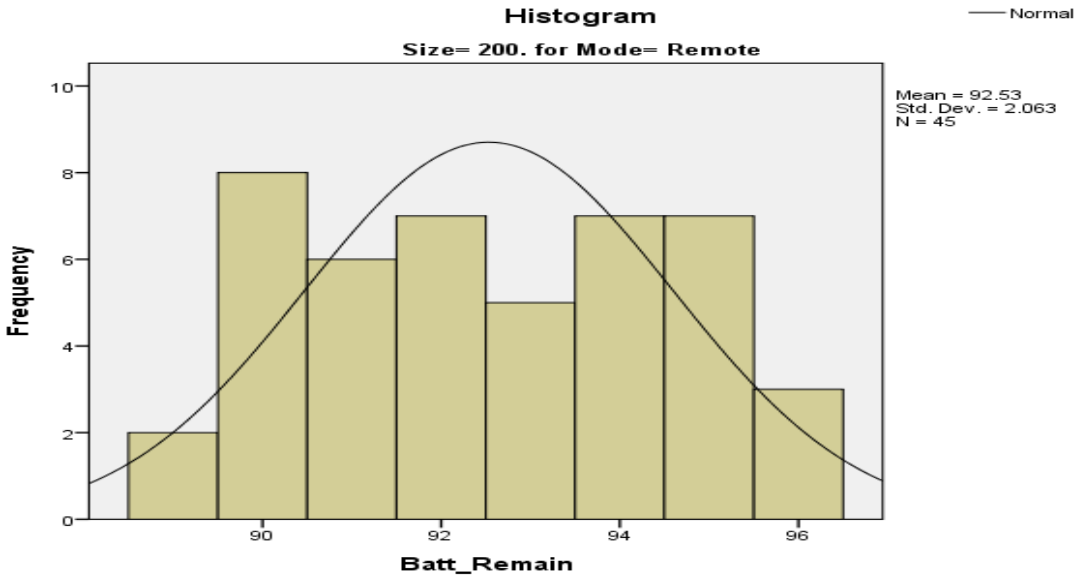
		Kolmogorov-Smirnov[b]			Shapiro-Wilk		
	Mode	Statistic	df	Sig.	Statistic	df	Sig.
Batt_Remain	Local	.165	47	.002	.906	47	.001
	Remote	.139	45	.029	.936	45	.015

a. Size = 200

b. Lilliefors Significance Correction

The **Local Mean** value is 95.17 and the **Remote Mean** is 92.53 as shown in the Descriptive table on previous page and Histograms below.





Normality Tests for Size 400

Table 233

Case Processing Summary[a]

		Cases					
		Valid		Missing		Total	
	Mode	N	Percent	N	Percent	N	Percent
Batt_Remain	Local	45	100.0%	0	0.0%	45	100.0%
	Remote	47	100.0%	0	0.0%	47	100.0%

a. Size = 400

Table 234

Descriptives[a]

	Mode			Statistic	Std. Error
Batt_Remain	Local	Mean		83.84	.797
		95% Confidence Interval for Mean	Lower Bound	82.24	
			Upper Bound	85.45	
		5% Trimmed Mean		83.85	
		Median		84.00	
		Variance		28.589	
		Std. Deviation		5.347	
		Minimum		75	
		Maximum		93	
		Range		18	
		Interquartile Range		10	
		Skewness		.052	.354
		Kurtosis		-1.190	.695
	Remote	Mean		72.13	1.466
		95% Confidence Interval for Mean	Lower Bound	69.18	
			Upper Bound	75.08	
		5% Trimmed Mean		72.11	
		Median		72.00	
		Variance		101.027	
		Std. Deviation		10.051	
		Minimum		57	
		Maximum		88	
		Range		31	
		Interquartile Range		19	
		Skewness		.056	.347
		Kurtosis		-1.418	.681

a. Size = 400

Table 235

Tests of Normality[a]

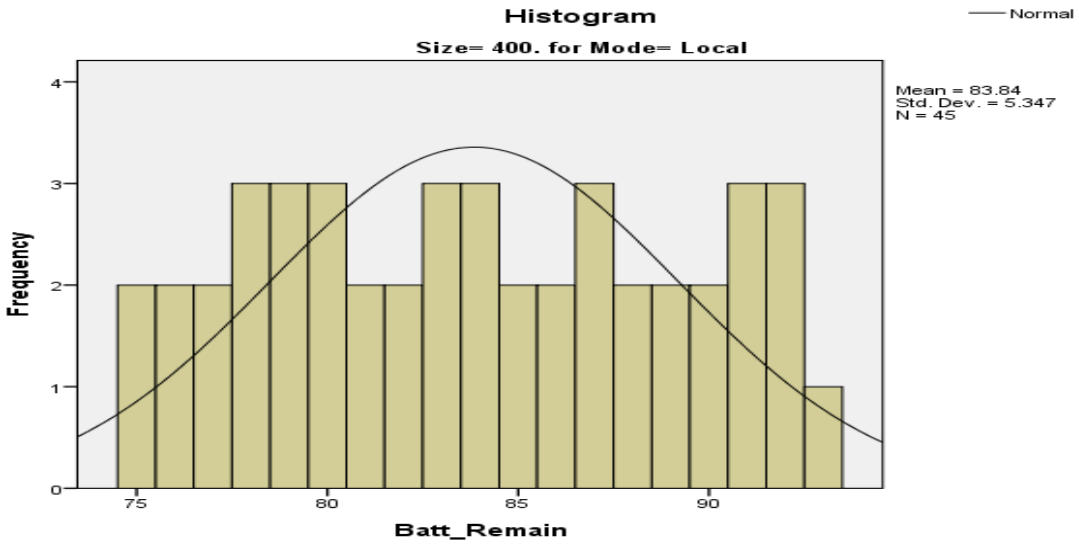
	Mode	Kolmogorov-Smirnov[b]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Batt_Remain	Local	.097	45	.200*	.953	45	.064
	Remote	.114	47	.165	.926	47	.005

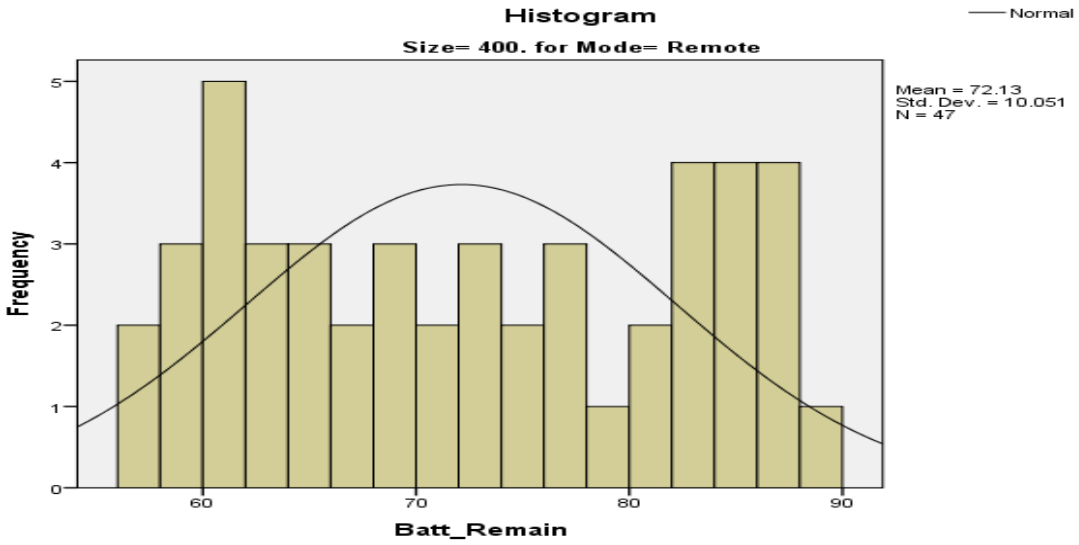
*. This is a lower bound of the true significance.

a. Size = 400

b. Lilliefors Significance Correction

In all the Normality Tests performed in the Battery Remaining variable, The **Sig.** values in the Shapiro-Wilk section of Tests of Normality table are all under 0.05. The curves in all the Histograms are all non-normal. As a result, the Mann-Whitney Test will be performed on all sizes in the Battery Remaining variable. The **Local Mean** value is 83.84 and the **Remote Mean** is 72.13 as shown in the Descriptive table on previous page and Histograms below.





Test Results for Exp3 v 6 Battery Remaining variable

Table 236

Ranks[a]

	Mode	N	Mean Rank	Sum of Ranks
Batt_Remain	Local	45	34.90	1570.50
	Remote	44	55.33	2434.50
	Total	89		

a. Size = 50

Test Statistics[a,b]

	Batt_Remain
Mann-Whitney U	535.500
Wilcoxon W	1570.500
Z	-4.353
Asymp. Sig. (2-tailed)	.000

a. Size = 50

b. Grouping Variable: Mode

Table 237

Ranks[a]

	Mode	N	Mean Rank	Sum of Ranks
Batt_Remain	Local	45	57.14	2571.50
	Remote	43	31.27	1344.50
	Total	88		

a. Size = 100

Test Statistics[a,b]

	Batt_Remain
Mann-Whitney U	398.500
Wilcoxon W	1344.500
Z	-5.088
Asymp. Sig. (2-tailed)	.000

a. Size = 100

b. Grouping Variable: Mode

Table 238

Ranks[a]

	Mode	N	Mean Rank	Sum of Ranks
Batt_Remain	Local	47	61.89	2909.00
	Remote	45	30.42	1369.00
	Total	92		

a. Size = 200

Test Statistics[a,b]

	Batt_Remain
Mann-Whitney U	334.000
Wilcoxon W	1369.000
Z	-5.714
Asymp. Sig. (2-tailed)	.000

a. Size = 200

b. Grouping Variable: Mode

Table 239

Ranks[a]

	Mode	N	Mean Rank	Sum of Ranks
Batt_Remain	Local	45	61.60	2772.00
	Remote	47	32.04	1506.00
	Total	92		

a. Size = 400

Test Statistics[a,b]

	Batt_Remain
Mann-Whitney U	378.000
Wilcoxon W	1506.000
Z	-5.311
Asymp. Sig. (2-tailed)	.000

a. Size = 400

b. Grouping Variable: Mode

From the results above, the Remote Mean value is significantly higher than the Local Mean in size 50. However the trend reverses in the remaining sizes, the Local Mean is significantly higher than the Remote Mean.

6.6 Findings from Data Analysis

Memory Variable Comparisons

At size 50, the Local group (Exp3) uses significantly less memory than in any of the other remotely executed experiments (Exp4, Exp5, and Exp6). At the middle range sizes of 100 and 200 it is unclear as to which group definitively consumes the least amount of memory. In Exp3 v 4 (**table 13 -16,** page 42) and Exp3 v 6 (**table 172-175**, page 134) comparisons, the Local group uses more memory at size 100 than in size 200. The expectation would be the bigger the size of computation the more memory would be used. This actually happens in Exp3 v 5 (**table 93 -96**, page 87/88), the Local group uses less memory in size 100 than in size 200. These experiments ran in the same environment as baseline Exp1, where all non-essential applications were disabled. Applications like the OS (Operating System) and phone application could not be disabled. There were a series of spikes and drops in the Exp1 v Exp2 Memory chart (page 29) which could only have been caused be these applications still running. The same applications could have utilising memory at the same time App1 was running Exp3 at size 100 and would explain the high memory use at this time. Across each comparison it is clear that when the size is at 400, the Remote groups use significantly less memory than the local group. As the size increases pass 400, the computations would get bigger which would mean the device memory consumption would increase. To save on this memory consumption the computation should run Remote mode when the size is equal or greater than 400.

CPU Variable Comparisons

In Exp3 v 4 CPU comparison (**table 28 – 31**, page 51), there is no significant difference between local or remote CPU loads in all sizes. This is very much like the baseline experiments, Exp1 v Exp2 CPU chart (page 29). In that experiment there is little between the CPU load averages yet there was background processes operating in Exp2 as evident from the Exp1 v Exp2 Memory chart (page 29). In Exp3 v 5 (**table 108 – 111**, page 97), the Remote group used less CPU load at size 50. However as the size increased, the more CPU load was utilized by the remote group. In Exp3 v 6 (**table 188 – 191**, page 143), almost the same trend occurs, low CPU load at size 50 but increase as the size gets bigger. However at size 400, the Remote CPU load decreases. The timings results may explain why the CPU load increased on the Remote groups

Computation Times Comparisons

At size 50 and 100, the Remote groups ran the computation significantly quicker than the Local group in all experiment comparisons. At size 200 and 400, the trend reversed. The Local group ran the computation quicker than the Remote group. Exp3 v 4 comparisons are on page

60, **table 44-57**, Exp3 v 5 are on page 106, **table 124 – 127** and Exp3 v 6 are on page 152, **table 204-207**. The instance on Azure that is used to complete the Remote computation use 1 small instance or 1 CPU core. The speed of this instance has not been disclosed by Microsoft. The device CPU as outline earlier in the dissertation has speed of up to 1.4 GHz and has two cores. This means the device CPU would be more suitable for bigger computations than the instance on Azure. The instance can be scaled up to use more cores, which will be discussed in the conclusion. When the computation are running in the Remote mode, the device CPU is still running processes to get the result from Azure. The longer the computations take, the longer these processes take. This would explain the high CPU load in CPU comparisons at size 200 and 400.

Total Timings Comparisons

Exp3v 4 comparisons are on page 69 **(table 61 -64)**, Exp3 v 5 are on page 115 **(table 140-143)**, and Exp3 v 6 are on page 161 **(table 220 -223)**. In all experiments the overall timings are a lot higher on the Remote groups compared with the Local group. This is due to a design defect in App1 that was found after the data analysis tests were performed. The time stamp at the end of the Intent Service, WebService, was taken after the result was broadcast to the Main Activity instead of before the result was sent. However the computation times are correct, they show that at size 200 and 400 the computation took significantly longer in Remote group. This would mean the Total Timings for these sizes would be significantly higher in the Remote group than the Local group.

Battery Remaining Comparisons

This variable will show which experiment was the most energy efficient. In Exp3 v 4 comparison (**table 7-80**, page 78) at size 50, the Remote group has significantly more battery power remaining than Local group. In all the other sizes, there is no significant difference. In Exp3v 5 (**table 156-159**, page 124/125) the local group has significantly more battery than the remote group. Finally in Exp3v 6 (**table 236-237**, page 170), in size 50 the Remote group has significantly more battery power remaining. However in the other sizes, the Local group has significantly higher battery power remaining. This shows us that both Exp3 and Exp4 are most energy efficient run experiments.

Chapter 7 Conclusions

Following on from the findings in the Evaluation chapter, this dissertation can answer the question posed in Chapter 2, - Under what resource conditions is it energy efficient to migrate a partition from an application to remote device or to run the application locally?

7.1 Answer to research question

The findings show that running components of an application remotely can in some cases optimize the mobile device's memory. This is particular true when the components in question have a high memory usage. In all remotely executed experiments, when the parameter was set at 400, they performed at their best. As discussed in the findings in memory comparison, as the size of the computation increases so too does the device's memory consumption. This could have an impact on the memory resource on the device. The Azure instance is able to utilize 1.75 GB of memory compared to the device's 1 GB of memory. From the findings in this dissertation, it is clear that when the size is 400 or greater the computation should run remotely.

The experiments showed that the device's CPU has a better specification than the instance in Azure. Therefore able to handle bigger computations. As indicated in the computation timings on previous chapter, the small instance contains a single CPU core. This can be scaled up to four cores. There is a setting on Azure of what the ideal CPU load of the instance should operate at, the default setting is set at 60% - 80%. If the load gets to 80% the instance will automatically scale up to include a second instance. Since the load never got close to 80%, the instance stayed at one core. In order for the Remote mode to conserve the devices CPU, the instance has to be set to a higher specification. Technically this can be easily achieved by setting up Azure to run two or even three cores but this will have an impact on the cost of hosting the instances. The bill alone, which is located on the disc, for hosting an A1 instance on a pay as you go subscription was €59.80 for the period of 15/7/15 to the 14/8/15. This would be a hefty bill on top of the bill from the mobile device's service provider. From the findings of this dissertation, it appears the CPU on the mobile device used for the experiments is better suited for large computations compared to an instance on the Azure. Therefore the CPU load does not need to be included in the cost efficiency formula.

Exp5 and Exp6 were run on 3G mobile network. The download speed was 2.15 Mbps and upload speed was 1.45 Mbps for Exp5. The speeds were even slower for Exp6, download speed 0.49 Mbps and upload 0.13 Mbps. The time to send and receive data would have taken a lot longer than on Exp4, which was using UPC 50 Mb broadband Wi-Fi. The download speed

for this experiment was 19.27 Mbps and upload speed was 6.27 Mbps. Exp4 was just as energy efficient as Exp3, which was using the devices resources. The slower the network speed, the longer the HTTP connection was open. In this scenario, the Remote mode is not energy efficient even if it is saving memory usage while completing a size 400 or higher computation. In conclusion, for the remote mode to be cost efficiency it must meet two conditions;

1. Download speed > 20 Mbps
2. Size (parameter input) => 400

An If condition statement could be set up as follows:

```
var download speed = d;
var input = size;

If (d > 20 && size => 400){
        //code for starting Remote mode
        }else{
                //code to run Local mode
                }
```

7.2 Future Work

This dissertation has come to the conclusion that the main stumbling block with offloading or partitioning components of a mobile application, like the proposed application App2, to the cloud is high network latency, low download and upload speeds. They are two areas of research that could overcome these issues.

1. Data Compression
2. Using 4G Networks

7.2.1 Data Compression

The experiments showed that the remotely run computation with low parameters performed really well. To solve the problem of receiving bigger data over slow network, it might be possible to compress data before being sent from servlet to the mobile device. The energy used to unpack the data might be less than the energy used to keep a connection open.

7.2.2 Using 4G Networks

In conjunction with data compression solution, the experiments could be carried out over 4G networks. Some mobile network providers can provide network speeds up to 20 to 25 Mbps. This is the bench mark required for a remotely executed computation to compete with a locally run computation. Unfortunately due to lack of resources, this dissertation could not utilize a 4G network. It would be interesting to see the results of the same experiments utilizing these solutions.

7.2.3 Build the proposed Application

Unfortunately due to time restrictions, the proposed application in Chapter4, App2 was not built. The building blocks are there to create the application. With further research into 4G networks and data compression, a more energy efficient application could be designed and built using the proposed architecture for App2.

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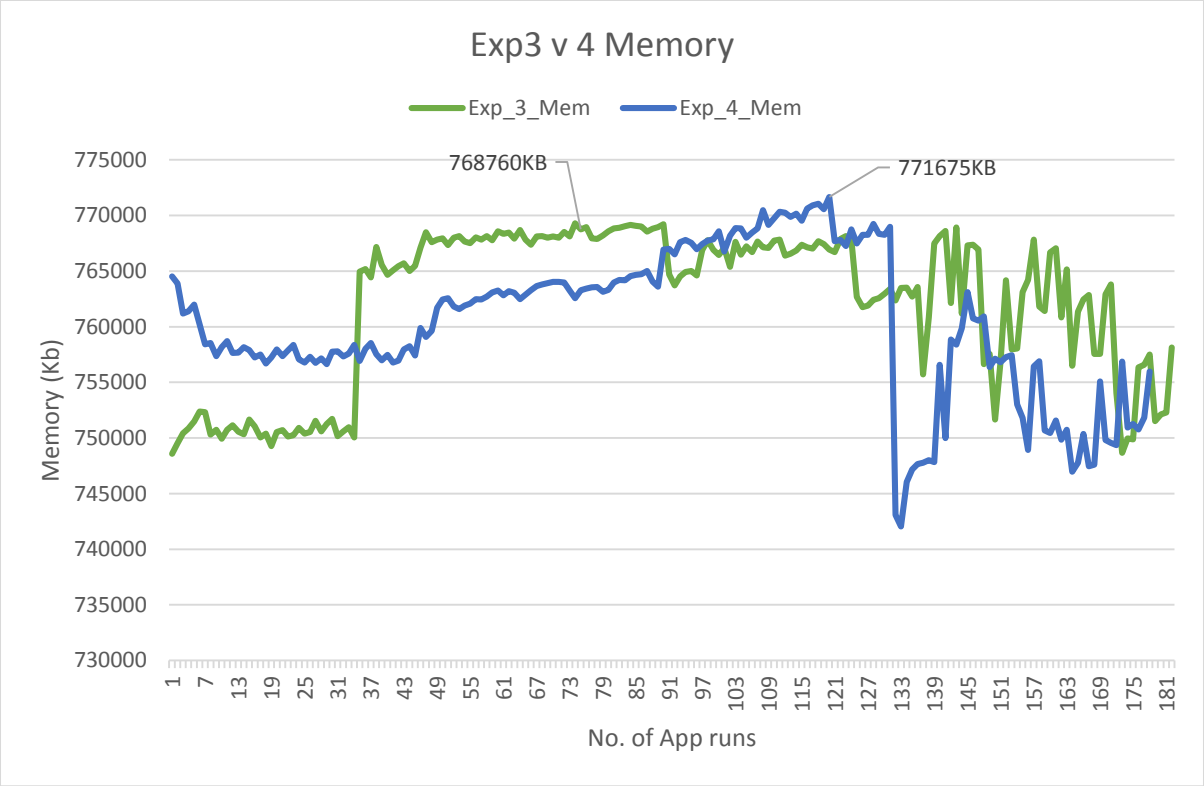
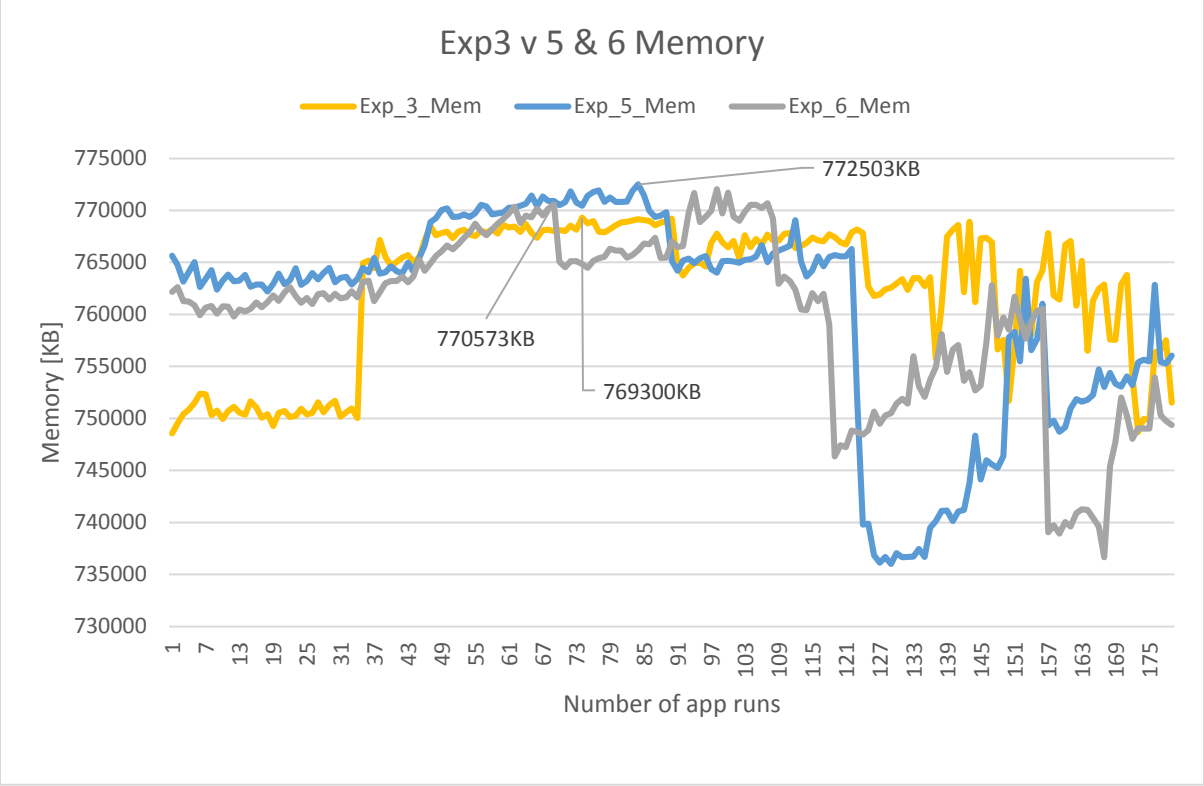
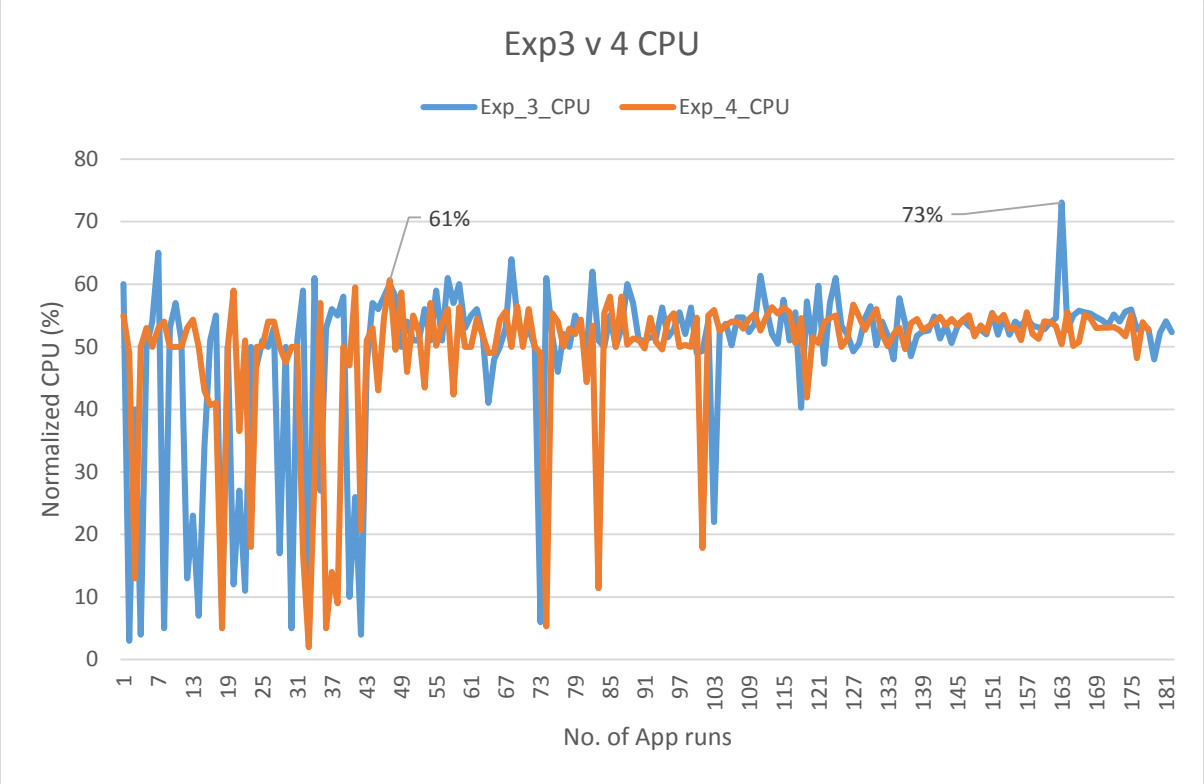
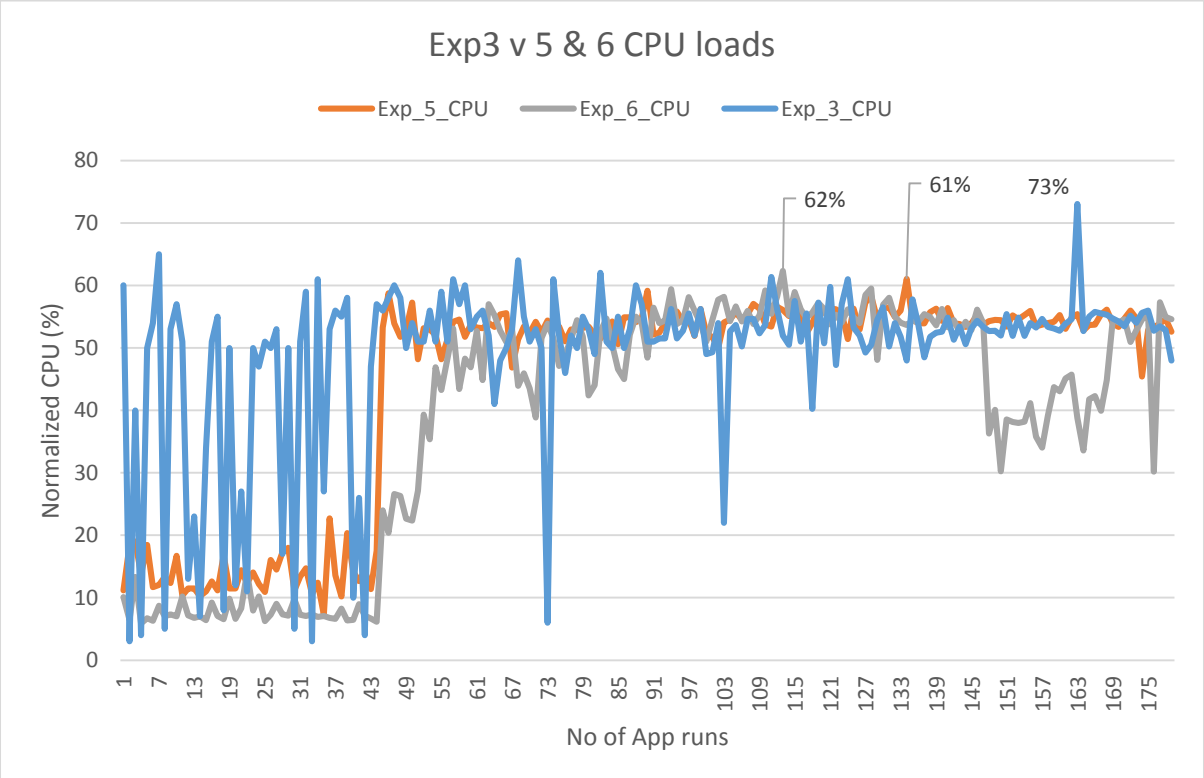
Appendix

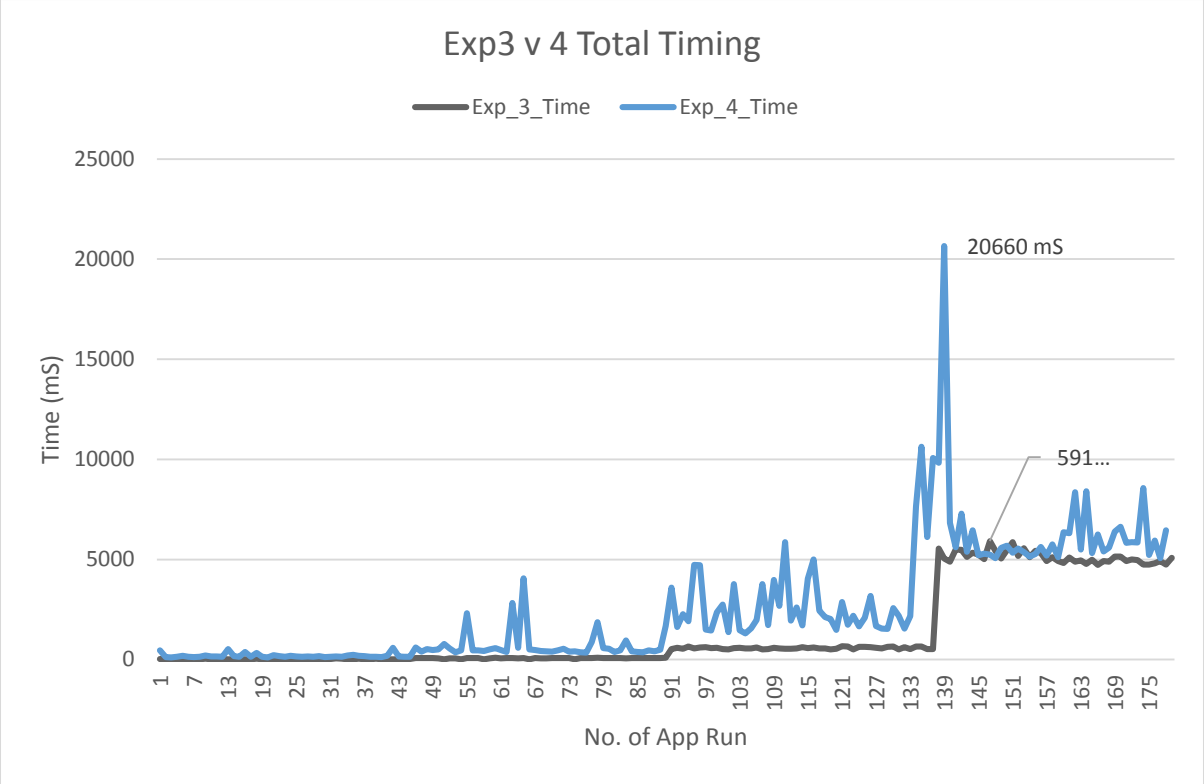
Following comparison charts contain the maximum value of each experiment variable.

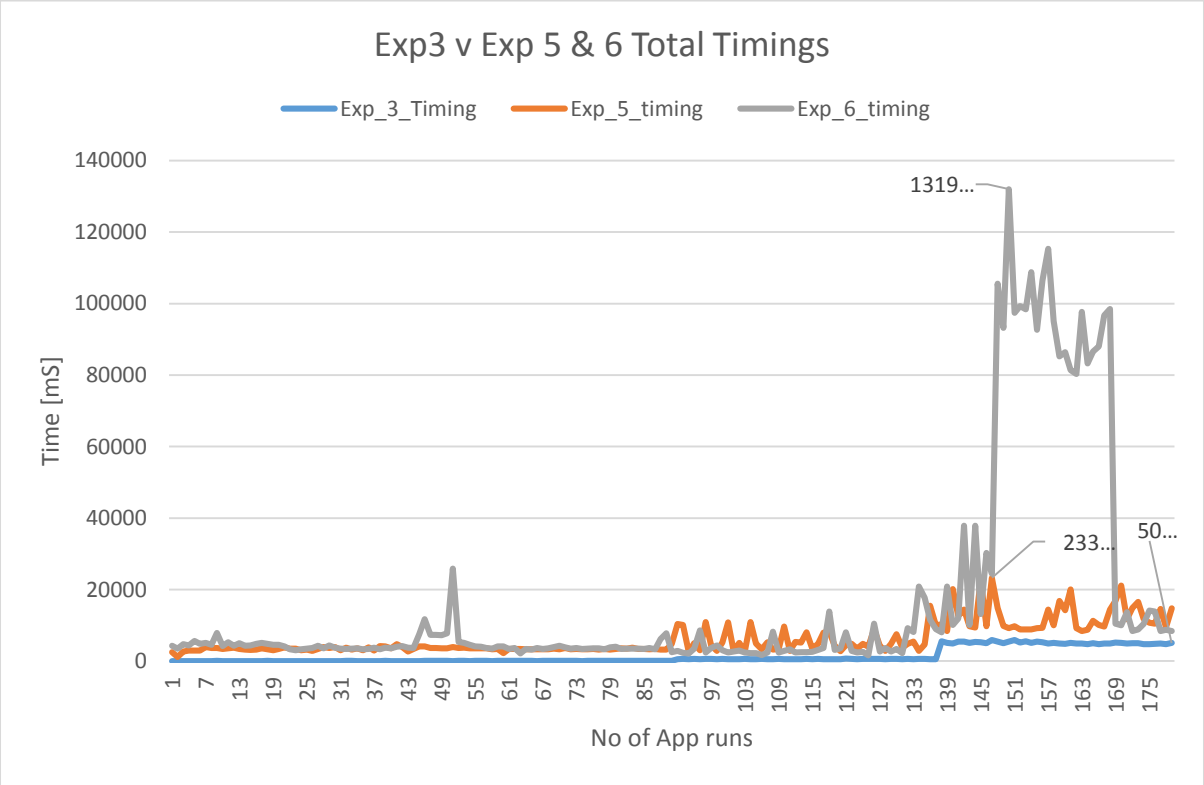


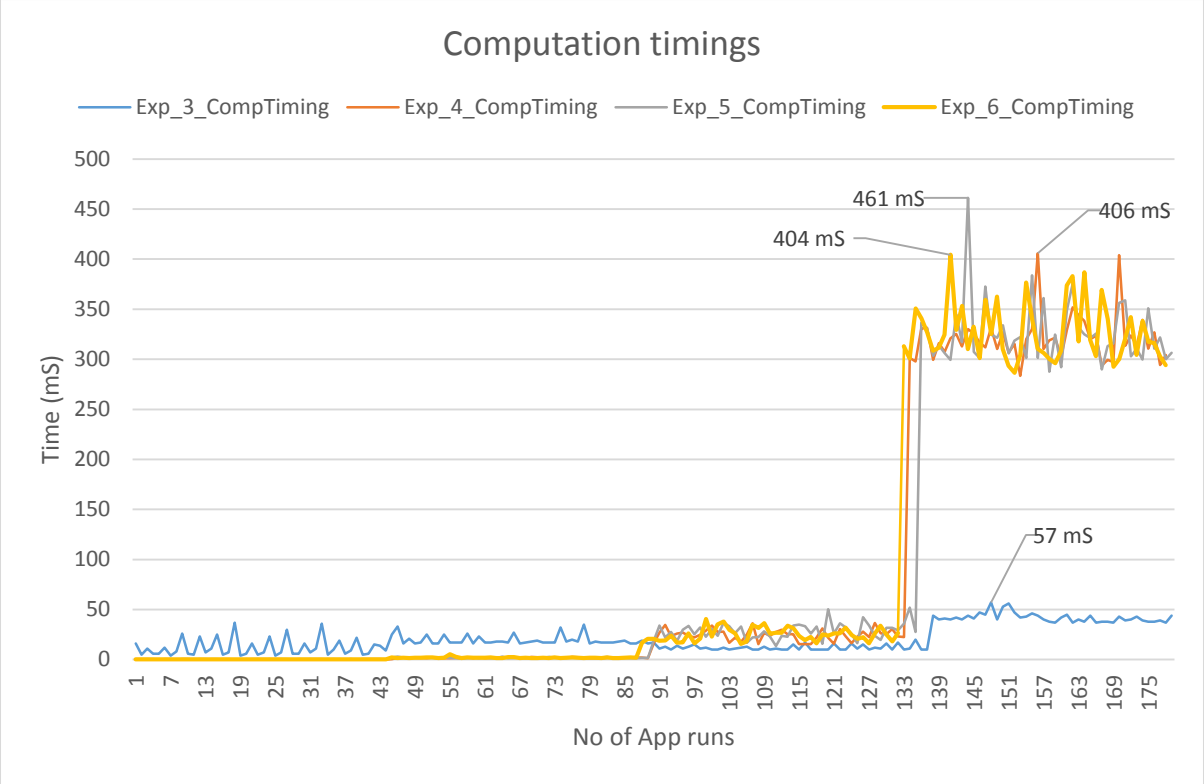


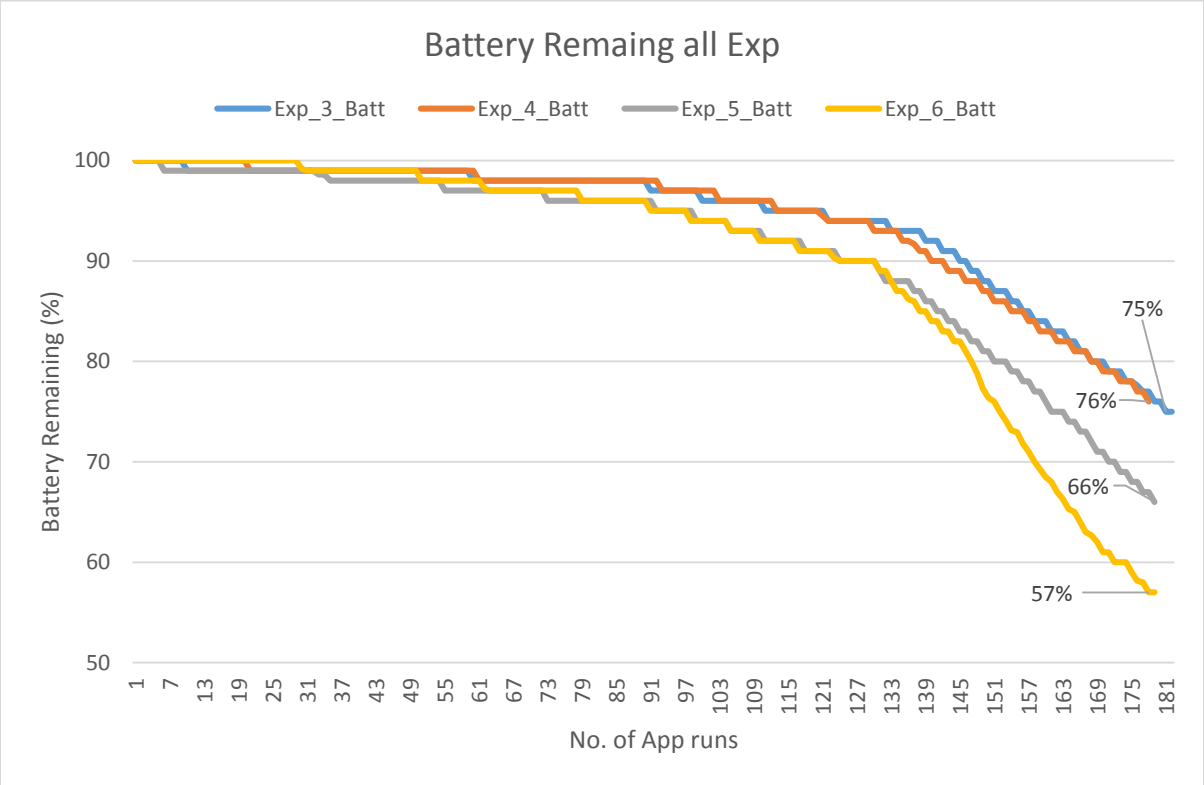

Exp3 v 4 CPU
Exp_3_CPU
Exp_4_CPU
Normalized CPU (%)
No. of App runs
61%
73%


Exp3 v 5 & 6 CPU loads
Exp_5_CPU
Exp_6_CPU
Exp_3_CPU
Normalized CPU (%)
No of App runs
62%
61%
73%


Exp3 v 4 Total Timing
Exp_3_Time
Exp_4_Time
25000
20000
15000
10000
5000
0
Time (mS)
20660 mS
591...
1 7 13 19 25 31 37 43 49 55 61 67 73 79 85 91 97 103 109 115 121 127 133 139 145 151 157 163 169 175
No. of App Run


Exp3 v Exp 5 & 6 Total Timings
Exp_3_Timing
Exp_5_timing
Exp_6_timing
140000
120000
100000
80000
60000
40000
20000
0
Time [mS]
1319...
233...
50...
1 7 13 19 25 31 37 43 49 55 61 67 73 79 85 91 97 103 109 115 121 127 133 139 145 151 157 163 169 175
No of App runs


Computation timings
Exp_3_CompTiming
Exp_4_CompTiming
Exp_5_CompTiming
Exp_6_CompTiming
Time (mS)
No of App runs
461 mS
406 mS
404 mS
57 mS


Battery Remaing all Exp
Exp_3_Batt
Exp_4_Batt
Exp_5_Batt
Exp_6_Batt
Battery Remaining (%)
No. of App runs
75%
76%
66%
57%