OPTIMAL POLICY FOR NESTED TASK INTERRUPTIONS IN A WORKFLOW PROCESS

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Dedicated to ***my parents***.

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ABBREVIATIONS

ABM	Agent-based modeling
CT	Completion time
DES	Discrete Event Simulation
IL	Interruption lag time
IP	Interruption point
RL	Resumption lag time
SD	System Dynamics
TL	Transitional lag time
TCT	Total completion time
TP	Task performance
TTP	Total task performance

ABSTRACT

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Interruptions are the phenomena that exist and appear in many places in life; they appear everywhere in every kind of activities either in doing personal activities on a daily basis or in doing complicated activities and processes in complex systems in industries. The role and the effect of interruptions have begun to appear a lot significantly in the industries in the last few years especially the ones that related to the task or job interruptions in businesses that affect directly to the flow process of the work. It is important to reference that the interruptions can be found in many different formats depending on the work environments. Interruptions are considered as a request for a change in process, job, think, direction, move or just for a short period of pause; these interruptions have the potential to carry treasured information that can allow people to control and manage activities in the incredibly dynamic environment successfully. This control obligation is universal in many different work environments ranging from office work to a more complicated and complex world of industries and businesses. Thus, interruptions have the potential for a tremendous positive impact on work success or the potential for a significant negative impact on work success. Industries hypothesize this interruption as a useful source of valuable information to improve the workplace and flow process. Increasing the frequency of interruptions can lead to increasing the magnitude of information obtainable from a highly dynamic activities environments. Consequently, that leads to improving the coordination between people for the entire organization. However, this possible enhancement and improvement in performance and workflow process of work, utilizing the insight information from interruptions, has shown to be extremely problematic

and challenging. The efficacy of the information attained from interruptions is relevant to the ongoing revolution of the workflow process.

In this dissertation, we divide the research study into two different phases. In the initial phase, we study the workflow process interruptions from the standpoint of human subject experimentation to understand, explore, comprehend, and exploit interruptions phenomena while doing a particular task. This phase leads us to comprehend and learn whether or not the workflow process interruptions affect on task performance, transitional lag time, interruption lag time, and resumption lag time regarding the range and the level of interruptions. We conduct experiments in two stages, and we use factorial designs in these experiments. In the second stage of this phase, we use the obtained information from the first stage to design the experiment for this stage. Subsequently, the experiment is complete and proposes new policy regulations for the workflow processes under the occurrence of the nested interruptions circumstances. In the second phase of the dissertation, we study the workflow process interruptions from the standpoint of a simulation model. The apparent primary goal of this phase is to understand and comprehend the effect of the workflow process interruptions in the context of various policies. In this study, we compare, test, and evaluate the new proposed policy compared to the current practice of handling interruptions when nested interruptions exist and occur. As a result, the proposed policy improved the workflow process by a substantial and noticeable amount of time-saving in total completion time for the workflow process.

1. INTRODUCTION

In this chapter, we introduce the workflow process interruptions in general context. Then we provide the objectives and the significance of this Ph.D. research study. Finally, we conclude the chapter by providing the roadmap to the rest of the dissertation.

Interruptions are the phenomena that exist and appear in many places in life; they appear everywhere in every kind of activities either in doing personal activities on a daily basis or in doing complicated activities and processes in complex systems in industries.

The role and the effect of interruptions have begun to appear a lot significantly in the industries in the last few years especially the ones that related to the task or job interruptions in businesses that affect directly to the flow process of the work. It is important to reference that the interruptions can be found in many different formats depending on the work environments. Interruptions are considered as a request for a change in process, job, think, direction, move or just for a short period of pause; these interruptions have the potential to carry treasured information that can allow people to control and manage activities in the incredibly dynamic environment successfully. This control obligation is universal in many different work environments ranging from office work to a more complicated and complex world of industries and businesses. Thus, interruptions have the potential for a tremendous positive impact on work success or the potential for a significant negative impact on work success. Therefore, many industries and organizations persistently introduce knowledge of interruptions into their workplace and locations in order to familiarize their people to understand this phenomenon; they introduce interruptions using the various format of materials and resources, for instance, workshops and seminars. They hypothesize this interruption as a useful source of valuable information to improve the workplace and flow process. Increasing the frequency of interruptions can lead to increasing the magnitude of information obtainable from a highly dynamic activities environments. Consequently, that leads to improving the coordination between people for the entire organization.

However, this possible enhancement and improvement in performance and workflow process of work, utilizing the insight information from interruptions, has shown to be extremely problematic and challenging. The efficacy of the information attained from interruptions is relevant to the ongoing revolution of the workflow process. As an outcome, most interruptions are not suitable for practice in real life systems. Hence, some studies attempt to quantify the cost of interruptions in workplaces to minimize its undesirable effects on the entire system.

Interruptions of ongoing actions or tasks have blowout across the workplaces in different industry domains since the worldwide increase in the progress of new advanced technology usage and the worldwide super fast speeding in rate and pace we all living and experience every second. Our ordinary life is replete of interruptions, which generate difficulties in different circumstances. Their noticeable adverse effects are well known: a decline in performance in work tasks or jobs. People are often interrupted at the workplace. Sources of task interruptions are, for instance, a friend asking questions while doing some work on the computer, conversation on a cell phone and other tasks in demanding the need for completion in a definite time to meet a goal.

Therefore, the well-organized handling of interruptions is a natural segment of our daily actions and activities. Efficient administration of interruptions is vital in many tasks and fields in different domains such as aviation, office work, industry work, car driving, and health care. For instance, workflow process interruptions are a common stressor in a healthcare environment. Sometimes the need to switch and change from one task to another task that is considered a critical or a vital task is a positive move even when the previous task is overdue for some time. Hence, it is difficult to distinguish whether the workflow process interruptions cause positive or negative outcomes; entirely depends on the circumstances and type of working environments.

In summary, interruptions can show a significant role in the success of the workflow process in different domains ranging from personal daily work to scheduling task and job activities a in a complex environment such as industries. It is considered to be one of the essential elements that need to be handled carefully to achieve high expectations for the output. However, it has shown to be extremely problematic to control workflow process interruptions. The efficient management of handling the workflow process interruptions in different circumstances and comprehending the complexity of interruptions are crucial for smoothly polished workflow processes.

1.1 Objectives and Significance

In order to study interruptions and obtain insightful information about the workflow process interruptions in a complex system. It is indispensable to understand the trend in research that possibly will help explore and exploit the workflow process interruptions phenomenon. Also, many techniques and methodologies have been used and introduced in prior studies by many researchers in different domains to study interruption phenomenon in general and especially the workflow process interruptions. However, preceding studies either considering interruptions as a constant and a particular phenomenon element in their systems such as in manufacturing processes research studies, or studying the psychological effects of interruptions on individuals while doing different types of tasks and jobs; they are predominantly substantive research studies. It has been a long journey for researchers to comprehend the complexity of interruptions from various angles and aspects. These studies might help people, businesses, organizations, and companies to obtain insightful information from certain interruptions phenomenon in order to expand and ease the workflow processes.

The principal objective of this Ph.D. dissertation is to comprehend the complexity of interruptions from a different angle that might be the critical link joining various research domains together. For instance, in manufacturing research community; they consider the workflow process interruptions as constants and controllable elements that can be placed and managed anytime in their systems while other research communities such as Human factors community they study the effects of interruptions on individuals. For instance, most studies focus on how interruptions affect people from different perspectives such as fatigue, time, psychological effect, brain damage, performance, and multitasking as another level of challenge and difficulty. Therefore, the fundamental objective of this research is to link various domains together such as Human Factors research and manufacturing processes research as well as add supplementary information to the contemporary research about interruptions.

In this dissertation, we divide the research study into two different phases. In the initial phase, we study the workflow process interruptions from the standpoint of human factor research community to understand, explore, comprehend, and exploit interruptions phenomena while doing a particular task. This phase leads us to comprehend and learn whether or not the workflow process interruptions affect on task performance, transitional lag time, interruption lag time, and resumption lag time regarding the range and the level of interruptions. We conduct experiments in two stages, and we use a factorial design in these experiments. In the first stage of this phase, we use only two tasks to identify the workflow process interruption points (IP) that affect task performance, transitional lag time (TL), interruption lag time (IL) [1], and resumption lag time (RL) [1]. In the second stage of this phase, we use the obtained information from the first stage to design the experiment for this stage. Also, we expand the experiment by adding and introduce the depth of the interruptions as a new variable. Subsequently, the experiment is complete and proposes new policy regulations for the workflow processes under the occurrence of the nested interruptions circumstances.

In the second phase, we study the workflow process interruptions from the standpoint of other research community specifically operations research and stochastic systems simulation community. The apparent primary goal of this phase is to understand and comprehend the effect of the workflow process interruptions in the context of various policies. Also, this phase includes the evaluation of the outcome of the previous phase in order to make and improve the policy that might increase the performance of a workflow in systems. This phase is considered as the link that joins two or more different research communities together to try to solve the workflow process interruptions bottleneck. This phase leads us to understand how various policies affect the workflow of the system and how the workflow process interruptions show a vital role in a workflow process.

The contribution of this Ph.D. dissertation can be addressed in the following points:

- This research challenges to solve one of the real problems in industries; which considered as a bottleneck problematic for the workflow processes. Purely, this research attempts to provide a new policy rule when nested interruptions occur. This new rule might help industries to understand and implement the concepts using the existing methods instead of investing in new consultations and techniques; which might take time to analyze and drain the entire resource and the business capital as well.

- This research proposes and introduces a new variable for future investigations and considerations in different domains that is the depth of the workflow process interruptions and how this variable show a vital role in the entire system especially in the healthcare community.

- This research conducts two phases experiment, human subject experiments and simulation models, to challenge exploiting the workflow process interruptions, and comprehend the complexity of interruptions by combining two different research domains in a unite research proposal.

This dissertation is organized and prepared into the following chapters. Chapter 2 delivers the necessary background information that is required and needed for this dissertation, the motivation behind this research study, and the problem description in a general context. Chapter 3 provides a literature review that is related unswervingly to this research study. Chapter 4 delivers the first stage of the experimental phase in details including the discussion and the outcomes from this stage. Chapter 5 provides the second stage of the experimental phase in details including the discussion and the outcomes from this stage. Chapter 6 deliver the proposed policy based on the results of the experiments in the first phase. Chapter 7 delivers the second phase of this research study that is about the simulation evaluation for proposed policy against the current practice of actions in handling the nested task interruptions in the workflow process. Finally, Chapter 8 delivers the summary of this research and the final remarks for this study as well as the recommendations for future studies.

2. BACKGROUND AND MOTIVATION

In this chapter of the research, we deliver the essential contextual material in 2.1 that leads to understanding the flow of this research study as well as providing the motivation behind it in 2.2. Then, we conclude this chapter by providing the research problem statement in 2.3.

2.1 Background

The fundamental component in a natural working environment is something called a task. A group of these fundamental components together create a work. In order to complete and finish this work, these fundamental components must be processed and executed sequentially or in parallel. Therefore, it is essential to know, explore, and exploit this fundamental component and comprehend its categorization and classification for the reason that this research study is built on it.

2.1.1 Tasks categorizations

What is a task? A task is a piece of work need to be processed, done or undertaken during a certain limit of time. Daily life is composed of many small tasks that must be done and completed at different times of the day. These tasks can be different from each other in content, in processing, in handling, or in the way of executing it. However, these tasks have a standard measure that is a time which indicates the length of a task. Some tasks take a long time to complete or process, and others might take a fraction of seconds to complete and finish. Therefore, a task is the first unit or block in the entire system. In this study, a task is a piece of work that needed to be finished and completed according to explicit instructions to follow.

Many different types of human task behavior, task classifications or categorizations, have been introduced in the literature. The task categorization is started and created by Taylors work method analysis in 1911 [2]. Then, in 1953 Miller [3] proposed and suggested a traditional human task analysis. In 1983, Card and others introduced Goals, Operators, Methods, Selection rules analysis (GOMS) [4]. In the same year 1983, Rasmussen [5] developed and introduced the skill, rule, and knowledge (SRK)-based behavior tasks. These types of tasks (SRK) are extensively used and stated by many researchers in the area of cognitive science. There are many other approaches to categorize human task behaviors. For instance, Adaptive Control of Thought-Rational (ACT-R) by Anderson [6] and it is based on cognitive science to comprehend cognitive actions by uniting perceptual operation and basic cognitive actions. According to ACT-R, there are two types to acquire knowledge; procedural knowledge and declarative knowledge. The definition of the two types are as follow [7]:

- Procedural knowledge is about how to show and express the knowledge and information that we have without any conscious.
- Declarative knowledge is usually used and interpreted in describing things to other people.

Another approach to categorizing human task behaviors is by a mechanism type. Sohn [8] introduced this type of categorization in 2003. There are two types of mechanisms; executive mechanism and automatic mechanism. The definition of the two types of mechanisms are as follow:

- The executive mechanisms is about goal-driven activities, actions, intentions and previous knowledge.
- Automatic mechanisms is mainly about stimulus-driven actions, and the response of the stimulus association is a crucial element in this type of mechanisms.

The (SRK)based behavior tasks are founded on the traditional top-down scheme approach. In SRK-based tasks, we have three different categories. These categories are as follow:

- Skill-based behavior is the first category; it refers to the routine and smoothes completing of highly combined patterns of physical motor actions without cognitive resources in a standard environment setting [9], or it refers any stored patterns of instructions as shown in [10].For instance, answering phone calls, and copying papers, Table 2.4. The characteristics of this category are shown in Table 2.1 below.

Table 2.1.
Skill-based characteristics

Type of activity	Routine tasks
Error to opportunity	small ratio
Ease of detection	Easy
Process rule	not by rules, nature rule

- Rule-based behavior is the second category; it represents the problem-solving process and execution that based on learning rules and methods of the execution process. Also, the rule-based needs the conscious control of the action as well as the availability rule of the critical choice. However, reasoning is not mandatory to perform the tasks.For instance, expanding the acronyms and abbreviation, Table 2.4. The characteristics of this category are shown in Table 2.2 below.

- Knowledge-based behavior is the third category; it refers to limited resources when processing information and happens in unknown circumstances. Also, tasks in this category are performed slowly in a serial manner as they are required to have complete attention to solve such unknown problems [9] as well as no prior training or procedures accessible. For instance, Solving and calculating

Table 2.2.
Rule-based characteristics

Type of activity	Problem solving
Error to opportunity	High ratio
Ease of detection	Difficult
Process rule	rules for operation

for new chemical formula, Table 2.4. The characteristics of this category are shown in Table 2.3 below.

Table 2.3.
Knowledge-based characteristics

Type of activity	Problem solving
Error to opportunity	High ratio
Ease of detection	Difficult
Process rule	heuristics, experiments

Table 2.4.
SRK-based behaviors

Skill-based behavior	**Rule-based behavior**	**Knowledge-based behavior**
Answering phone calls	expanding acronyms	calculating a chemical formula
copying papers	and closed form math	Figuring the best quantity

According to SRK categorizations above, rule-based behaviors are used in this study. Rule-based behavior is principally composed of cognitive activities, and they are the appropriate choice for this research.

In order to conduct this study properly, we designed the tasks that are similar to the control operations rooms in industries. The designed tasks for the experiments consist of both skill-based and rule-based components. We use myopen lab software, open-source software, to mimic the gauges and the controllers and they are as follow:

- Sample Design 1 is shown in Figure 2.1 below for Task 1: The instruction to complete the task is below:
  - Step 1: Start at point 1 and make sure it is ON (Green Light)
  - Step 2: At point 2. Type in the box the following code: 2n64CgbTvj
  - Step 3: At Point 3. Adjust the level of the tank and increase it to 90 using the left slide (A3765).
  - Step 4: At point 4. Adjust the Switches to the following: **Note: ON is GREEN LIGHT**
    1. Row mj6539 (OFF, ON, ON, OFF, ON, OFF)
    2. Row jy4672 (ON, ON, OFF, OFF, OFF, ON)
    3. Row hs4590 (ON, OFF, ON, ON, OFF, ON)
  - Step 5: At point 5 (Switch 2356). Increase the volume or tune it till you have the lights as follow:
    * (RED, BLACK, BLACK, RED, BLACK, BLACK, BLACK, BLACK)
  - Step 6: At point 6 (Switch 1212). Increase or decrease the volume or tune it till you get the following:
    * (BLACK, RED, RED, BLACK, RED, BLACK, BLACK, BLACK)
  - Step 7: At point 7 (Switch 5957). Increase or decrease the volume or tune it till you get the following:
    * (BLACK, RED, BLACK, BLACK, RED, BLACK, BLACK, BLACK)
  - Step 8: At point 3. Decrease the tank level to 30 using the left slide (A3765)
  - Step 9: At point 8. Using control 1 and 2, adjust the air pressure to 25 and 75, respectively.

- Step 10: At point 9. Using control 4 and 3, adjust the air pressure to 40 and 90, respectively.
- Step 11: At point 10. Using control 5 and 6, adjust the air pressure to 45 and 30, respectively.
- Step 12: Check point 7 (Switch 5957). Change the volume till you get:
  - (RED, BLACK, RED, BLACK, BLACK, BLACK, BLACK, BLACK)
- Step 13: Check point 4 Row mj6539, change to the following settings:
  - (ON, OFF, ON, ON, OFF, ON)
- Step 14: Check point 5. Change the volume till you get:
  - (RED, RED, RED, BLACK, BLACK, BLACK, BLACK, BLACK)
- Step 15: Check point 9. Increase the value of control 4 to 80.
- Step 16: Check point 8. Decrease the value of control 2 to 25.
- Step 17: Press Switch.

• Sample Design 2 is shown in Figure 2.2 below for Task 2: The instruction to complete the task is below:

- Step 1: Start at point 1 and make sure it is ON (Green Light)
- Step 2: At point 2. Type in the boxes the following:
  - CodeA #: 76D%!idM$b
  - CodeB #: Dm9U9k̂EiN
  - CodeC #: 3KbS7!mX*v
  - CodeD #: M9u2&tHLNQ
  - CodeE #: sT4M%rH4!p
- Step 3: At point 3. Increase Power 1 to 6.
- Step 4: At point 3. Increase Power 2 to 8.
- Step 5: At point 3. Increase Power 3 to 2.

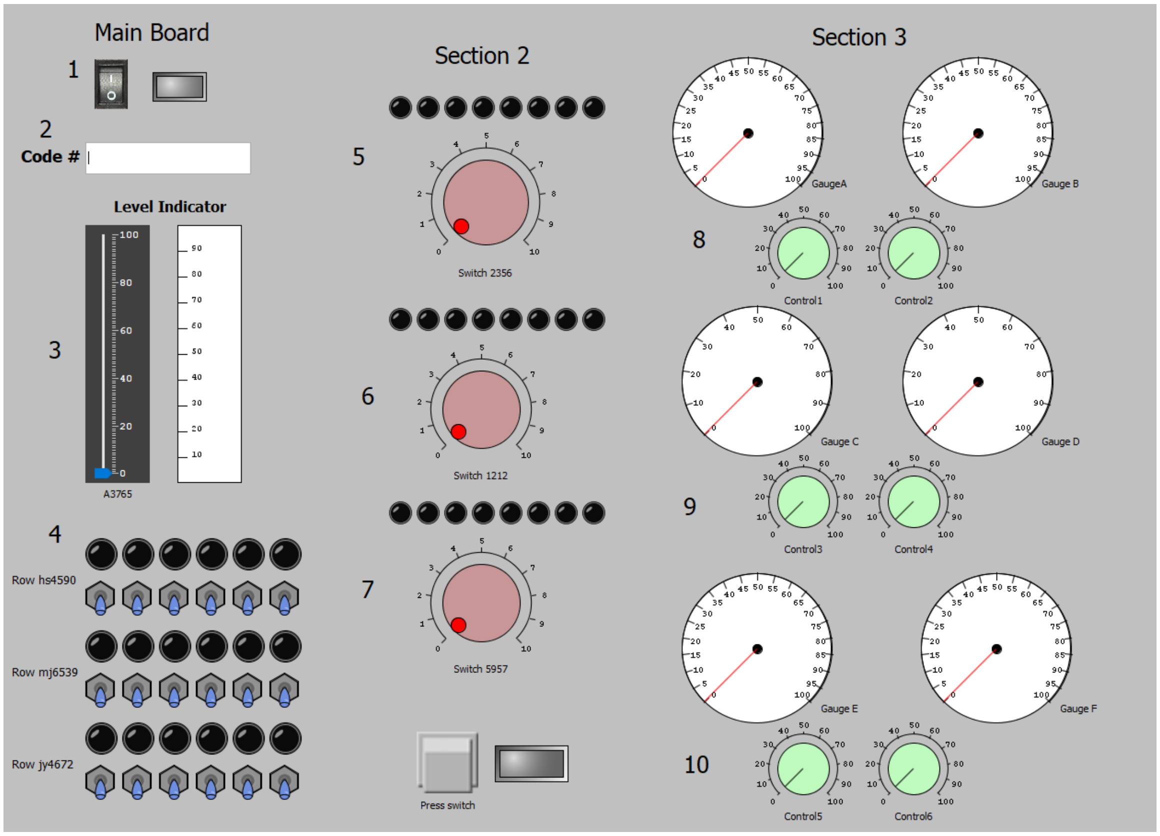

Figure 2.1. Design 1 for Task 1

- Step 6: At Meters Board. Change the following using the sliders:
  * Meter 1231. Set the value at 50, then press switch 1231. You should get Green Light.
  * Meter 6539. Set the value at 95, then press switch 6539. You should get Green Light.
  * Meter 1456. Set the value at 30, then press switch 1456. You should get Green Light.
- Step 7: At Tank Level Indicators. Check and adjust the level using the sliders:
  * TANK T299 The value must be 50.

  * TANK A543 The value must be 30.
  * TANK C128 The value must be 85.
  * TANK Q21Q The value must be 20.
  * TANK K350 The value must be 70.
  * TANK U201 The value must be 90.
- Step 8: Press Switch.

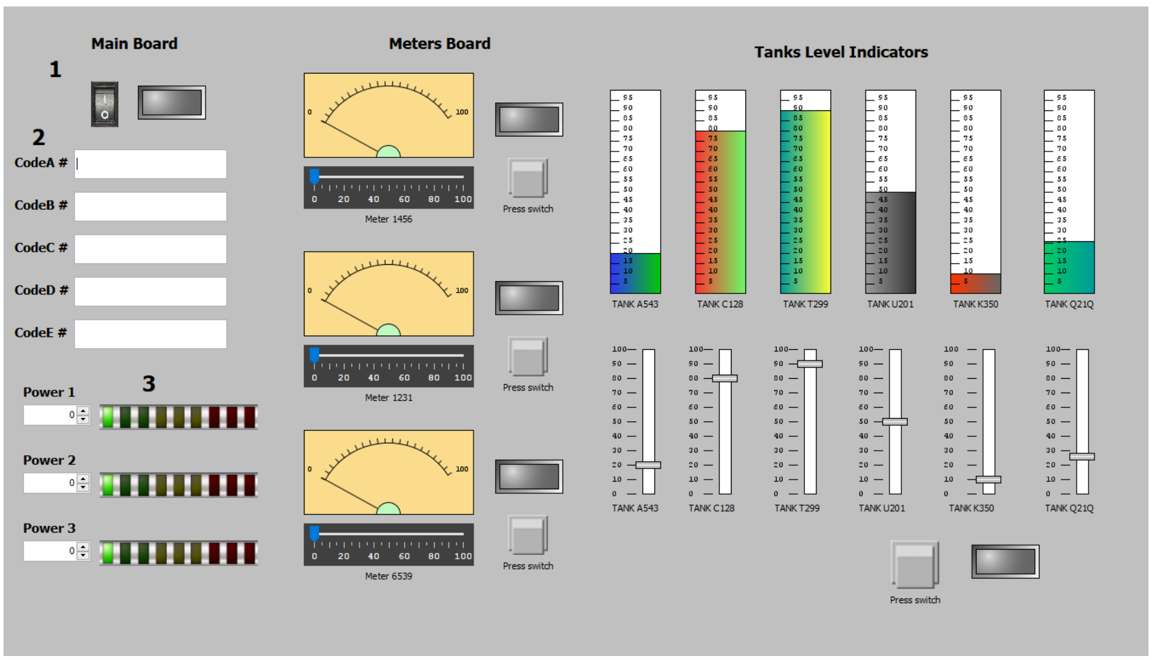

Figure 2.2. Design 2 for Task 2

- Sample Design 3 is shown in Figure below for Task 3: The instruction to complete the task is below:
  - Step 1: Start at point 1 and make sure it is ON (Green Light)
  - Step 2: At point 2. Type in the boxes the following:
    * CodeA #: 76D%!idM$b
    * CodeB #: Dm9U9k̂EiN

- Step 3: At point 4. Change the value of Control 1 from 0.01 to 0.11.
- Step 4: At point 4. Change the value of Control 2 from 0.06 to 0.25.
- Step 5: At point 4. Change the value of Control 4 from 0.04 to 0.50.
- Step 6: At point 4. Change the value of Control 3 from 0.07 to 0.17.
- Step 7: At point 5.
  * For gauge 2546. Use the slide to set the value to 60.
  * For gauge 5874. Use the slide to set the value to 20.
- Step 8: At point 6. Adjust the Switches to the following:
  * Switches 54AB (OFF, ON, ON, OFF, ON, OFF)
- Step 9: At point 7. Adjust the Switches to the following:
  * Switches AC23 (ON, ON, ON, OFF)
  * Switches HL33 (OFF, ON, ON, OFF)
- Step 10: At point 3. In the box, Type the following report:
  * The gauges are adjusted based on the task ABju278 to increase the flow of the materials in pipe 8753
- Step 11: Press Switch.

Another essential aspect that related to tasks is the execution and processing of these tasks. There are several traditions that tasks can be performed and processed. Tasks can be performed or processed sequentially, and it can be clarified as finishing and completing one task after another as shown in Figure 2.4; Task 1 is processed first and wholly finished, then Task 2 is processed and fully executed and lastly Task 3 is processed. Tasks can be performed and processed in parallel mode, and it can be clarified as doing and performing two tasks or more simultaneously as shown in Figure 2.5; Tasks 1 and Task 2 are processed and executed together at the same time. Tasks can be performed and processed in nested mode. It can be described as doing and performing a task and then wholly shifting and altering the gear to perform

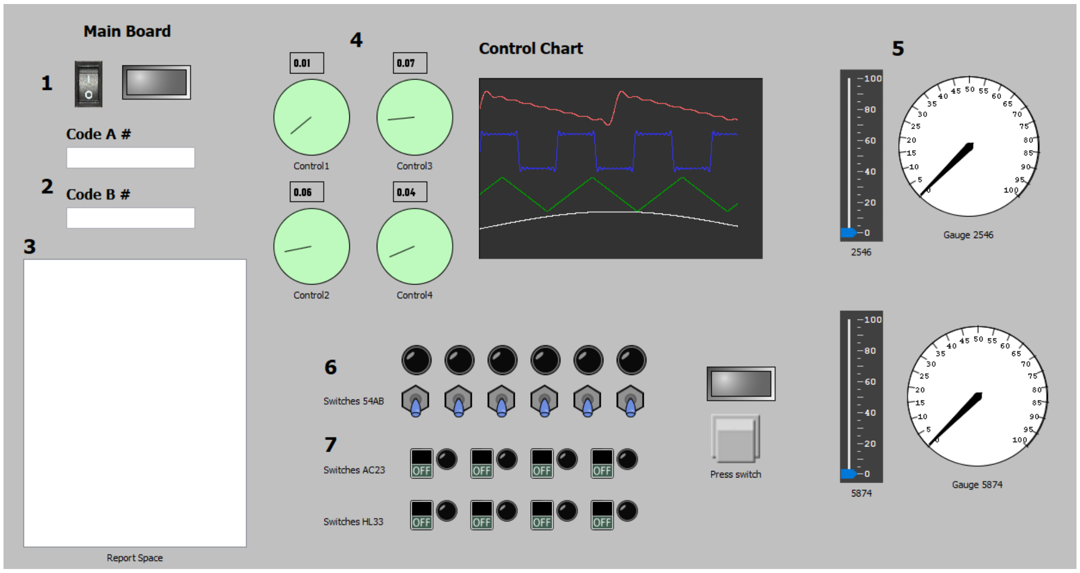

Figure 2.3. Design 3 for Task 3

and process another task after a certain amount of time as shown in Figure 2.6; For instance, Task 3 interrupted Task 2 at some point to be executed and finished then Task 2 is resumed.

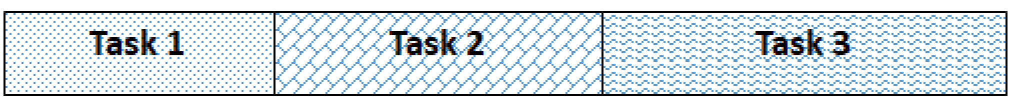

Figure 2.4. Sequential processing mode

For this dissertation, we deliberately choose the base model to be processing tasks sequentially. Also, we are deliberately doing the tasks in nested mode and style. However, in this research study, we do not consider the second type of processing that is parallels processing mode because of the nature of the real practice that we are trying to mimic and reproduce.

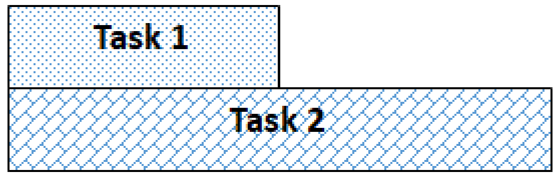

Figure 2.5. Parallel processing mode

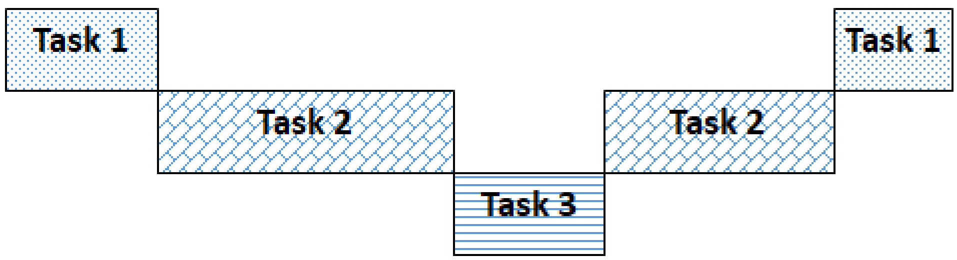

Figure 2.6. Nested processing mode

2.2 Motivation

In many industries, nested task interruptions appear extensively to be one of the bottleneck issues for ordinary working hours in different workplaces around the world. These nested interruptions might be costly and pricey if some policies, rules, and strategies do not exist to control, regulate, and govern the way of handling them systematically. The current way and method of handling nested interruptions by only arbitrarily distributing and allocating tasks based on the level of importance record of the task. This type of practice happens in a specific set of environments such as a controlling center of an organization or an industry.

In the contemporary literature review, there is no substantial basis to rely on when performing the distribution and allocation tasks to workers. There is a need to perform the distribution systematically when nested interruptions considered and occurred. Also, there is no substantial evidence proposes the existence of the interruption and resumption lag times that caused by the nested interruptions. Also, the current research studies do not examine factors that affect those lag times such as the depth of interruption and interruption points.

The motivation behind the problem is the phenomena of the nested interruptions that appear everywhere not only within the context of industries problem but even in other many workplaces. For example, on the personal level of performing and processing tasks, it is evident that performing routine tasks on a daily basis will stream smoothly. However, as new tasks jump into the picture of routine tasks; they cause interruptions on different levels in the schedule. Consequently, this action results and leads to unbalanced schedule as some tasks needed to be changed or modified to accommodate the new urgent tasks. Another motivation for this research is to fill up the gap in the literature which will eventually be the link that connects two or more diverse research communities. Also, this research study will create and develop new research direction as well as will be the first block and seed for a future research career.

2.3 Problem Description and Statement

In this research study, we consider a real problem situation that appears to be one of the bottleneck issues in operation control center in industries and businesses. It typically consists of dispatchers and workers waiting to process and execute a stream of tasks and jobs. In this study, we consider a dispatcher whose responsible for distributing and allocating tasks or jobs to workers. Jobs and tasks are streamed to the dispatcher at the beginning of the working day from different departments and sources, and they are continued to flow and stream in various time throughout the working day hours. Moreover, each task or job associated with a priority record. The higher the priority record for a task, the higher demand to be processed immediately without any suspension. Also, tasks and jobs are located in different workplaces within the boundary of the industry or the business. Once a dispatcher receives a task, this task will be directed to one of the workers to process and execute it immediately by interrupting the ongoing task. Once the worker processed the higher priority task and completed, the worker can go back to complete and resume the previous tasks that have lower priority records. Therefore, the worker must process the tasks in decreasing order based on the priority records. Since the locations of tasks differ, the parallel processing tasks do not exist and occur in this category of problem. The Figure 2.7 below, demonstrations the overall depiction of the entire procedure and process.

In this circumstance, the dispatchers goal when distributing and allocating tasks to the worker is to minimize the total completion time for all jobs and tasks before the end of the working day hours. Any tasks or jobs that performed, executed or completed after the end of working day hours are considered as after work accomplishments and subjected to be penalized with a certain amount of cost; these tasks associated with a penalty that cost the industries a considerable amount of misused time and money. Therefore, the primary objective of this research proposes a policy that might help industries, in such cases and situations, to identify the status of each ongoing tasks for each worker before surging with new tasks distributions; that cause delays in finishing and completing all the tasks before the end of the working day hours.

In this study, the experiments were focused on a specific type of work, i.e., changing, evaluating, and modifying the values of gadgets or gauges by following specific instructions. Also, the designed experiments were conducted in such a way that untrained college students can perform and execute the steps and instructions smoothly using only one display. These types of tasks are considered as low-difficulty tasks in implementations. The designed tasks for the experiments in this study are heterogeneous tasks, using only visual modality and only one screen. The steps in the experiments are considered as major steps as well as the designed tasks for the experiments consist of both skill-based and rule-based components together.

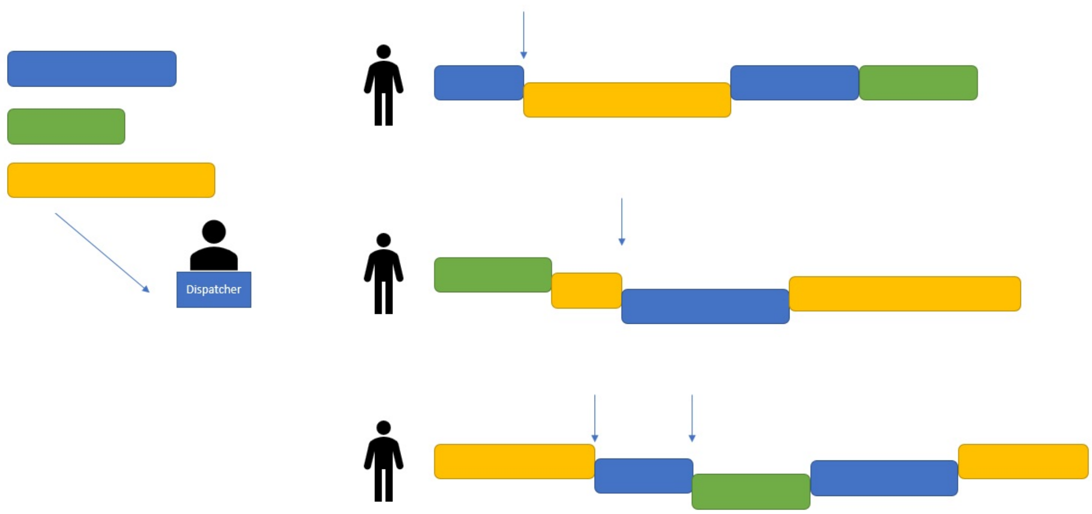

Figure 2.7. Overall Depiction of the problem

3. A LITERATURE REVIEW

In this literature review, we categorized the type of research work based on the research communities, primarily into two different categories as researchers study similar problems from a different angle of aspects. The first category is human factor research community. The second category is other disciplines that include operations research community and the manufacturing community. In both communities, there are common terminologies and terms, and common agreed on the adverse effects of interruptions mainly on the performance of their systems as well as their structures. For instance, the two terms distraction and interruption have often been used reciprocally in the literature of the health-care community [11], the variances between interruption and distraction have become well recognized in recent research studies.

In order to distinguish between the two terms (interruption or distraction), the research study [12] shows that Interruptions can be distinct as external actions which pause and break jobs continuity as well as lead to sequential multi-tasking. Another research study [13] defined an interruption as an external source that randomly arising that pauses and stops the continuity of the main principal job and task. As well as the study [14] shows that an interruption occurs when two or more diverse types of information sources are provided through one sensory medium. On the other hand, distractions can be recognized as the actions that use attentions resources and oppositely lead to concurrent multi-tasking. Interruptions and distractions are similar in many ways such that they occur when the decision makers performing on the primary job, but they are dissimilar in the sensory mediums number to perform the jobs.

All the interruption definitions in the literature can be listed as follow:

- A definition of an interruption is about an event that shortly or considerable time that required some attention of the individual that did not require to switch to a new type of job or task. Also, a break-in-task term is considered as a pause and an interruption, and it is clarified as an action which occurs and needed the recognition of the individual for a period of ten seconds or more continuously but then as an outcome altering and moving to new types of jobs or tasks [15]

- Another definition or an example of an interruption is that in a communication action between individuals in which an individual did not start the conversation, and which used asynchronously that is called a two-way communication action and broke the main action and event [16].

- A distraction from the on-going task, job in progress is defined as an interruption as well [17].

- An event or an action that needed an attention to move from the main in progress job or task towards some another outsource incident occurrence [17].

- Another definition of an interruption is an external action that is resulting in switching to new and different jobs and tasks [18].

- Another definition of an interruption in a communication action and event as well that is not started by an individual and happened using asynchronous communication channel, that is a two-way communication between two things, such as a direct facing conversation in work or on the cell phone far away from each other. A turn-taking interruption is another type of interruption as well, and it occurs within an individual communication action between two or more people when one of the individuals begins speaking before the other completes his or her sentence. Two main observations to consider: (a) the interrupter does not permit and give the chance to the other speaker to complete and finish her or his sentence or noise, (b) the interrupter individual can complete and continue the sentence or the noise [19].

- In the healthcare environment, a temporary-interruption, a short break, is an interruption that temporarily altered the doctor's care away from main and a vital in progress job but did not outcome in discontinued job. A discontinued job is one of interruption types that stop or pause one job, giving the opportunity to another job being executed simultaneously or separately. In other words, any activities that stop nurses from performing their primary task and shifted to do different tasks [20] [21].

- Interruption can be explained as a distraction resulting in a pause or a short stop in an on-going job activity. Distraction is explained and could be clarified as detected action such as shifting or altering away from a main job or using only voice to respond to a dissimilar secondary kind of job [22].

- A pause or stop in the performance of an individual action and movement in progress started by an externally or internally source to another individual with occurrence placed within the framework of a setting or place. This type of pauses or interruption outcomes in the holdup of a primary job to perform an unexpected job with the assumption that the early job will be continued later [23].

- Termination of productive action before the present job is completely finished for an outsource as an externally or internally forced cause or purpose [24].

- The initiation of asynchronous communication action when whichever a synchronous or an asynchronous communication action is in executing mode [25].

- Unimportant interruptions are explained as distractions which happened throughout a process that did not straight relate to the action to any individual and concluded in disruption of the operational workflow of any process [12].

- A communication that is not started by the individual being recognized when having an asynchronous bridge medium [16].
- An external interference of an unexpected action or job, that leads to a discontinue in the job performance [26].
- A pause in processing of an action on the job of making the right medicine to the individuals [27].
- An external influence causing the break or pause of productive action before an on-going action is finish and complete [20].
- Any externally originated action (e.g., a question from an individual or a person, a ring to the phone, any other kind of emergencies sound) that shifted the nurse's care to be abstracted from a main job [28].
- Interruptions could be explained as circumstances in which a health care worker stopped or terminated any type of administration job to join to a source of provocation. A distraction is explained as a provocation from an outside source that cause a noticeable answer or reply, but not the termination of on-going job [29].
- Distraction is clarified as the behavior detected when there is an alteration of attention throughout the implementation of the main job and using voice to respond to a secondary job that is connected to or not connected to the on-going job [14].
- An interruption is clarified as when an interference directed to a short pause in the core job. A distracting stimulus is clarified as any type of actions that could make an alteration from the on-going job or currently in progress, and a distraction is any noticeable behavior indicating positioning away from the core job [14].

Generally, interruptions rise the time to complete and finish a job or a task; interruptions lead to more errors, mistakes, faults, different kinds of interruptions push for delays in many environments and on the human performance side interruptions cause blocking, frustration, and increase anxiety. In the next subsection, I will introduce and summarize the previous research that handles and consider interruptions in their studies from different perspectives. Since two different communities consider interruptions in their studies; many terms can be used interchangeably to represent the same thing but in more than two different ways.

A research study [30] shows as a result of work interruption that the mean time lost in U.S. businesses is more than 2 hrs of employee productivity per day. The average time lost is considered as a massive amount of wasted time. Another research study shows that interruptions happen in health care systems 10 times per hour in [17]; about 15 times per hour in [26]; and about 5 times per hour throughout documentation tasks in [31]. A Study [23] reported that about 11 interruptions per hour in the emergency division that occurs for physician and nurses on a daily work basis. The research study showed that around 14 interruptions per hour in nurses daily work as well as the interruptions occur about 22% of the working time.

Interruptions were studied expansively in the past in different areas ranging from human factors in healthcare systems to human factors in aeronautical and space studies. However, all these studies focus on the harmful effects of the interruptions. Also, most of the previous studies consider task interruptions as secondary tasks to do while doing core or critical tasks. The majority of the studies that consider interruptions are in health care especially for nurses whose doing more than one principal task at a time. For example, Intensive care units (ICUs) stand out from the crowd as one of the complicated and challenging health-care dynamic work settings that interruptions exist in every detail of their tasks. All the previous research studies focus on their experiments on no more than two types of tasks. Nurses perform numerous and different procedures, nurses document patient care in a different location in the medical center, nurses run and operate different devices, nurses answer and reply to the need actions of different individuals and different group of people and families, and doing all these things due to the intersections of this task and can be defined as interruptions.Another example in ICUs, researchers demonstrate that it is possible during interruptions periods, healthcare worker or nurses can serially finish multiple jobs and tasks, and that might generate extra load on working memory [32]. Another example from ICUs, ICUs usually are deplete known to be fault-prone caused by interruptions [20]. In research studies [33] [12], it is shown that the interruptions joint with multiple simultaneous handling jobs and tasks enable mistakes and errors and effect on the boundaries of human working memory and attentional resources [29]. Another example by the different researcher [11] showed that the interruptions might result in the healthcare peoples disremembering to resume a task. Moreover, another research studies [26] [34] show that interruptions can lead to lengthier task resumptions. A research study [29] shows that the failure to recover information after the existence of the interruptions.

Many research studies consider the information systems, such as e-mails [35], online messaging and communications, and different other web activities like surfing and browsing, generate some amount of information that an individual or a human can receive. The sum of information can exceed the capacity of an individual, or a human could handle. Human performance could be effortlessly overloaded with information from such different types of systems as shown in these research studies [19] [28]. On the other hand, a research study that argues the importance of the multitasking in a working environment and how these play significant roles in their work. It is argued that as well the multitasking ability is inevitable in many working settings [30].

Several research studies commented the importance of task differentiation in different research disciplines; researchers verify that the multitasking is doable and achievable if it does not excessively consume the effort to do different tasks at the same time such as taking and walking simultaneously without having difficulties to control both tasks. More examples, it is conceivable to drive a car while listening to music or radio. However, it is hard to talk and eat at the same time without pausing one task and presume the other task. Hence, the type of tasks plays the main role in performing more than one task together such as receiving many calls at exact time. Also, even if multi-tasking is doable and achievable in many cases, the performance of jobs and tasks may not be exactly the same compared to the situation without multi-tasking [36] [37] [38].

In many studies, researchers verify that the interruption surge the completion time for any task or job, interruptions cause nervousness and anxiety, interruption cause more errors devoted by a worker, interruptions cause frustrations, and interruptions affect the entire performance of a worker [39] [28] [40].

There are many different models of working memory and one most well-known model [41] called memory-for-goals model. This model has been broadly considered in interruption literature to discover the working-memory recovery mechanisms when interruptions occurred [11]. However, research studies [27] [42] [43] show that the aged information is problematic to recall and retrieve than the new information kept the working memory.

In the early research studies, the authors consider only one type of tasks and study the effect of the interruptions on these tasks from different standpoints [23] [39] [16].

Resumption time is one of the most critical elements when an interruption occurs between tasks or jobs. Many studies study and show the effect of interruptions on the resumption or continued time when resume the principal interrupted job or task. A research study [41] shows that the effect of the interruptions on the actual memory repossession for information when the interruption occurred. Working memory can be referred to the momentary stockpile and executing of data throughout reasoning actions [44] and it is under the assumption to have bounded space [33] [45].

The interruptions occur as well in the manufacturing systems. However, researchers in the simulation and manufacturing community consider and handle interruptions differently. Researchers consider interruptions that can occur at the specific time and these interruptions can be controlled. The most famous problems that deal with and handle interruptions called flow shop and job shop scheduling problems.

4. EXPERIMENT - PHASE 1

In this chapter of the research study, we elucidate and provide the thorough process of the first stage of the experiment. In this stage, we address the research question that is related to whether interruptions affect on the completion time of tasks, transitional lag time, interruption lag time, and resumption lag time or interruptions do not show a significant part in a workflow process for the system. We embrace the process of executing the experiment in details. Then, we complete the chapter with the discussion on the consequences of this stage.

4.1 Introduction and Background

It is essential to comprehend the process of executing tasks sequentially before understanding and comprehending the nested tasks executing. Performing tasks sequentially means executing a task and then finish, then moving to another task and finish it. In other words, finishing and completing one task after another as shown in Figure 2.4; Task 1 is processed first and solely finished, then Task 2 is processed and fully executed and processed. However, in this study we consider the sequential processing of tasks as follow, the process is shown in Figure 4.1:

1. A subject starts executing and processing a task and complete, then
2. The subject moves to another location or site to perform and process another task, then
3. The subject starts processing and accomplishing the marking task.

Furthermore, Another type of processing tasks is processing in nested mode. Performing tasks in nested mode mean executing and performing a task and then wholly

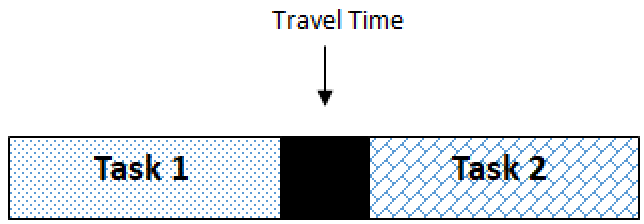

Figure 4.1. Sequential processing with travel time

shifting and altering the gear to perform and process another task after a certain amount of time as shown in Figure 2.6; For instance, Task 3 interrupted Task 2 at some point to be executed and completed then Task 2 is continued and finished. However, in this study we consider the nested processing of tasks as follow, the process is shown in Figure 4.2:

1. A subject starts executing and processing a task, then
2. At an arbitrary point of time, the subject is asked to stop the processing of the ongoing task and move to another location to perform another task, then
3. The subject moves to another location or site to perform and process another task, then
4. The subject starts processing and accomplishing the marking task, then
5. The subject moves back to the previous location to continue processing the previous task, then
6. The subject continues the processing of the previous task.

In Figures 4.1 and 4.2, time traveling is represented as the black squares. Since this time is fixed, it will be measured as a constant value. In order to avoid the confusion, the black squares are used to represent transitional, interruption, and

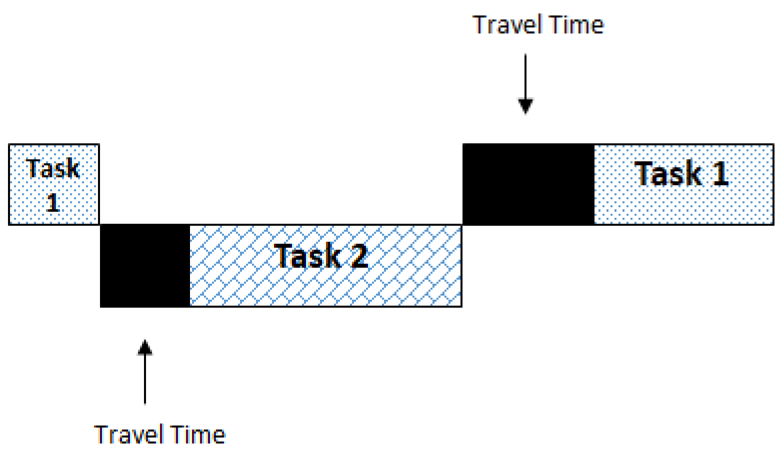

Figure 4.2. Nested processing with travel time - Two Tasks

resumption lag times. Moreover, in order to address the research question of whether interruptions affect the entire system or not, we necessarily need to elucidate the following measurements:

- A completion time (CT) for a task it can be clarified as the time it takes to complete and finish a single task as shown in Figure 4.3
- A transitional lag time (TL) it can be clarified as the time it takes to shift and alter to process another task. A transitional lag time (TL) is distinct within the context of sequential processing tasks. As shown in Figure 4.3
- A Total completion time (TCT) it can be clarified as the total time it takes to complete a group of tasks from performing task 1 to the completing of task 2 as shown in Figure 4.3
- An interruption lag time (IL) [1] it can be defined as the time it takes to shift, alter, and move to another place or location in order to process another task

when an interruption occurred. An interruption lag time (IL) is distinct within the context of nested processing tasks mode as shown in Figure 4.3

- A resumption lag time (RL) [1] - it can be clarified as the time it takes to shift, alter, and move back to the previous place or location in order to process the previous interrupted task. A resumption lag time (RL) is distinct within the context of nested processing tasks mode as shown in Figure 4.3

- An Interruption points (IP) it can be defined as the moment or the time that occurred and cause the stop of the ongoing task, and it can occur at any time in the process. An Interruption points (IP) is distinct within the context of nested processing tasks mode as shown in Figure 4.3

- A Task performance (TP) It can be simplified as the number of correct answers for each task.

- A Total Task performance (TTP) It can be explained as the total number of correct answers for a group of tasks together; that is for Task 1 and Task 2.

This part of the research study addresses the question of whether interruptions affect the workflow process of a system or not. The effect of work performance by interruptions, which specially designed to mimic the operation center room, is examined regarding total completion time, transitional lag time, interruption lag time, resumption lag time, and total task performance.

4.2 Method

4.2.1 Research Framework

A controlled laboratory experiment was conducted to examine the effects of interruption on the workflow process in a system. In this stage of the experiment and study, the effects of interruptions in the workflow process are measured in total completion time for the whole tasks together, total task performance contributed by the

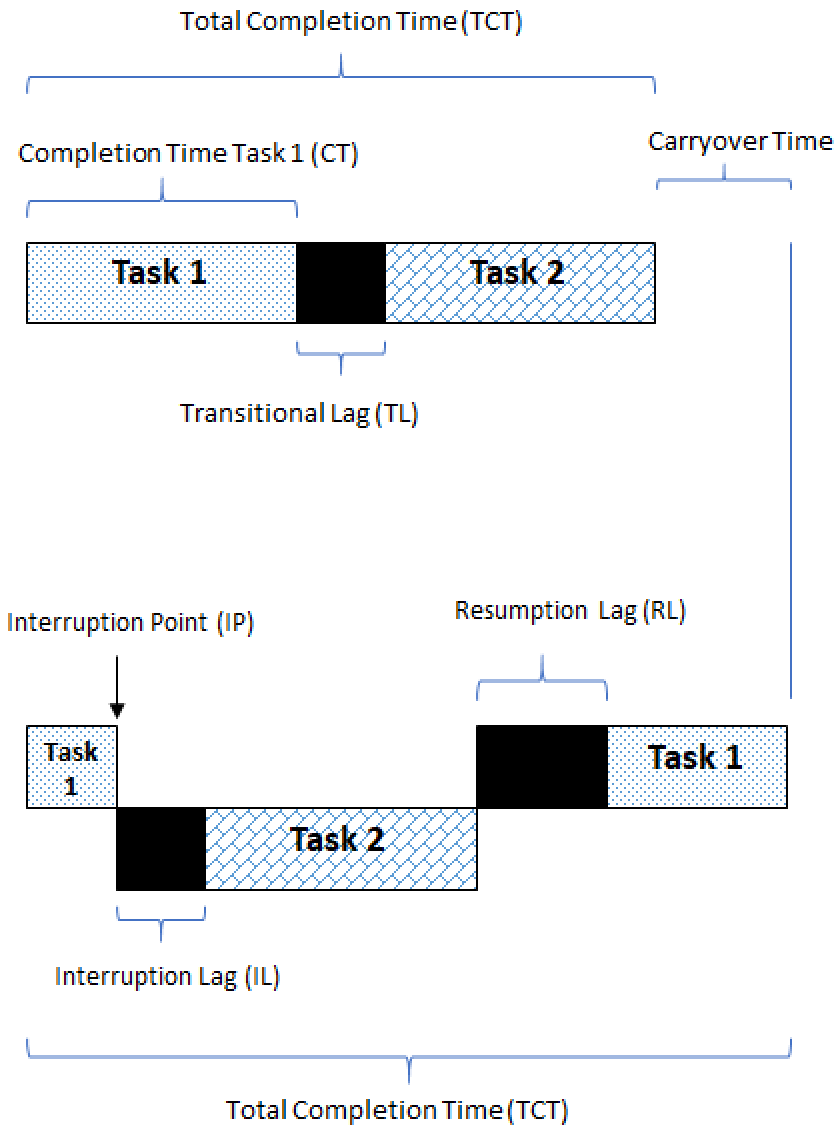

Figure 4.3. Experiment 1 Anatomy

participants, completion time for each task separately, and the lag times (IL, TL, RL). In this study, we consider only two tasks, that is task 1 and 2. The participant performed two tasks sequentially and in a nested mode. Figure 4.3 explains the experiment framework for this study. The designed tasks for the experiments in this study are heterogeneous tasks, use only visual modality and only one screen.

4.2.2 Participants

All participants for this study were college students at Purdue University including both undergraduate and graduate. The brief statistics about the participants in the following points:

- Twenty-four students participated in the experiment.
- The average age of the participants is twenty-two years.
- The percentage of males who participated in the experiment is 55%, and the percentage of females who participated in the experiment is 45%.
- The percentage of graduate students who participated in the experiment is 35%.

4.2.3 Experiment Design

A two-factor factorial with random factors is conducted in this experiment. Precisely, in this design, one of the factors is fixed which is the first factor; that has two levels (No interruption, Interruption). Another factor in this design is considered as a random factor which is the interruption points since many levels can be considered as an interruption point. This two-factor factorial with random factors called the two factors mixed model; that is one factor has a fixed level, and the other factor has a large number of levels which are of interest. Also, this design is considered as a restricted model because of the levels of the factors; that is if a level occurred, any other level could not occur at the same time. In this experiment design, we consider the following as the independent variable:

- The interruption occurrence or the interruption points are well-thought-out recognize as an independent variable. In this study, the interruption points will be in different zones as shown in Figure 4.4.

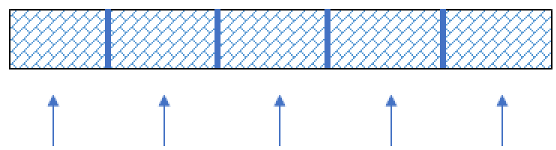

Figure 4.4. Interruption Zones

Furthermore, individual variances in the students who participated in this study could have been well-organized considered as another independent variable in this stage of the experiment. However, since the participants were bounded to Purdue college students who were registered in university courses, considering that knowledge and proficiency are not very different in different settings. Furthermore, because of the nature of performing and processing this type of tasks is not dissimilar from the real work as the only rule to execute the task is to follow the manual instructions.

Similarly, in this experiment design, we consider the following as the dependent variables:

- Task Performance (TP) and Total Task Performance (TTP) according to the nature of the tasks, accuracy is considered as a measure of work performed in a workflow process in a system. The number of wrong inputs out of the total reading gauges is the primary measurement for work performance.

- Completion Time (CT) for a task and Total Completion Time (TCT) for a group of tasks are considered as well as the dependent variables. Task completion time is considered as a quantitative measurement in minutes. The completion time for each task is recorded. In a case where no interruption occurs, the completion time for each task can be calculated easily. On the other hand, when an interruption occurs, the completion time is carefully calculated as it is a summation of two periods of times.

- Transitional lag time (TL) is considered as a dependent variable in order to study the effect of interruptions on TL in a workflow process.
- Interruption lag time (IL) is considered as a dependent variable in order to study the effect of interruptions on IL in a workflow process.
- Resumption lag time (RL) is considered as a dependent variable in order to study the effect of interruptions on RL in a workflow process.

4.2.4 Procedure

In the beginning, each participant was asked to fill out the consent form and demographic questionnaire before the start of the experiment. Then, five minutes of a training session that was introduced to the participant with a sample of the task performed and processed. The participants then process and perform the two tasks sets according to the randomization table that was created earlier to cover most interruption points, each interruption point will be in one of the zones as shown in Figure4.4. Each participant exposed two tasks, some of them received a no interruption scenario as follow:

1. The participant is asked to start doing Task 1 at location 1 (a room inside a building, e.g., GRIS Grissom Hall) and finish it, then
2. The participant is asked to move to the nearby location (another room in the same building, location 2), then
3. The participant is asked to start doing Task 2 and finish it.

Similarly, others participants received an interruption scenario as follow:

1. The participant is asked to start doing Task 1 at location 1 (a room inside a building, e.g., GRIS Grissom Hall), then

2. The participant is stopped (interrupted) at an arbitrary time during Task 1, then

3. The participant is asked to move to the nearby location (another room in the same building, location 2), then

4. The participant is asked to start doing Task 2 and finish it without any interruption, then

5. After the participant finishes Task 2, the participant is asked to move to the location of Task 1 (location 1) and finish Task 1.

For this study, we divided the interruption zones into five regions equally as the length of each task will not exceed 7 minutes.

4.3 Results and Discussion

This section of this chapter analyses the results of experiment 1. The experiment went as expected with no strange actions that would have introduced error to the mixed model. It is worth to mention that only one point is removed because of the interruption time is very high. Since the travel time is just a constant value, it is excluded from the computation and analysis parts. However, it is essential as well to consider it in different dynamic working environments.

First, the analysis of the lag times can be explained as follow. As shown in Figure 4.5, in this kind of tasks there is no considerable evidence for differences between Transitional Lag (TL) time and Interruption Lag (IL) time. Similarly, as shown in Figure 4.6, in this kind of tasks there is no substantial evidence for differences between Transitional Lag (TL) time and Resumption Lag (RL) time. Correspondingly, as shown in Figure 4.7, in this kind of tasks there is no significant evidence for differences between Interruption Lag (IL) time and Resumption Lag (RL) time. The core deduction from this part is that there is no reliable and substantial evidence for differences between Transitional Lag time (TL), Interruption Lag time (IL), and Resumption Lag time (RL).

The study in [1] covers the definition of Interruption Lag time (IL) and the Resumption Lag time (RL) only and test the case of interruption. In this study [1], they found that there are no significant differences between Interruption Lag time (IL) and Resumption Lag time (RL). The result of this experiment support the results from the study [1] with different kind of task types. Additionally, the experiment results supplement and extend the study results by including the Transitional Lag time (TL) into the conclusion of the analysis.

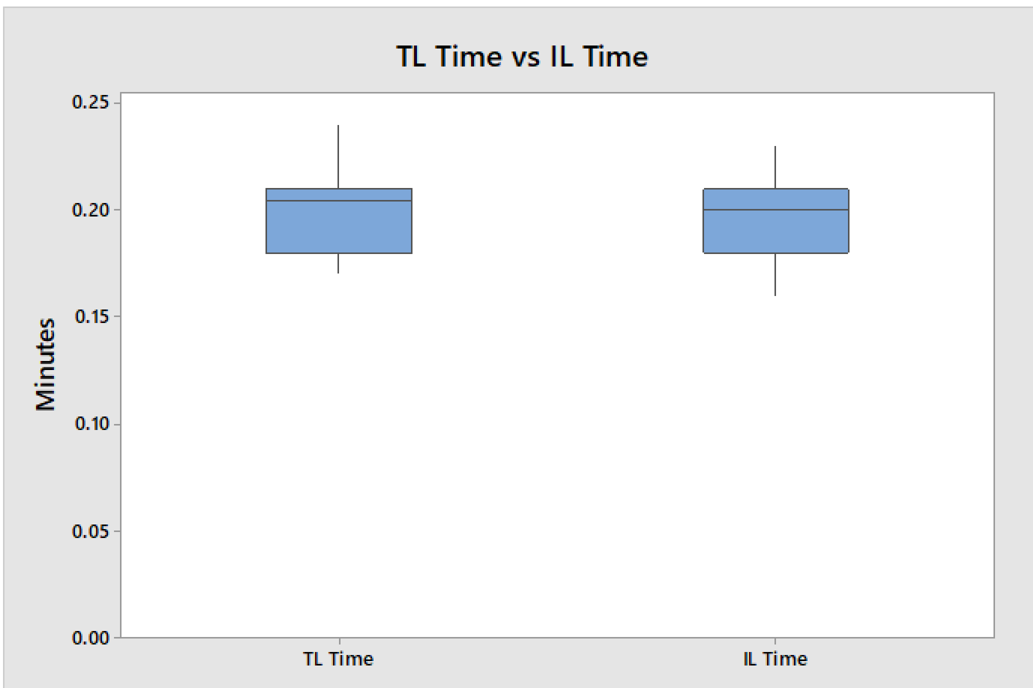

Figure 4.5. Transitional Lag Time and Interruption Lag Time

As an observation, the lag time is considered two times or twice in the case of Interruptions for the case of performing two tasks.

Similarly, in order to test the interruption points, the measurements were taken from different zones. Task 1 was the task that is interrupted by task 2. Therefore, as shown in Figure 4.8 and in Figure 4.9, the interruption points does not affect the

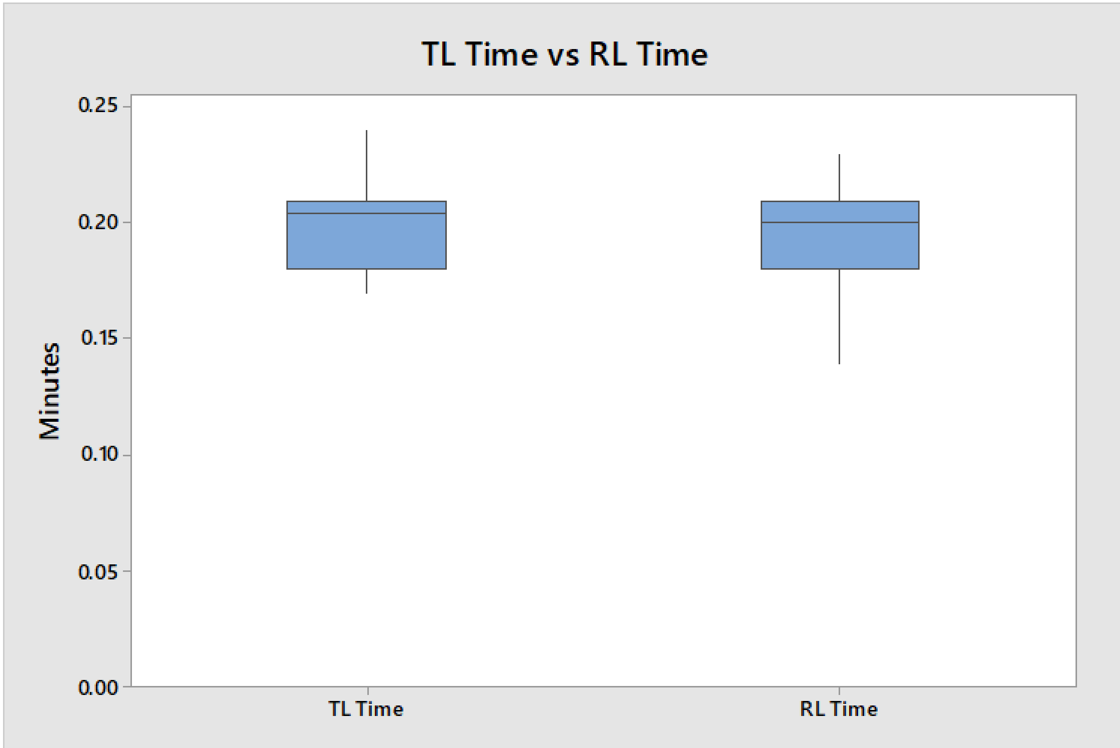

Figure 4.6. Transitional Lag Time and and Resumption Lag Time

completion time of task 1. Consequently, there is no substantial evidence of differences in the completion time of task 1 when the interruption occurred. As a conclusion, it appears that interruption point plays no role in the completion time for tasks or jobs distinctly.

On the other hand, in this experiment by considering the completion time for both tasks, that is the total completion time for the task 1 and task 2. It turns out that the interruption occurrence plays a significant role in the total completion time for the whole process to execute the complete set of tasks as shown in Figure 4.10.

4.4 Limitations

In this section of the chapter, we provide some limitations in executing the experiment 1. These limitations can be summarized as follow. One of the Possible concerns

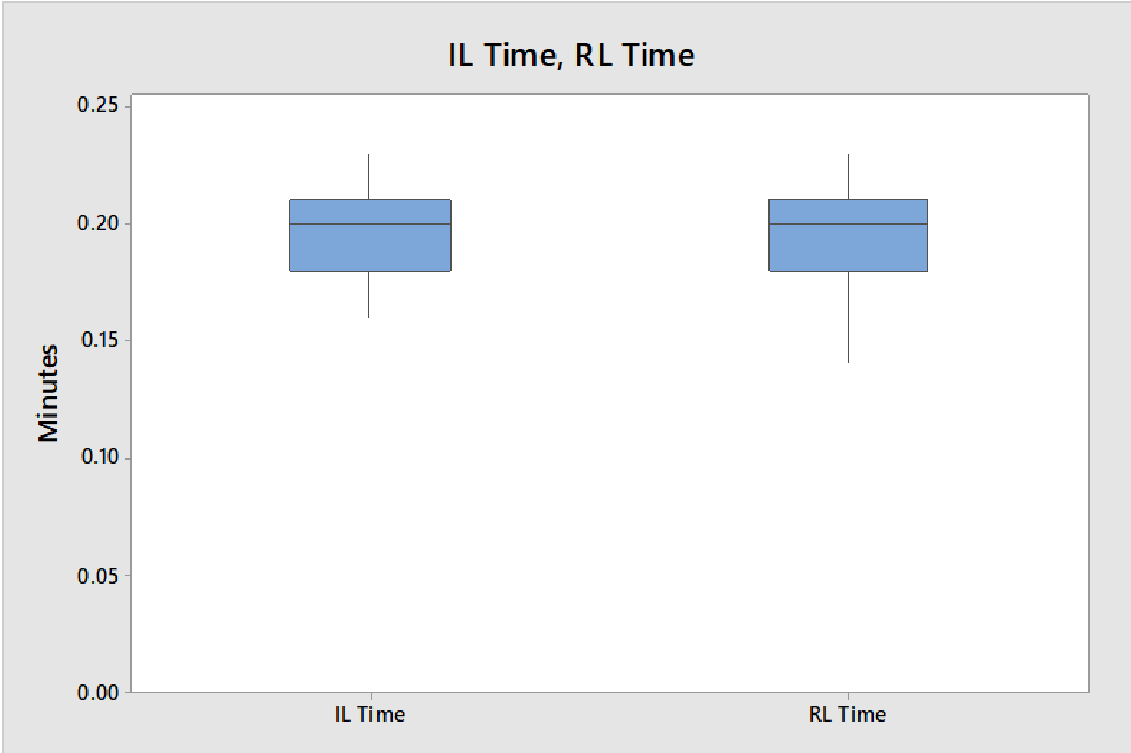

Figure 4.7. Interruption Lag Time and Resumption Lag Time

about this experiment is the representativeness of the participant; the participant recruiting strategy used in this study was intended to be for college students, and there was no guarantee the familiarity of doing such tasks. The other possible concern is that the time to execute tasks in the real world take a little bit longer in time for different varieties of tasks, as well as the distance between different locations of the tasks is reasonably far away. Another one of the critical limitations is the workload for the individual. The workload was not evaluated in this research study. Therefore, the effect of the workload on the results is unknown and needed to be considered in future studies. However, I do not expect that the workload had any effect of this research study, but it was tested, evaluated, or controlled in the proposed experiments.

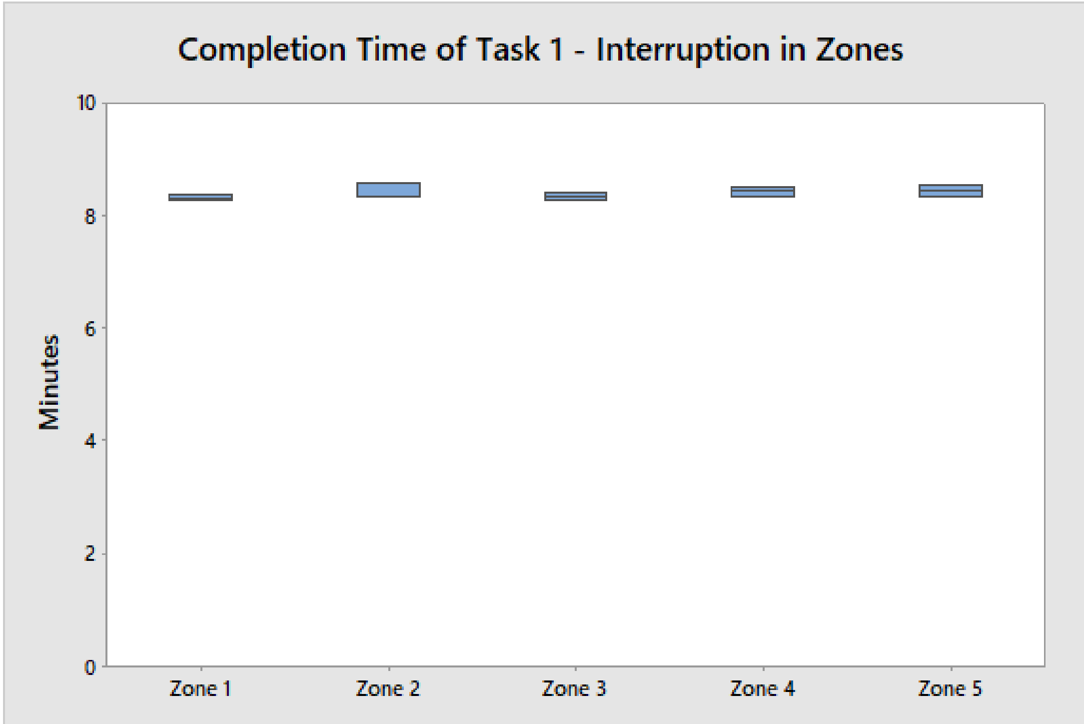

Figure 4.8. Completion time for Task 1 - interrupted in different zones

4.5 Conclusion

In this first experiment, we study, examine, and exploit the effect of interruption existence in the workflow process and the interruption points; that is potential areas that could play a significant role in the whole process. We use two tasks in order to accomplish the objective of this experiment 1. The result of this experiment suggests that processing all tasks sequentially is continuously better than processing tasks in the nested mode. In the nested mode, the travel time and distance play a significant role as they fluctuate substantially fast enough within the working hours. However, in this study we consider the travel time as a constant value because it is different from one environment to another environment. The carryon information that is used for the next experiment as follow. The interruption points (IP) do not affect the completion time for each task as well as the task performance (TP); that is the

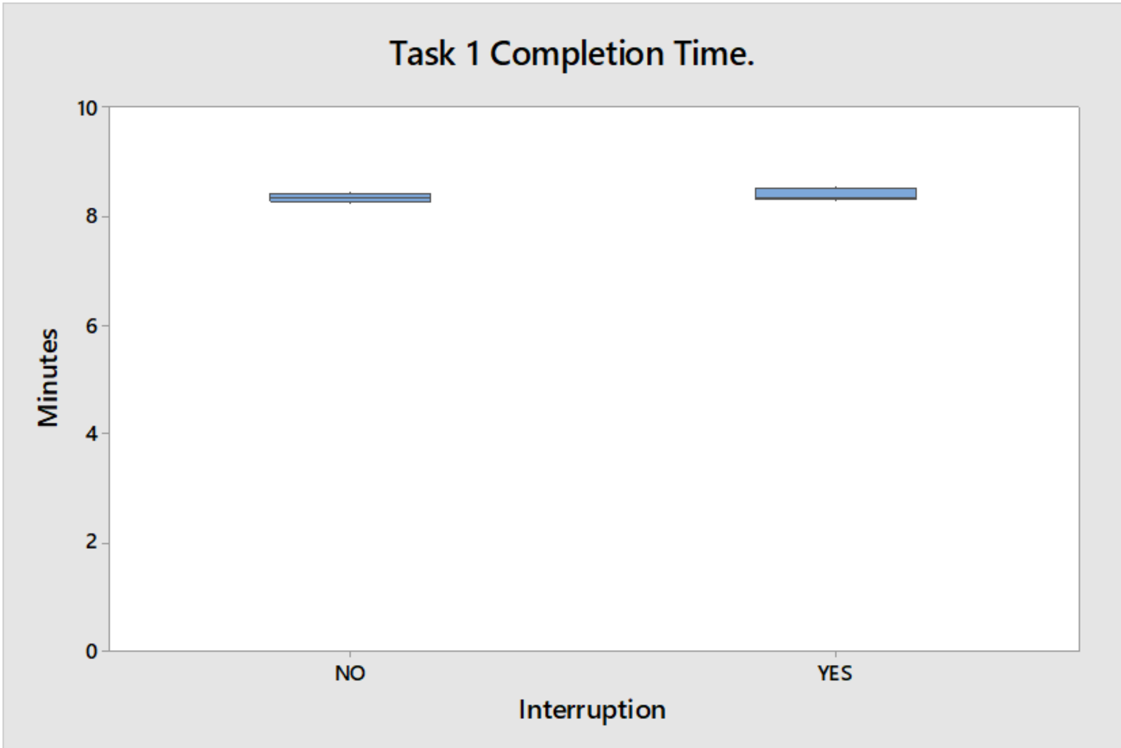

Figure 4.9. Task 1 completion time

accuracy of each task. It is essential and vital to include and incorporate the result to reduce the complexity of the experiment.

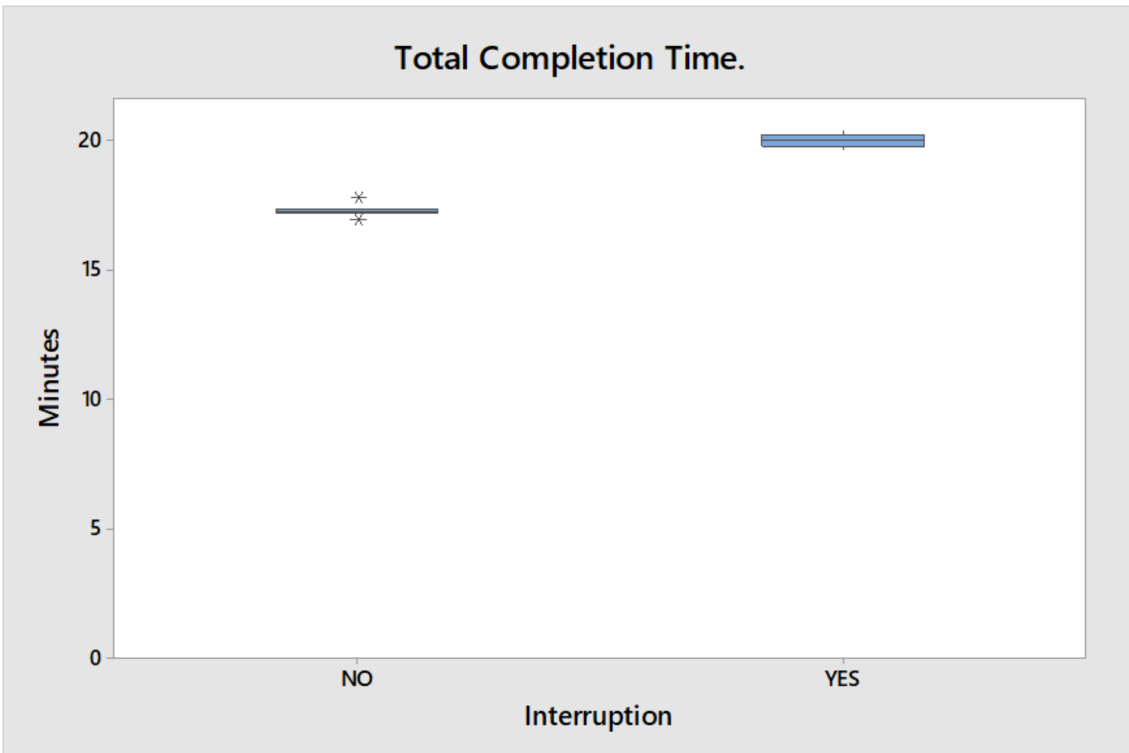

Figure 4.10. Total completion time for the complete set of tasks

5. EXPERIMENT - PHASE 2

In this chapter of the research study, we explicate and provide the exhaustive process of the second stage of the experiment. In this stage, we address the research question that is related to whether interruptions affect on the completion time of tasks, transitional lag time, interruption lag time, and resumption lag time or interruptions do not show a significant part in a workflow process for the system. Also, we address the research question that is related to whether the number of interrupted tasks affects a workflow process or not. We embrace the process of executing the experiment in details. Then, we complete the chapter with the discussion on the consequences of this stage and observations.

5.1 Introduction and Background

It is indispensable to understand and comprehend the process of sequentially before understanding and comprehending the nested tasks executing mode. Performing tasks sequentially means executing a task and then finish, then moving to another task and finish it. In other words, finishing and completing one task after another as shown in Figure 2.4; Task 1 is processed first and exclusively finished, then Task 2 is processed and completely executed and handled. However, in this study we consider the sequential processing of three tasks as follows, the process is shown in Figure 5.1 below:

1. A subject starts executing and processing a task and complete, then
2. The subject moves to another location or site to perform and process another task, then
3. The subject starts processing and completing the marking task, then

4. The subject moves to another location or site to perform and process another task, then

5. The subject starts processing and finalizing the marking task.

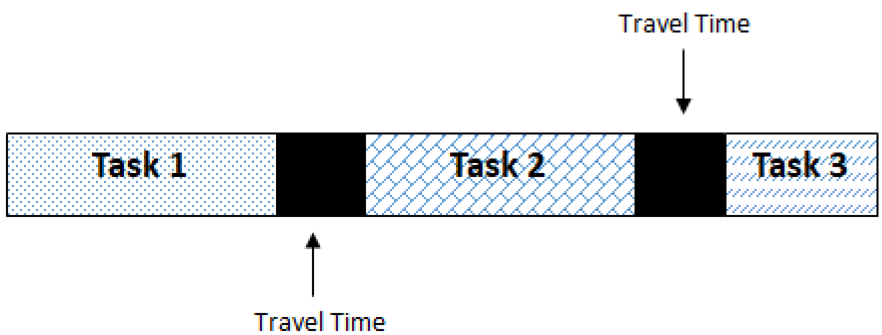

Figure 5.1. Sequential processing with travel time - Three Tasks

Furthermore, it is necessary as well to understand the other type of processing tasks; that is processing in nested mode fashion. Performing tasks in nested mode mean executing and performing a task and then wholly shifting and altering the gear to perform and process another task after a certain amount of time as shown in Figure 2.6; For instance, Task 3 interrupted Task 2 at some point to be executed and completed then Task 2 is continued and finished. However, in this study we consider the nested processing of tasks as follow, the process is shown in Figure 5.2:

1. A subject starts executing and processing a task, then

2. At an arbitrary point of time, the subject is asked to stop the processing of the ongoing task and move to another location to perform another task, then

3. The subject moves to another location or site to perform and process another task, then

4. The subject starts processing and the marking task, then

5. At an arbitrary point of time, the subject is asked to stop the processing of the ongoing task and move to another location to perform another task, then

6. The subject moves to another location or site to perform and process another task, then

7. The subject starts processing and finishing the marking task, then

8. The subject moves back to the previous location to continue processing the previous task, then

9. The subject continues the processing of the previous tasks in backward orders.

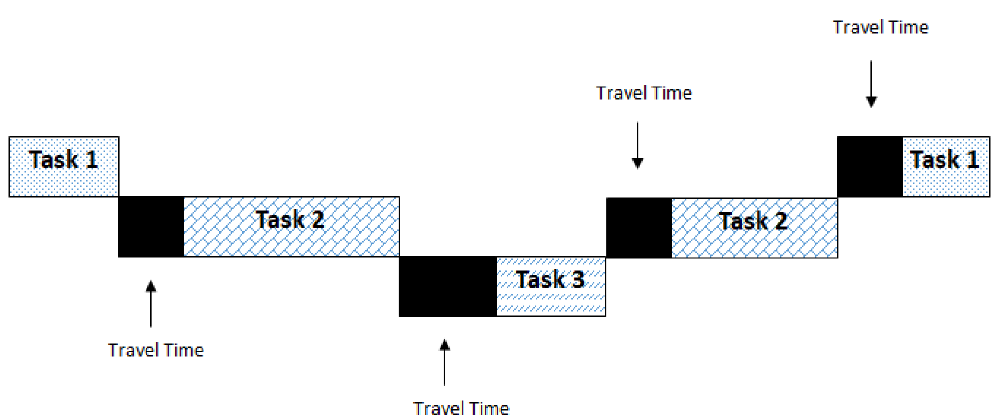

Figure 5.2. Nested processing with travel time - Three Tasks

Moreover, in order to address the research question of whether interruptions affect the entire system or not, we unavoidably need to illuminate the following quantities:

- A completion time (CT) for a task it can be clarified as the time it takes to complete and finish a single task as shown in Figure 5.3

- A transitional lag time (TL) it can be clarified as the time it takes to shift and alter to process another task. A transitional lag time (TL) is distinct within the context of sequential processing tasks. As shown in Figure 5.3

- A Total completion time (TCT) it can be clarified as the total time it takes to complete a group of tasks from performing task 1 to the completing of task 3 as shown in Figure 5.3

- An interruption lag time (IL) it can be defined as the time it takes to shift, alter, and move to another place or location in order to process another task when an interruption occurred. An interruption lag time (IL) is distinct within the context of nested processing tasks mode as shown in Figure 5.3

- A resumption lag time (RL) - it can be clarified as the time it takes to shift, alter, and move back to the previous place or location in order to process the previous interrupted task. A resumption lag time (RL) is distinct within the context of nested processing tasks mode as shown in Figure 5.3

- An Interruption points (IP) it can be defined as the moment or the time that occurred and cause the stop of the ongoing task, and it can occur at any time in the process. An Interruption points (IP) is distinct within the context of nested processing tasks mode as shown in Figure 5.3

- A Task performance (TP) It can be simplified as the number of correct answers for each task.

- A Total Task performance (TTP) It can be explained as the total number of correct answers for a group of tasks together; that is for Task 1, Task 2, and Task 3.

Moreover, it is necessary to describe and introduce another critical terminology in order to enlighten one of the corners of this experiment; that is the depth of interruptions. The depth of interruption can be distinguished as the number of nested

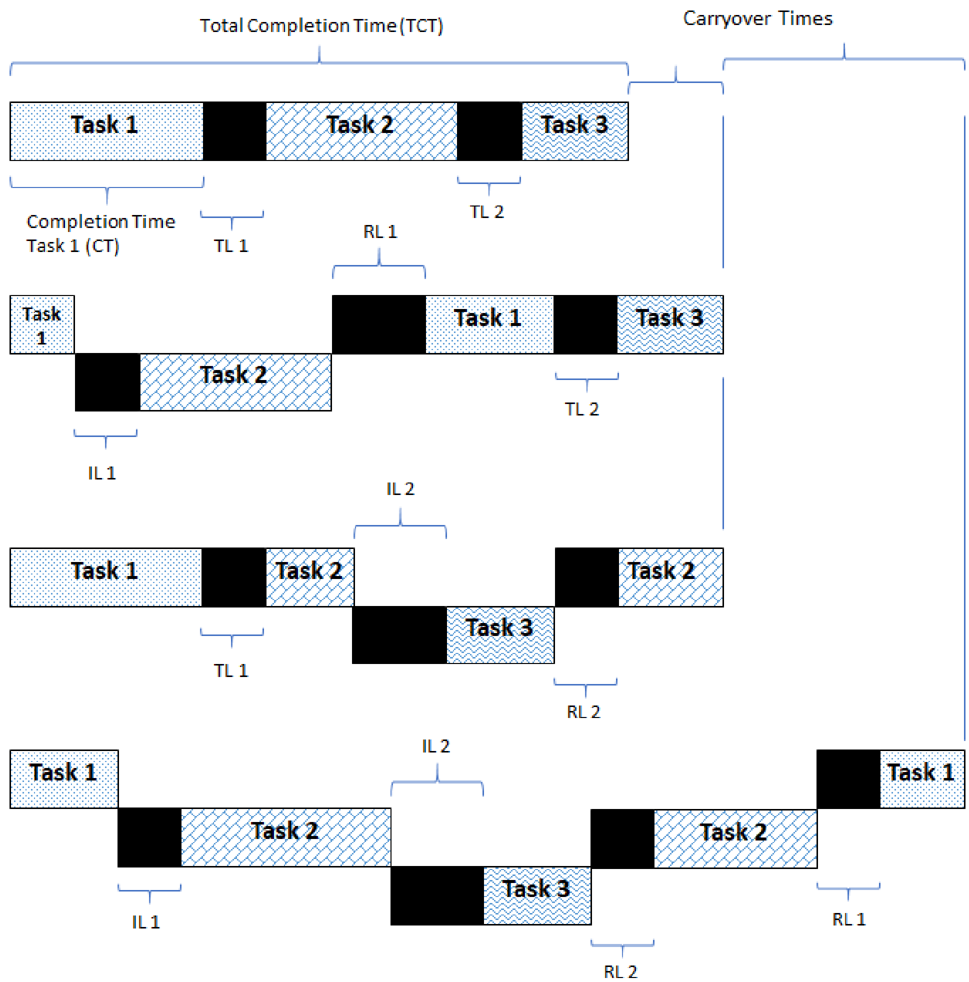

Figure 5.3. Experiment 2 Anatomy

interruptions happen and occur in a workflow process. In this experiment, we introduce three levels of interruption depth. The base level is defined as the Level-0 when tasks processed and executed sequentially without any interruptions as shown in Figure 5.4. The next level is defined as Level-1 when only a task is interrupted by another task, and then the previous is resumed as shown in Figure 5.5. The last level is defined as Level-2 when a task is interrupted by a second task and the second task is interrupted again by a third task in nested fashion mode as shown in Figure 5.6.

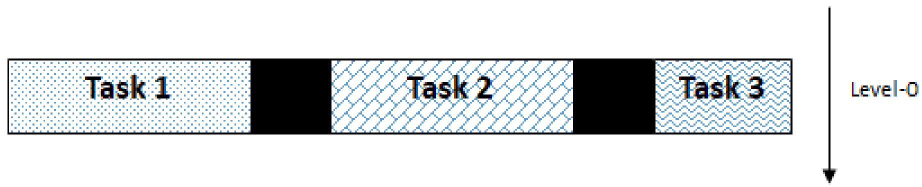

Figure 5.4. Level-0 - Depth of interruptions

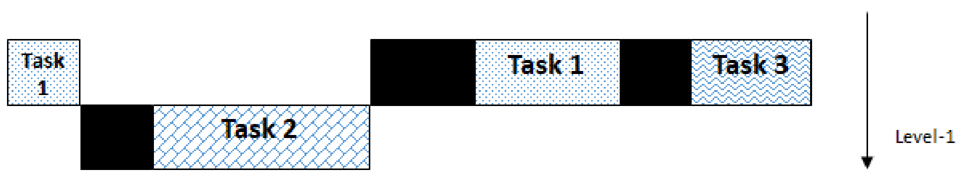

Figure 5.5. Level-1 - Depth of interruptions

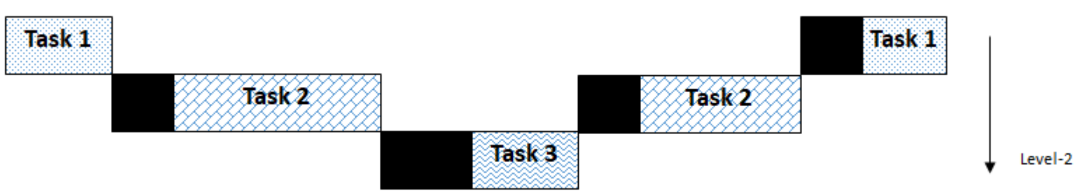

Figure 5.6. Level-2 - Depth of interruptions

This part of the research study addresses the question of whether interruptions affect the workflow process of a system or not. The effect of work performance by interruptions, which specially designed to mimic an operation center room, is inspected regarding total completion time, interruption lag time, transitional lag time, resumption lag time, and total task performance.

5.2 Method

5.2.1 Research Framework

A controlled laboratory experiment was conducted to inspect the effects of interruption on the workflow process in a system. In this stage of the experiment and study, the effects of interruption were measured in total completion time for the whole tasks together. In this study, we consider only three tasks, that is task 1, task 2, and task 3. The participant performed three tasks sequentially and in a nested mode fashion. Figure 5.3 explains the framework of experiment in this research study. The carryon information that is used for this experiment as resulted from the previous experiment as follows. The interruption points (IP) do not affect the completion time for each task as well as the task performance (TP); that is the accuracy of each task. Hence, we exclude the interruption points as a factor in this experiment. It is essential and vital to include and incorporate the result to condense the complexity of the experiment in order to reach a clear and better depiction for answers to the research questions.

5.2.2 Participants

All participants for this study were college students at Purdue University including both undergraduate and graduate. The brief information about the participants in the following points:

- Twenty students participated in the experiment.

- The average age of the participants is about twenty-three years.
- The percentage of males who participated in the experiment is 60%, and the percentage of females who participated in the experiment is 40%.
- The percentage of graduate students who participated in the experiment is 25%.

5.2.3 Experiment Design

In this experiment, we consider the interruption occurrence as the first independent variable and the depth of interruptions as the second independent variable. However, it is hard to code these variables traditionally. Hence, we express the depth of interruptions differently in the experiment design that is tangled within the experiment design itself. This tangled process is necessary in order to create the Level-2 of depth interruptions and make the design well balanced and consistency. Consequently, we consider the interruption existence for the first task as the first independent variable and again the interruption occurrence for the second task as another independent variable.

Accordingly, the experiment design is a 2 x 2 full factorial design. The full factorial design combinations are shown in Table 5.1. The levels of interruptions are depicted in Figure 5.7 below as well.

Table 5.1.
A 2 x 2 full factorial design combinations

1st Indep. Variable	**2nd Indep. Variable**	**Depth of Interruption**
No Interruption	No Interruption	Level-0
No Interruption	Interruption	Level-1
Interruption	No Interruption	Level-1
Interruption	Interruption	Level-2

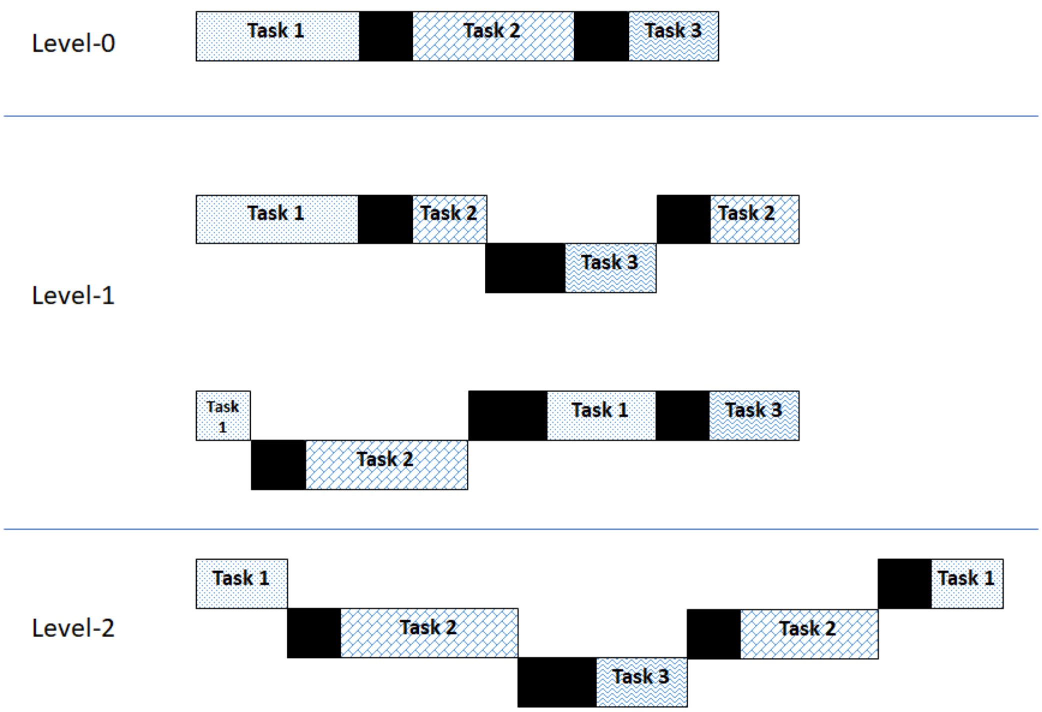

Figure 5.7. Depth of Interruptions - All possible combinations

In this experiment design, we consider the following as the independent variables as mentioned earlier:

- The interruption occurrence in the first task as an independent variable.
- The interruption occurrence in the second task as an independent variable.

Furthermore, individual variances in the students who participated in this study could have been prudently considered as another independent variable in this stage of the experiment. However, since the participants were bounded to Purdue college students who were registered in university courses, the assumptions of knowledge, experience, and proficiency are not very divergent. Furthermore, because of the nature of performing and processing this type of tasks is not dissimilar from the real work as the only rule to accomplish the task is to follow the manual instructions.

Similarly, in this experiment design, we consider the following as the dependent variables:

- Task Performance (TP) and Total Task Performance (TTP) according to the nature of the tasks, accuracy is considered as a measure of work performed in a workflow process in a system. The number of wrong inputs out of the total reading gauges is the primary measurement for work performance.
- Completion Time (CT) for a task and Total Completion Time (TCT) for a group of tasks are considered as well as the dependent variables. Task completion time is considered as a quantitative measurement in minutes. The completion time for each task is recorded. In a case where no interruption occurs, the completion time for each task can be calculated easily. On the other hand, when an interruption occurs, the completion time is carefully calculated as it is a summation of two periods of times.
- Transitional lag time (TL) is considered as a dependent variable as we would like to study the effect of interruptions on TL in a workflow process.
- Interruption lag time (IL) is considered as a dependent variable as we would like to study the effect of interruptions on IL in a workflow process.
- Resumption lag time (RL) is considered as a dependent variable as we would like to study the effect of interruptions on RL in a workflow process.

5.2.4 Procedure

In the beginning, each participant was asked to fill out the consent form and demographic questionnaire before the start of the experiment. Then, five minutes of a training session that was introduced to the participant with an illustration of the task performed and processed. The participants then process and perform the three tasks sets according to the randomization table that was created earlier according to the experiment design. Each participant exposed three tasks, some of them received a no interruption scenario or Level-0 as follow:

1. The participant is asked to start doing Task 1 at location 1 (a room inside a building, e.g., GRIS Grissom Hall) and finish it, then
2. The participant is asked to move to the nearby location (another room in the same building, location 2), then
3. The participant is asked to start doing Task 2 and finish it, then
4. The participant is asked to move to the nearby location (another room in the same building, location 3), then
5. The participant is asked to start doing Task 3 and finish it.

Similarly, others participants received an interruption scenario or Level-1, the first possible combination in this level, as follows:

1. The participant is asked to start doing Task 1 at location 1 (a room inside a building, e.g., GRIS Grissom Hall) and finish it, then
2. The participant is asked to move to the nearby location (another room in the same building, location 2), then
3. The participant is asked to start doing Task 2, then
4. The participant is stopped (interrupted) at an arbitrary time during Task 2, then
5. The participant is asked to move to the nearby location (another room in the same building, location 3), then
6. The participant is asked to start doing Task 3 and finish it without any interruption, then

7. After the participant finishes Task 3, the participant is asked to move to the location of Task 2 (location 2) and finish Task 2.

Similarly, others participants received an interruption scenario or Level-1, the second possible combination in this level, as follows:

1. The participant is asked to start doing Task 1 at location 1 (a room inside a building, e.g., GRIS Grissom Hall), then
2. The participant is stopped (interrupted) at an arbitrary time during Task 1, then
3. The participant is asked to move to the nearby location (another room in the same building, location 2), then
4. The participant is asked to start doing Task 2 and finish it, then
5. The participant is asked to move to the previous location (another room in the same building, location 1), then
6. The participant is asked to resume processing Task 1 and finish it, then
7. The participant is asked to move to the nearby location (another room in the same building, location 3), then
8. The participant is asked to start doing Task 3 and finish it.

Correspondingly, others participants received an interruption scenario or Level-2 as follows:

1. The participant is asked to start doing Task 1 at location 1 (a room inside a building, e.g., GRIS Grissom Hall), then
2. The participant is stopped (interrupted) at an arbitrary time during Task 1, then

3. The participant is asked to move to the nearby location (another room in the same building, location 2), then
4. The participant is asked to start doing Task 2, then
5. The participant is stopped (interrupted) at an arbitrary time during Task 2, then
6. The participant is asked to move to the nearby location (another room in the same building, location 3), then
7. The participant is asked to start doing Task 3 and finish it, then
8. The participant is asked to move to the previous location (another room in the same building, location 2), then
9. The participant is asked to resume processing Task 2 and finish it, then
10. The participant is asked to move to the first location (another room in the same building, location 1), then
11. The participant is asked to resume and process Task 1 and finish it.

5.3 Results and Discussion

This section of this chapter analyses the results of experiment 2. The experiment went as expected with no strange actions that would have introduced error to the 2 x 2 full factorial model. Since the travel time is just a constant value, it is essential as well to see and test it thoroughly for different working environments. In the case of nested mode, the distance between the location of task 1 and task 2 is full of dynamic and uncertain actions as noises while the distance between the task 2 and 3 is entirely quiet and might not include in any noise. Supplementary, the difference in time because of the crowd exist at different levels at different times of the day; this phenomena shows and mimic the situation that reflects the real working environment when for instance moving and traveling from place to another place. The dynamic situation appears to be an unrestrained characteristic in the workflow process.

First, we test using the two-sample t-test again whether there is a difference between the lag times for different levels to see the effect of the depth of interruptions, that is the different depth of interruptions. The results show that there are no noteworthy differences between Level-0 and Level-1 and that supports the result of experiment 1. However, for Level-2 and Level-0 it shows that there is a significant difference in the lag times as shown in Figure 5.8.

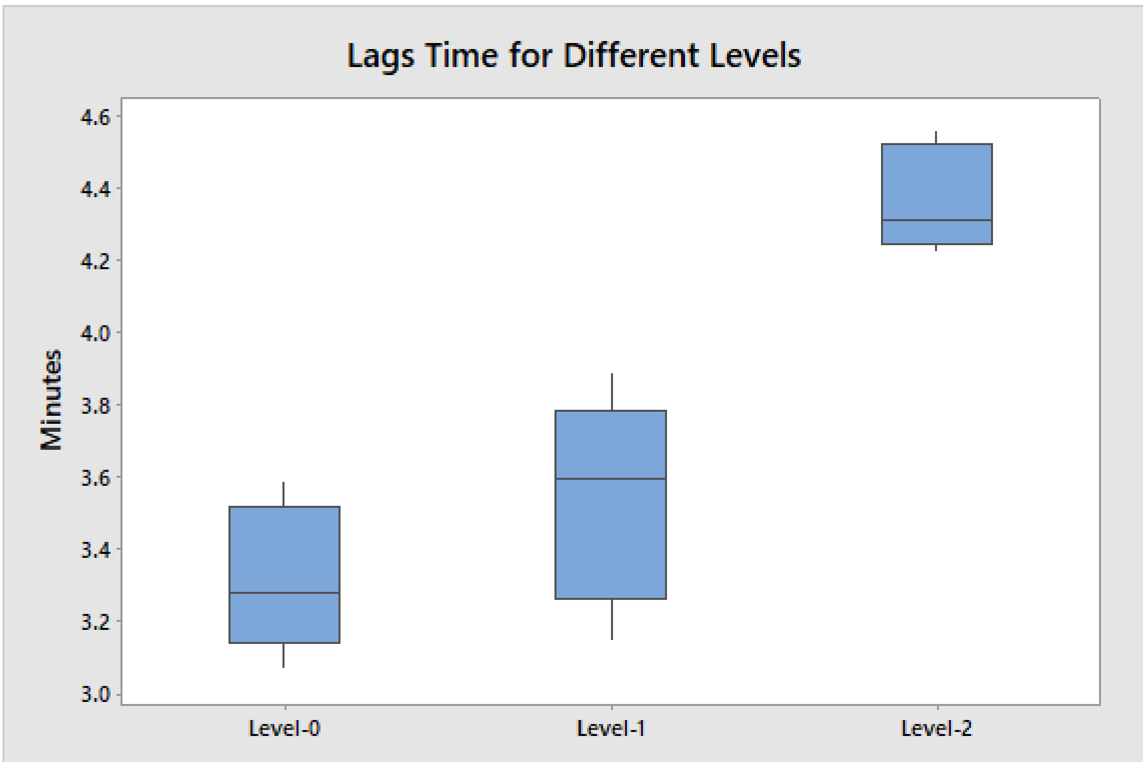

Figure 5.8. Lag Times for Different Levels

In this study, based on the observations a linear model is fitted to see and exploit the lag times in the context of different levels of the interruption. Additionally, another model is fitted to the collected data which is the exponential model as shown in Figure 5.9. Based on thoroughly thought, the number of interruptions increases linearly with the number of tasks performed in a nested fashion. According to the result, a linear model fits better to the data. However, there is no conclusion can be drawn from this analysis as the number of data is only 20 data points, and it might be required to do and to perform more levels of interruptions in the experiment design.

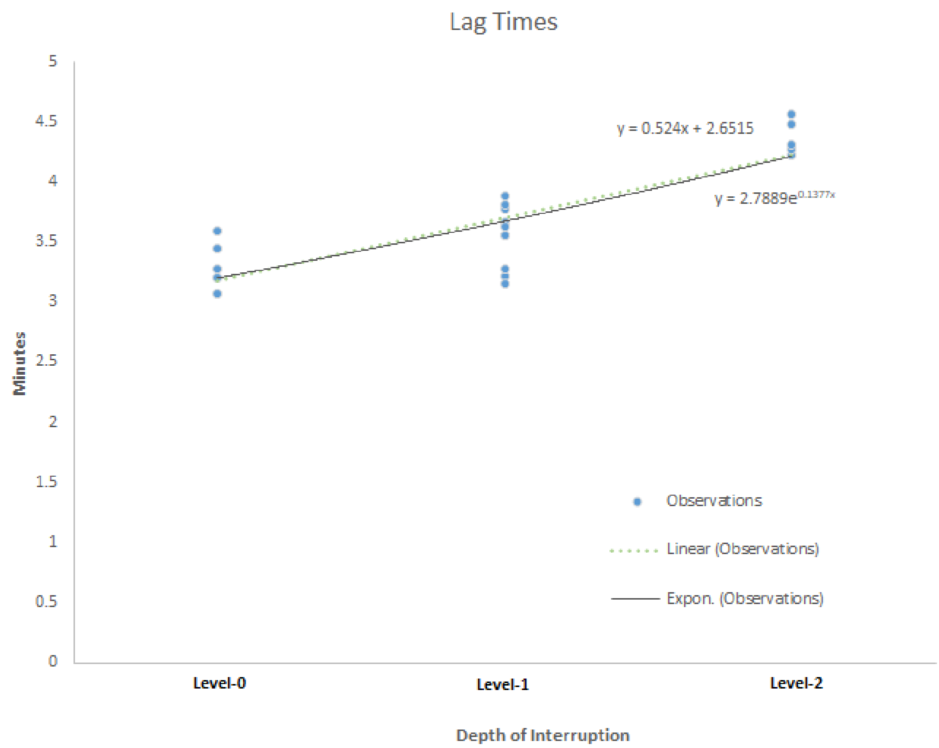

Figure 5.9. Fitting Linear and Exponential Models

Likewise, the result of the 2 x 2 full factorial design can be interpreted as follow. the interruption occurrence in both task 1 and task 2 play a significant role in the total completion time for the whole process with the p-value of 0.000. Correspondingly, the reason behind making the interruption occurrence vital and significant in the workflow process is the number of interruptions occurred in the complete set of tasks, that is the whole process. It has been recognized that the working environment and its surrounding is very energetic and dynamic. Hence, the depth of interruptions plays a crucial role in the total completion time for the whole process.

5.4 Limitations

In this section of the chapter, we provide some limitations in executing the experiment 2. These limitations can be summarized as follow. One of the Possible concerns about this experiment is the representativeness of the participant; the participant recruiting strategy used in this study was intended to be for college students, and there was no guarantee the familiarity of doing such tasks. The other possible concern is that the time to execute tasks in the real world take a little bit longer in time for different varieties of tasks, as well as the distance between different locations of the tasks is reasonably far away. Another one of the critical limitations is the workload for the individual. The workload was not evaluated in this research study. Therefore, the effect of the workload on the results is unknown and needed to be considered in future studies. However, I do not expect that the workload had any effect of this research study, but it was tested, evaluated, or controlled in the proposed experiments.

5.5 Conclusion

In this second experiment, we study, examine, and exploit the effect of depth of interruptions existence in the workflow process; that is one of the main contributions to the research community. This factor definition might be considered as the first and essential block in future studies in diverse research communities. We use three tasks in order to achieve the goal of this experiment 2; that is to achieve the second level of nested interruption. The result of this experiment suggests that processing all tasks sequentially is continuously better than processing tasks in the nested mode because of the depth of interruptions factor. In the nested mode, the travel time and distance play a significant role as they fluctuate substantially fast enough within the working hours and these considered as constants in this study.

The next chapter provides the recommendations from this experiment, and the previous experiment. We propose a new policy in order to handle and the nested processing of tasks in the workflow process in industries.

6. A POLICY PROPOSAL

In this chapter, we propose a recommended policy for the workflow process when interruptions exist in the system in nested fashion mode. First, we review and provide the recommendations from the first experiment, and then we provide the recommendation from the second Experiment. All these recommendations are prudently considered thoroughly. Last, a policy is proposed based on the recommendations and observations of the complete experiment.

6.1 Recommendations and Observations from Experiment 1

In the first experiment, we study, examine, and exploit the effect of interruption existence in the workflow process and the interruption points; that is potential areas that could play a significant role in the whole process. In this experiment, we use two tasks only in order to accomplish the objective of this experiment. The results of this experiment suggest and recommend the following:

- Since the interruptions play a significant role in the total completion time for all tasks, it is recommended that it is better to process all tasks sequentially. Processing tasks sequentially avoid the twofold consideration of time when moving from one location to another location; as shown in the study, the travel time is well-thought-out as a critical player in the workflow process of this kind.
- In this kind of processing tasks, the interruption points have no significant effect of completion time for tasks exclusively. Also, in this kind of processing tasks and this kind of tasks that only depend on following a set of instructions, interruption occurrence and interruption points do not affect the transitional lag time (TL), interruption lag time (IL), and resumption lag time (RL)Hence, the

interruption can occur at any level if necessary. However, it is not recommended to interrupt the ongoing task within the last 10-20% of completion. The reason is that we notice that the time to a worker to move from one location to another location and then moving back to the original location will be greater than 10-20% of completion time.

6.2 Recommendations and Observations from Experiment 2

In this second experiment, we study, examine, and exploit the effect of depth of interruptions existence in the workflow process. We use three tasks in order to achieve the goal of this experiment; that is to achieve the second level of nested interruption. The result of this experiment suggests and recommend the following:

- Since the interruptions play a significant role in the total completion time for all tasks, it is recommended that it is better to process all tasks sequentially. Processing tasks sequentially avoid the twofold, threefold, or fourfold consideration of time when moving from one location to another location in the existence of interruption depth; as shown in the study, the travel time is well-thought-out as a critical player in the workflow process of this kind.

- In this kind of processing tasks, the interruptions depth have no significant effect of completion time for tasks exclusively. Also, in this kind of processing tasks and this kind of tasks that only depend on following a set of instructions, interruption occurrence, and interruptions depth do not affect the transitional lag time (TL), interruption lag time (IL), and resumption lag time (RL). Hence, the interruption can occur at any level if necessary. However, it is not recommended to interrupt the ongoing task within the last 15-30% of completion depending on the depth of interruption. The reason is that we notice that the time to a worker to move from one location to another location and then moving back to the original location will be higher than 15-30% of completion time especially in the nested mode tasks processing.

6.3 The Recommended Policy

Based on the recommendations and observations points from the two experiments, we propose a recommended policy that gives a better understanding about the complexity level of interruption in the nested mode, for the individual (a decision maker) who is responsible for distributing tasks or jobs in similar circumstances. This proposed policy as well provide a systematic way to void the unnecessary interruptions that cause the delay in the workflow process. Hence, the recommended policy as follow:

1. Managing to process the tasks sequentially is better than processing the tasks in the nested fashion mode. Hence, processing tasks sequentially as possible for this kind of circumstances is the first primary key in this type of workflow process.

2. In the case of interruption, it is not recommended to exceed a certain number of nested interruptions. It is best to find the worker with less number of interruptions in depth. However, it is not recommended to interrupt the ongoing tasks within the last of 10-30% of completion time. Hence, in many cases, it is a trade-off between the number of tasks in depth and the 10-30% of completion time of a task. Consequently, knowing the location and place for the new urgent incoming task will help in choosing the right better choice that lead to minimizing the total completion time for all tasks in the workflow process.

In the next chapter, we evaluate the recommended policy against the current practice of distributing tasks in the nested mode in the workflow process.

7. SIMULATION MODEL

In this chapter, we start introducing what the simulation is. Then, we provide a short introduction about simulation as background. Then, we introduce a simulation model to test and evaluate the recommended policy that drawn from experiment 1 and experiments 2 from the previous chapters. Also, we introduce a simulation model that reflects the current policy to compare it with the recommended policy. Lastly, we report the comparison results.

7.1 Introduction

Simulation as a word can be explained and clarified as imitation, mimicking, or mirroring a situation, a process, or environment settings. The prime goal of the simulation mirrors the real-world circumstances or situations in order to find solutions for a better understanding of the problematic and complex occurrences. A model is an abstraction of anything; for instance, a real system, phenomena, or an idea.

A simulation model can be described as a model that can be used to investigate an extensive authenticity of what if inquiries about the real-world systems. Possible changes in the scheme of any system can be replicated and simulated in order to observe their impact on the entire system as well as the interactions between the system components. All these lead to finding suitable parameters before execution of any policy, plan, or strategy to the real-world system. Hence, a simulation model can be used as an Investigation tool for building new policy, strategy or plan to the systems. Also, it can be used to see and examine the effect of changes to the entire system.

Moreover, it can be used as a design tool to examine and test the performance of the new plan, policy, or strategy to the system in the early stages of planning.

With the increased in advanced technology, new power capabilities introduced to help discover and exploit the complex systems. Correspondingly, a simulation model is used when uncertainty is very high, and many hidden factors cannot be captured easily in the process.

There are many advantages of using the simulation model in experimenting with a new policy, a new strategy to the real-world complex systems, but there are some disadvantages as well. A simulation model is tremendous forecasting and predicting power that analyzes complex systems, but good theories are needed to match the complexity level of understanding and to interpret the results. Building a simulation model does not require data, but validation and justification the simulation model does need to data. A simulation model can run any what-if scenarios that could be needed, but all scenarios must comply with the world logic of interpreting the meanings.

In this dissertation, Discrete Event Simulation (DES) is applied to evaluate the proposed policy against the currently applied policy that is arbitrary assigning tasks to individuals in the workflow process in existence of nested tasks interruption phenomena.

7.2 Simulation Model

In this simulation model, Individuals or workers are considered as machines. Also, tasks are considered as jobs. The primary objective of the simulation tests and compare the proposed policy against the currently applied policy that is arbitrary assigning tasks to individuals in the workflow process in existence of nested tasks interruption phenomena. In this dissertation, data from the previous experiments are used to input the model as well as are used to test and evaluate the proposed policy. These data can be summarized as follow:

- Individuals are considered as machines or servers and in this study we have three servers.

- Tasks are considered as jobs.
- Interarrival time follow Poisson Distribution with a rate of 40 Tasks per hour.
- Tasks follow Normal Distributions as follow:
  1. Task 1 - $\mu = 8.3\ mins\ and\ SD = 0.21\ mins$
  2. Task 2 - $\mu = 7.01\ mins\ and\ SD = 0.22\ mins$
  3. Task 3 - $\mu = 7.05\ mins\ and\ SD = 0.21\ mins$
- Lag times follow Normal Distribution with mean $\mu = 0.21\ mins$ $and\ SD = 0.0156\ mins$

It is important to mention that in this study we run the model to execute different numbers of incoming jobs to the dispatcher. For instances, the model runs to complete 100, 200, 300 jobs and tasks. Also, the algorithms that had been used to simulate the proposed policy, as well as the current practice policy, are described in the following subsections 7.2.1 and 7.2.2

7.2.1 Current Practice Policy Algorithm

The current practice policy algorithm that is executed in this study is described as follow:

1. **START** when a dispatcher receives a new task.
2. **INITIALIZE** Group0, Group1, Group2, Group3
3. **FOR** each worker:
   - **COMPUTE** number of tasks
     - **IF** number of tasks = 0
       Assign worker to Group0

  - **ELSE IF** number of tasks = 1

    Assign worker to Group1
  - **ELSE IF** number of tasks = 2

    Assign worker to Group2
  - **ELSE**

    Assign worker to Group3

4. **END**

5. **CHOOSE** Group0, Group1, Group2 uniformly

   - **CHOOSE** worker uniformly who has task with priority less than new task
     - **IF** the new task has a priority rank equal to the exist rank

       THEN WAIT UNTIL the worker who finishes ongoing task with the same rank THEN

       ASSIGN new task to the worker.
     - **ASSIGN**

       new task to worker

6. **FINISH**

7.2.2 Proposed Policy Algorithm

The proposed policy algorithm that is executed in this study is described as follow:

1. **START** when a dispatcher receives a new task

2. **INITIALIZE** Group2, Group1, Group2, Group3, AlmostFinishGroup

3. **FOR** each worker:

   - **COMPUTE** number of tasks
     - **IF** number of tasks = 0

       Assign worker to Group0

  - **ELSE IF** number of tasks = 1
    Assign worker to Group1
  - **ELSE IF** number of tasks = 2
    Assign worker to Group2
  - **ELSE**
    Assign worker to Group3

4. **END**

5. **CHOOSE** Non-Empty Group Starting from Group0.

   - **FOR** each worker within the group:
     - **COMPUTE** Remaining Time:
       IF Remaining Time less than 15%: ASSIGN worker to AlmostFinish-Group
   - **CHOOSE** worker uniformly who has task with priority less than new task
     - **IF** the new task has a priority rank equal to the exist rank
       THEN WAIT UNTIL the worker who finishes ongoing task with the same rank
       ASSIGN new task to the worker
     - **ASSIGN** new task to worker

6. **FINISH**

7.3 Results and Discussion

This section of this chapter analyses the results of the simulation stage for this dissertation. The simulation went as expected with no strange outliers in the throughput of the simulation model. To recall, in this simulation study, the primary objective is to test and evaluate the recommended or the proposed policy against the most common (current practice), that is an arbitrary distribution of tasks and jobs in the workflow when the nested interruptions occur. In this simulation, the input to the simulation model is the result of the previous experiments, that is experiment 1 and experiment 2. These data can be summarized as follow:

- Individuals are considered as machines or servers and in this study we have three servers.
- Tasks are considered as jobs.
- Interarrival time follow Poisson Distribution with a rate of 40 Tasks per hour.
- Tasks follow Normal Distributions as follow:
    1. Task 1 - $\mu = 8.3\ mins\ and\ SD = 0.21\ mins$
    2. Task 2 - $\mu = 7.01\ mins\ and\ SD = 0.22\ mins$
    3. Task 3 - $\mu = 7.05\ mins\ and\ SD = 0.21\ mins$
- Lag times follow Normal Distribution with mean $\mu = 0.21\ mins$ $and\ SD = 0.0156\ mins$

In this model, we use 200 replications for each run for a different number of tasks to execute. The first number of tasks was 100 tasks and jobs. Then, we increase the tasks and jobs number by 100 tasks. So, in total, three test (100 jobs, 200 jobs, and 300 jobs) are implemented and executed with 200 replications for each run. The average number of minutes were shown in the table 7.1 and Figure 7.1 and 95% confidence interval for all the three cases are as follow:

- For 100 Jobs and Tasks:
    - **Proposed Policy** - (189.4, 203.7) minutes.
    - **Current Practice** - (197.7, 211.3) minutes.
- For 200 Jobs and Tasks:

- **Proposed Policy** - (375.8, 405.1) minutes.
- **Current Practice** - (408.3, 427.6) minutes.

- For 300 Jobs and Tasks:
  - **Proposed Policy** - (601.7, 629.7) minutes.
  - **Current Practice** - (661.1, 684.9) minutes.

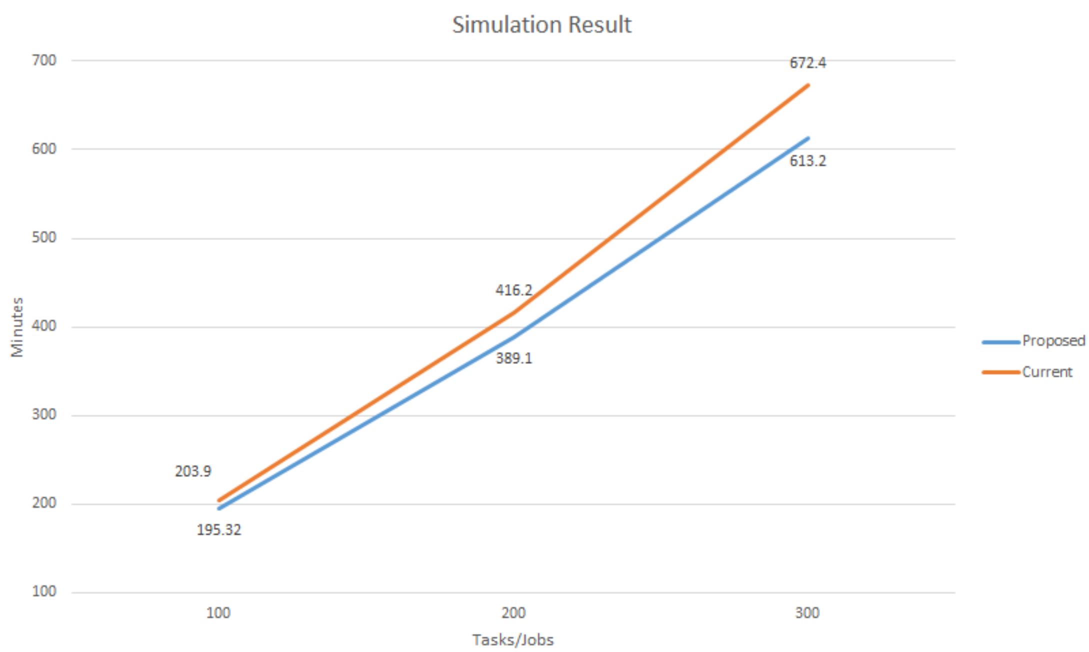

Figure 7.1. Average Results - Simulation

Table 7.1.
Average Results - Simulation

No. of Tasks	Proposed (min.)	Current (min.)	Diff. %
100	195.3	203.9	4.4
200	389.1	416.2	6.9
300	613.2	672.4	9.6

From the results above, it is noticeable that the proposed policy by far is better than the current practice policy. As the number of jobs and tasks increase, the difference between the proposed policy and the current policy is getting bigger. Also, the number of wasted minutes increase exponentially with the occurrence of interruptions numbers as well as the depth of interruptions, that is the level of the interruptions.

The significance of the simulation can be explained as follow. The simulation shows that the result of only three servers or individuals. Increasing the number of individuals as well as increasing the number of the incoming of jobs and tasks will lead to the increase of the completion time for all jobs. Additionally, in this simulation, we set the interarrival rate to be 40 tasks and jobs per hour.

8. CONCLUSION

Interruptions are the phenomena that exist and appear in many places in life; they appear everywhere in every kind of any on-going activities either in doing personal actions on a daily basis or in doing complicated activities and processes in complex dynamic systems in businesses.

The role and the effect of interruptions or breaks have begun to appear a lot meaningfully in the industries in the past few years particularly the ones that related to the task or job interruptions in businesses that affect unswervingly to the flow process of the work. It is vital to reference that the interruptions can be found in many different formats depending on the work environments.

In this dissertation, the research study is divided into two different phases. In the initial phase, the study is about the workflow process interruptions and breaks from the standpoint of human subject experimentation to understand, explore, grasp, and exploit interruptions phenomena while doing a particular and a specific task that designed particularly for this dissertation. This phase leads the research to comprehend and learn whether or not the workflow process interruptions affect on task performance, transitional lag time, interruption lag time, and resumption lag time regarding the range and the level of interruptions. The experiments were conducted in two stages, and the factorial designs were used in these experiments.

In the first stage, the result of this experiment suggests that processing all tasks sequentially is continuously better than processing tasks in the nested mode. In the nested mode, the travel time and distance play a significant role as they fluctuate substantially fast enough within the working hours. However, in this study, the travel time is considered a constant value because it is different from one environment to another environment. In the second stage of this phase, the obtained information is used from the first stage to design the experiment for this stage. We study, examine, and exploit the effect of depth of interruptions existence in the workflow process; that is one of the main contributions to the research community. This factor definition might be considered as the first and essential block in future studies in diverse research communities. Three tasks were used instead of two tasks in the previous experiment in order to achieve the goal of this experiment 2; that is to achieve the second level of nested interruption. The result of this experiment suggests that processing all tasks sequentially is continuously better than processing tasks in the nested mode because of the depth of interruptions factor. Subsequently, the experiment is complete and proposes new policy guidelines for the workflow processes under the occurrence of the nested interruptions circumstances.

In the second phase of this dissertation research, the study the workflow process interruptions from the standpoint of a simulation model is conducted, and Discrete Event Simulation (DES) is applied as the primary driver. The fundamental goal of this phase is to understand the effect of the workflow process interruptions in the setting of different policies. In this study, the comparison between the new proposed policy compared and the current practice of handling interruptions is applied when nested interruptions exist and occur. It is noticeable that the proposed policy by far is better than the current practice policy. As the number of jobs and tasks increase, the difference between the proposed policy and the current policy is getting bigger. Also, the number of wasted minutes increase exponentially with the number of interruptions as well as the depth of interruptions. Finally, this dissertation can be extended in two ways as explained in the next section.

8.1 Future Research

This dissertation can be extended in two ways, and these are as follow:

- The design of experiment in experiment 1 can be extended to study specific culture, gender type, or for specific settings and environment. Also, age could be studied as a factor as well because in some industries, regions, and different environments they consider employee or worker's age as one of the critical constraints.

- Another extension that worth mentioning and considering is the workload on the individuals and the type of jobs and tasks activities as well. It is expected that the type of activities will play a vital role in the completion time when the nested interruption phenomena exist.

- The design of the experiment in the second experiment could be extended by considering more levels of nested interruption as this will direct the research to conclude about the relationship between the lag times and the level of interruptions as well as considering different types of tasks instead of using heterogeneous tasks.

- Systems Dynamics (SD) approach could be used to study the whole process as a complete system. In particular, System Dynamics will explore and study the types and the flow rate of different tasks to the dispatcher. It is possible as well to explore the effect of the interaction between different dispatcher in case of more than a dispatcher is available.

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VITA

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