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Ubiquitous Learning Laboratory For Pediatric Nursing: A Cultural Algorithm Approach

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UBIQUITOUS LEARNING LABORATORY FOR PEDIATRIC NURSING: A CULTURAL ALGORITHM APPROACH

by

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DEDICATION

To my Wife, Kim. Thank you for your patience, understanding, and encouragement. This journey could not have been completed without you.

To my family and good friends. Thank you for reminding me that Life is a learning experience that has its ups and downs – it's ultimately up to you what you want to take away from it.

With Success, realize that there is always room for improvement and that new challenges are always around the corner. For Failure, remember to get-up and dust yourself off and see that you are a better person for taking that chance. When all is said and done, when you wake-up the next morning, be thankful for the opportunity to move forward with what you learned either way.

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Chapter 1: INTRODUCTION

Reynolds introduced Cultural Algorithms (CA) in his PhD Thesis in 1979[1]. CA is an extension of an evolutionary algorithms called Genetic Algorithms (GA) [2]. Just like GA, CA manipulates a generation of individuals (called the Population Space) to solve a problem[3]. Instead of genetic cross-over and mutation operations that blindly drive the evolutionary process, CA orchestrates this process with the addition of a high-level component called the Belief Space. In fact, each component continually refines the other via a communication channel between the two as evolution takes place. Moreover, this interaction and refinement gives CA adaptive properties. All of these enhancements allow CA to evolve a solution much more quickly than a corresponding GA would.

Section 1.1: Definition of Culture

In the general sense, culture can be defined as the cumulative collection of knowledge, beliefs, experience, notions of time, and spatial relations that is acquired by a group of people in the course of generation through individual and group striving[2]. For Cultural Algorithms (CA), culture is defined as the knowledge source of the data (i.e. Belief Space) that influences the behavior of all individuals within its population (i.e. Population Space)[4]. Given that Cultural Knowledge can be viewed as representing a complex system it can be appreciated at many different levels of granularity in both time and space.

One example of culture is the body of knowledge produced by the Nursing Community. It has an established set of guiding principles (i.e. beliefs) that influence the skills of Nurses. Moreover, as a Nurse develops these skills and gains the experience required to provide quality patient care, she/he might also find better methods to deliver health care. Such improvements

might even be accepted by the Nursing Community itself. This collaborative effort showcases an ever-evolving learning environment.

Section 1.2: Cultural Knowledge

Clinical judgment is viewed as an essential skill for virtually every health professional [5]. The term clinical judgment has been used interchangeably with other terms such as Critical Thinking [6] or Clinical Reasoning [7]. For the purpose of this thesis, clinical judgment is defined as the interpretation or conclusion about a patient's needs, concerns, or health problems, and/or the decision to take action (or not), use or modify standard approaches, or improvise new ones as deemed appropriate by the patient's response [5]. Clinical reasoning is the process by which Nurses make their clinical judgments, and includes both the deliberate process of generating alternatives, weighing them against the evidence, and choosing the most appropriate. This process can be characterized as engaged, practical reasoning and critical thinking[5].

Measuring clinical judgment is not a simple process, however. The assessment should range on a continuum from unacceptable (unsafe) to expert (exceeds expectations) [6]. New Registered Nurses (RN)s are expected to be at the entry (safe practice) point [6]. Measurements (i.e. expectations) should incorporate a combination of correct assessment or diagnosis (i.e. identifying the problem), distinguishing similar scenarios from one another, and performing the correct course of medical treatment. Unfortunately, only 35 percent of new RN graduates, regardless of educational preparation and credentials, meet entry expectations for such clinical judgment[6]. This is a problem.

Section 1.3: Problem Scenario

There are many explanations as to why there are discrepancies in expected preparedness for clinical judgment. Some nurse educators may claim that the cause is due to the population of entering students with limited ability or low qualifications [6]. Another highly probable cause is the increased emphasis on teaching more and more content in the nursing education curricula at the expense of the application of knowledge [6]. Inconsistent coaching practices might be yet another[7]. Finally, accepted teaching paradigms might not be adequate for the ever-growing population of students known as Digital Natives[8].

Granted, the traditional classroom has a solid acceptance in terms of the quality and level of information that can be conveyed. It is not just a matter of content or the quality of teaching credentials that's the problem, however. Rather, it is rather a clashing of teaching styles versus evolving learning styles in an ever-widening generation gap between teacher and the new breed of Generation X students[8]. Moreover, the evolution of the virtual classroom (i.e. on-line lectures, blogs, etc.) and the distinction between it and the real world are becoming less apparent.

Section 1.4: Ubiquitous Haptic Learning to the Rescue

The notion of a virtual world as a learning tool is not a new one. One such world includes a virtual community referred to as "The Neighborhood" [9]. Moreover, the size or realism of a virtual world in general can be classified with varying levels of fidelity[10]. Both of the above examples describe digital institutions for the Nursing field in general. Their focus is to fill a void where in Registered Nurse Graduates can be shown to have the skills for the profession, but still lack the reasoning on how to apply those skills in a real-world medical situations[6]. There are many unique areas of Nursing that could benefit from such an approach, however.

This thesis will focus on the structure of a haptic learner for Pediatric Nursing. This learner will be developed on a mobile platform using the XNA 4.0 Game Programming Platform. The goal is to show that the haptic response of learning in a 2D game environment can be a valuable learning tool for teaching today's Nursing Students on-the-go. Cultural Algorithms has been used in other serious games[11]. More importantly, the use of Cultural Knowledge as a module refinement mechanism could prove invaluable to the game's impact on improving Clinical Reasoning. Specifically, we will investigate the use of Cultural Algorithms, a type of Socially Motivated Learning, to benchmark optimal learning pathways in Game Scenarios. These benchmarks will be useful in assessing the learning capabilities of students as they progress through the virtual game world. The structure of this thesis is described in the next section.

Section 1.5: Thesis Structure

The remainder of the thesis will be structured as follows. First in Chapter 2, an overview of Socially Motivated Evolutionary Learning Algorithms is provided. Next, in Chapter 3 the design of the ICARE Virtual Nurses World is provided. Chapter 4 then describes the implementation of the design within a portable Windows Phone Development Environment. Chapter 5 describes how the Cultural Algorithm will be used to generate optimal solution to posed problem scenarios in the Game. The results of the Cultural Algorithm learning process are given in Chapter 6. The results indicate the potential for the use of Cultural in extracting patterns of problem solving in critical situations. The conclusions follow in Chapter 7

Chapter 2: AN OVERVIEW OF SOCIALLY MOTIVATED EVOLUTIONARY ALGORITHMS

The motivation for early Artificial Intelligence (AI) was to have "Individual" intelligence[12]. For example, a famous AI endeavor in 1997 was to teach a machine (Deep Blue) how to defeat a Chess Master[13]. This idea still has applications for today such as the recent *IBM* Challenge with Watson on the television show Jeopardy! – *America's Favorite Quiz Show*. Now, the focus is more on a "Group" intelligence model[12]. Historically, Group Intelligence makes use of models of biological systems to motivate solutions to solve a problem. There is a whole spectrum of these systems that is still in use today[12] based upon differences in the scale of communication, both temporal and spatial, between agents in the system.

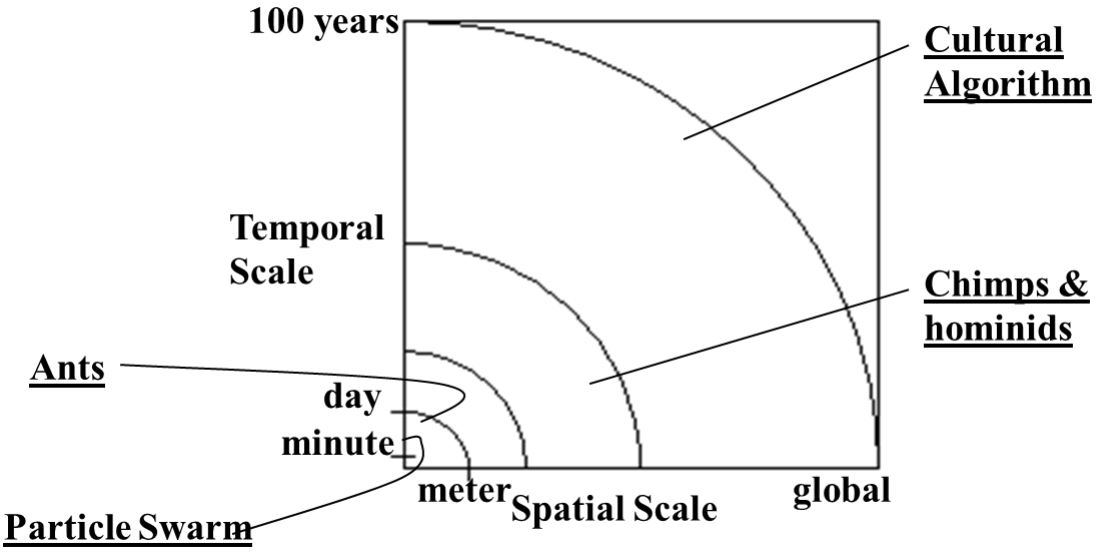

Figure 2-1Scale of Social Intelligence

For example, one of the lowest systems of group intelligence was based on ants (i.e. Ant Colony Optimization). This system was useful in solving the Traveling Salesman Problem[14]. Another biological system include Flocks of Birds (i.e. Particle Swarm Optimization), which is

good for solving optimization problems in real-valued functional spaces. Finally, a high-level biological system based on humans (i.e. Cultural Algorithms), which has been used to solve archaeology problems[15].

These levels of Social Intelligence have similarities. First, no matter which level of Social Network chosen, each can solve similar problems[12]. The higher the organism / species used the more complex the social interaction takes on. Each simply requires a larger physical space and temporal space to operate within. Second, no matter which Social Network chosen, they have similar functionality. For example, each starts with an initial population and has the notion of a common "knowledge". Next, each population has a measure of what is a good as well as what is a bad interaction (A.K.A Fitness Function). Finally, each population has a method for passing on that knowledge to subsequent population.

Section 2.1: Particle Swarms

Particle Swarms Optimization (PSO) is a population-based search algorithm based on the simulation of social behavior of birds within a flock [2]. James Kennedy and Russell Eberhart introduced PSO in a 1995 paper. The work capitalized on a previous method used to formally describe the aesthetics of bird flocking choreography[16]. In essence, they parallel solving optimization problems with a flock's ability to solving the problem of finding food.

Kennedy opted to call his artificial birds "Boids" and called the approach Particle Swarm Optimization since the basic form of knowledge for an individual was the location of the current best point or particle in the search space along with the positions of its neighbors[16]. The initial simulation relied on nearest-neighbor, velocity matching and a hint of "craziness" to give a "lifelike" appearance to the aggregate motion of his artificial flock[16]. The flock is composed

of 15-30 Boids and their flight takes place in a 100x100 2-D grid – each Boid occupies a 1x1 location within this grid.

For Boids, flocking relies on three steering behaviors: move away from boids that are too close (separation), move in the same direction and at the same velocity as the flock (alignment and velocity matching), and move toward the center of mass of the flack (cohesion)[17, 18].

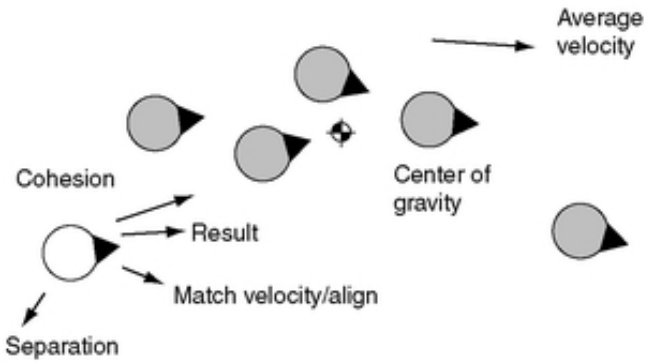

Figure 2-2Boid steering into a Flock

Kennedy extends the Boids Swarm simulation to collectively solve a problem – finding food. Kennedy nicknamed the 100x100 grid as "the cornfield vector." He began by designating a location for the cornfield in the grid. Next he randomly places 30 Boids within the grid. For each time increment, each Boid evaluates its current position using a fitness function. Moreover, it keeps tab of the best evaluation encountered so far and the corresponding XY-coordinates in the grid. Based on its own best evaluation location along with the best evaluation location from the flock overall, the Boid adjusts its velocity vector accordingly. See table 2-1 for the pseudo code listing of how this works.

Particle Swarm Optimization

```
Create and initialize swarm
Repeat
    For each swarm member s
        Evaluate current position with Fitness Function
        If current position evaluation better than s best location position
            Update s best position to current position
        If current position evaluation better than global best location position
            Update global best position to current position
    End
    For each swarm member s
        Update current velocity and direction based on personal best and global best positions
        Update current position with current velocity and direction
    End
Until stopping condition is true
```

Table 2-1Particle Swarm Optimization Pseudo Code

Section 2.2: Ant Colonies

Ant Colony Optimization (ACO) is a population-based search algorithm based on the stigmergic communication between ants to find the quickest path to a food source[14]. Dorigo et. al. capitalized on the previous work of Deneubourg et al.[19] that documented how individual ants utilize pheromone deposit trails to affect the foraging behavior of other ants. The end result is the discovery of the shortest path to a food source.

An artificial ant stochastically chooses each step in the path that it takes to find food[20]. In the absence of any pheromone deposits (i.e. group knowledge), any possible next step (minus those already travelled) is equally probable. If deposits are present at a next step, the probability of choosing that step and getting on a food trail increases. Pheromone deposits are additive – other ants can leave additional pheromones at a step on top of existing ones. They also

subtractive – they dissipate over time and eventually vanish if no other ants deposit more. As pheromones increase due to higher traffic on a path, so does the probability that other ants will follow along. Conversely, as pheromones decrease due to lack of traffic on a path, other ants are free to explore alternate ones.

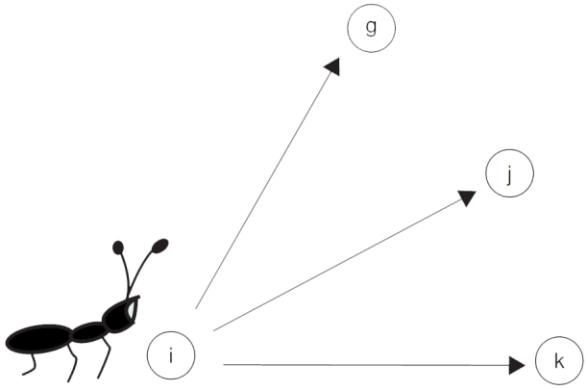

Figure 2-3An Artificial Ant Choosing the next "step" in its path to solve a problem

See table 2-2 for the pseudo code listing of how ACO works.

Ant Colony Optimization

Create and initialize ant colony, initialize pheromone trails
while termination condition not met **do**
ConstructAntSolutions /* each ant chooses it next step on solution path */
UpdatePhermones /* successful ants add them, bare trails remove them */
end while

Table 2-2 Ant Colony Optimization Pseudo Code

Section 2.3: Cultural Algorithms

The Cultural Algorithm (CAs) is an experimental framework that has been used to solve many problems [21-24]. It has been used to solve scheduling problems [25], constraint problems[26, 27], optimization problems [28-31] and even assisted archaeologists in extreme environments[32-36]. It is composed of two primary knowledge components: *Population Space*

and *Belief Space[37]*. The two form a symbiotic relationship where learning takes place as each continually updates and refines the other in an iterative fashion. The two components interact via an *Influence* and *Acceptance* communication channel. See figure 2-4 below for a high-level view of the two components within this framework. See table 2-3 for the CA pseudo-code.

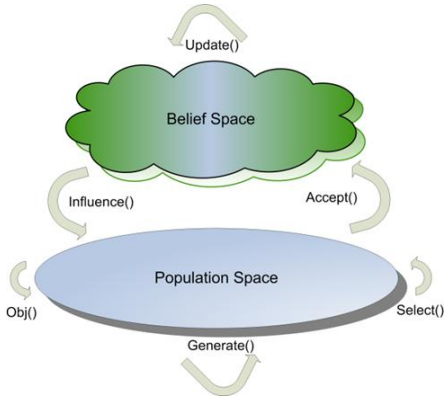

Figure 2-4Cultural Algorithm Framework

Pseudo-code of a Cultural Algorithm
Generate the initial population
Initialize the belief space
Evaluate the initial population
Repeat
Update the belief space via the Accept() function
Evaluate each Agent in the current population with Fitness Function
Select top agents based on Fitness
Until End Criteria

Table 2-3Cultural Algorithm Pseudo Code

Section 2.3.1: Population Space

The Population Space embodies a set of individuals. Collectively, they are given a problem or problems to solve. Each individual within the Population Space embodies experiential as well as procedural knowledge required to solve the problem at hand[2].

Section 2.3.2: Belief Space

In a general sense, culture can be defined as a cumulative deposit of knowledge, beliefs, experiences, notions of time, and spatial relations acquired by a group of people in the course of generations through individual and group striving[2]. For Cultural Algorithms (CAs), culture is defined as the knowledge source of data that influences the behavior of all individuals within its population. The knowledge sources have five knowledge designations: Normative, Situational, Domain, Historical, and Topographical.

Section 2.3.2.1: Normative Knowledge

Normative Knowledge represents the current best estimate of values that produce a good solution to the problem. It contains a list of attributes and the desirable range of values that each attribute can take. The upper and lower bound of each attribute is used to influence adjustments to individuals in the population space at each generation. These values are initialized at belief space creation and are continuously updated when superior individuals in the population are discovered.

Section 2.3.2.2: Situational Knowledge

Situational Knowledge is a list of the best individuals found at the end of each generation from the population space. Best individuals are evaluated using a Fitness Function that is applicable to the problem at hand. These individuals are used to influence the creation of the next generation. This is an improvement over randomly selecting individuals for reproduction utilized in traditional Evolutionary Algorithms.

Section 2.3.2.3: Domain Knowledge

Domain Knowledge is similar to Situational Knowledge in that it is a list of best individuals found in the evolutionary process. Again, best individuals are evaluated using a Fitness Function that is applicable to the problem at hand. The difference is that this list is not re-created at the end of each generation. Instead, this is a list of the best individuals overall since evolution began.

Section 2.3.2.4: Historical Knowledge

Historical Knowledge is a sequence of changes to the optimal solution to the problem over time. It is comprised of the current best solution to the problem. It also includes a measure of the directional change of each attribute of the current solution compared to the attributes of last best solution. Finally, it includes an overall measure of change in spatial distance between the current solutions in the search space to the last best solution position.

Section 2.3.2.5: Topographical Knowledge

Topographical Knowledge is a multi-dimensional grid of the problem's search space. Each cell in that grid tally's the frequency of individuals found so far. This helps direct evolution in two ways. First, it helps put focus on spatial location close to the best solutions in the problems search space. Second, it keeps the evolution from reaching local maxima by directing evolution (via mutation operations) towards previously unexplored areas of the search space.

Section 2.4: Conclusions

In this chapter the basic forms of Socially Motivated Computation were introduced. Since knowledge accumulated at the Cultural level can effectively reflect social activity at the

lower more detailed scales support by Ant Colony and Particle Swarm approaches, the approach taken here will focus on the Cultural Algorithms. This is because our virtual world can be viewed as a complex system such that hypothesized activities of interest can take place over a variety of scales. Thus, a mechanism such as Cultural Algorithms that supports the diversity of scales is necessary.

Chapter 3: I-CARE GAME DESIGN

In Chapter 1, it was demonstrated that only 35 percent of new RN graduates, regardless of educational preparation and credentials, meet entry expectations for clinical judgment[6]. Several possible causes for this problem included the qualifications of entering students[6], as well as inconsistent coaching practices[7]. Other possibilities included inadequate teaching paradigms for Digital Natives[8] and an emphasis on teaching content in nursing education curricula rather than the application of that knowledge[6]. The purpose of this thesis is to address the latter two possibilities.

Section 3.1: Proposed Method – A Haptic Virtual World

Generation X'ers embrace technology. They have already adopted new systems for communicating (instant message), sharing (blogs), socializing (chat room), meeting (3D worlds) and even learning (web surfing)[8]. Outside of school, they are fully engaged by their 21st century digital lives[8]. One means to gain that level of engagement in the classroom would be to adopt those same methods used outside of it[8]. Smart phones are the delivery mechanism of choice here – they are haptic in nature (i.e. they operate using the sense of touch and movement) and are ubiquitous (i.e. mobile and can be used in just about any place imaginable).

Section 3.2: Game Design

There are two styles of game development[38]. The first is carefully planned schedule driven design supported by the One Pager and the Game Design Documents that are discussed in section 3.2. The second is an organic design, which is basically a trial-and-error, bottom-up approach to game design to see what "works." The I-CARE application has aspects of both design methodologies.

Section 3.2.1: The One Pager

The One Pager is the attention grabber which is used to instill interest in the game. It is the elevator pitch of the game that discusses elements such as Title, Genre, Target Platform, and Unique Selling point.

Section 3.2.1.1: Title and Genre

The title of the game is Integrative Care of Children and Families (I-Care). I-Care is a 2nd Person 2.5D Educational Puzzle game. It encapsulates a virtual world that integrates several perceptual modes (i.e. visual, auditory, and haptic)

Section 3.2.1.2: Target Platform

I-Care is developed for a Windows Phone 7 platform utilizing XNA 4.0 technology. XNA 4.0 has the benefit of cross-platform carry-over to Windows 7 PC as well as the Xbox 360 with a minimal amount of code change. This creates a development environment ideal for branching into multiple segments. Moreover, the PC counterpart will be useful for the demonstration of product functionality either in a lecture, or in a training capacity.

Section 3.2.1.3: Target Market and Rating

Pediatric Nursing is rated Everyone 10+. Normally, the Everyone 10+ game rating could be an indicator for a Target Market –in this case, anyone that is at least 10 years of age. And although the word “Pediatrics” might reinforce that notion, the Target Market for Pediatric Nursing is different, however. In this case, the Target Market would be any Nursing Student that would like to supplement his/her lab experience with the hope of passing clinical training. The definition for Everyone 10+ is taken directly from the ESRB site and is as follows:

	Contains content that might be considered suitable for children 10 years of age and up. The content is mild to fairly moderate in impact. Games in this category may contain minimal cartoon, fantasy, violence, language, animated blood and/or minimal suggestive themes. The ESRB distributed this rating on October 1, 2004.

Table 3-1: Definition of Everyone 10+ Game Rating

Section 3.2.1.4: Premise

Think about the classic Clue board game. That game involves solving a murder mystery utilizing character interaction and discovery / observation of objects within a given room. I-CARE is similar except this game involves determining a Medical Diagnosis utilizing patient interaction (i.e. character dialogue), and accessing various rooms (i.e. Class Room, Equipment, Patient, Medical Supplies, etc.) in order to perform Medical Diagnostic task.

Section 3.2.1.5: Player Motivation

In order to win the Game, the Nursing Student visits all available rooms and makes a final diagnosis. While visiting each room, he/she accumulates badges that are necessary to move between the rooms. For example, in order to even make it into the Patient Room, the player must have first visited the Equipment Room and gathered the necessary supplies (i.e. medical gloves, thermometer, stethoscope, etc.) to perform the Medical Orders at hand -- the Equipment Room badge is gained once that criterion has been met.

Section 3.2.2: Game Design Document

The Game Design Document is the blue print to game development. There are many elements to this document including Key Design Elements, Game World Dimensions, Core Game Mechanics, Hierarchy of Challenges, Input Devices, and finally the User Interface[38]. As stated in Section 3.2, the development of the I-CARE application has both elements of

structured and organic methodologies. To this end, only those sections of the Game Design Document are included in this thesis.

Section 3.2.2.1: Key Design Elements

Like many games, I-CARE contains many high-level concepts called Key Design Elements[38]. Fundamentally speaking, documenting these concepts establishes the scope of the game. Moreover, this list serves as a basis for milestones that dictate the direction and corresponding flow of game development itself. The key design elements for I-CARE starts with the following case illustration:

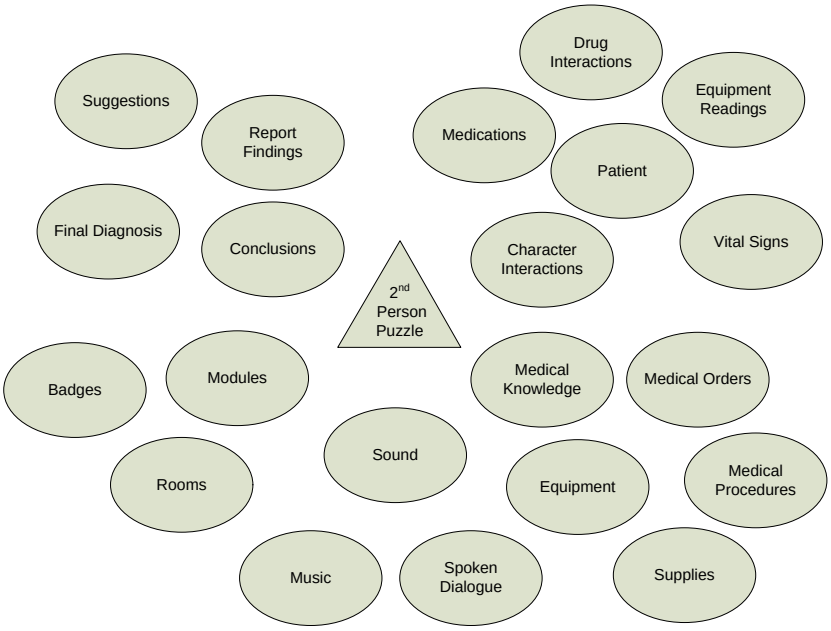

Figure 3-1: Key Design Elements

The triangle in the middle represents the I-Care game itself and describes the game's genre. The ellipses represent concepts that describe content that I-Care provides. The location and proximity of the ellipses to the game (i.e. the triangle) as well as to each other (i.e. other ellipses) indicates not only relative importance within the game, but also implicitly defines hierarchy within the game framework. For example, Medical Knowledge, Sound, Modules,

Conclusions, and Character Interactions comprise the highest level of detail about functionality contained within I-Care (Figure 3-2). Contrast that with more detailed functionality that Medical Knowledge contains in terms of Medical Orders, Equipment, Medical Procedures, and Supplies.

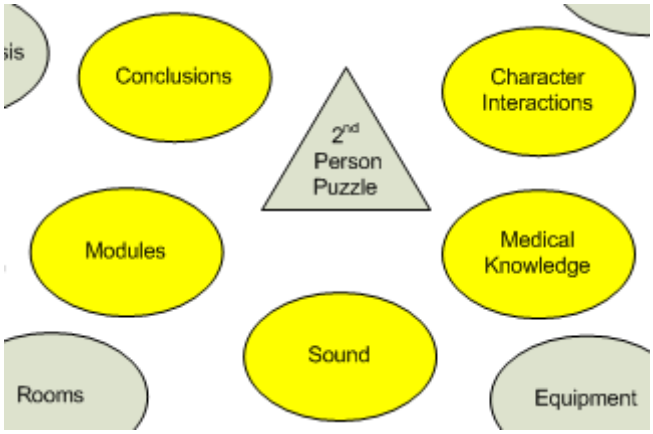

Figure 3-2Higher Levels of Functionality

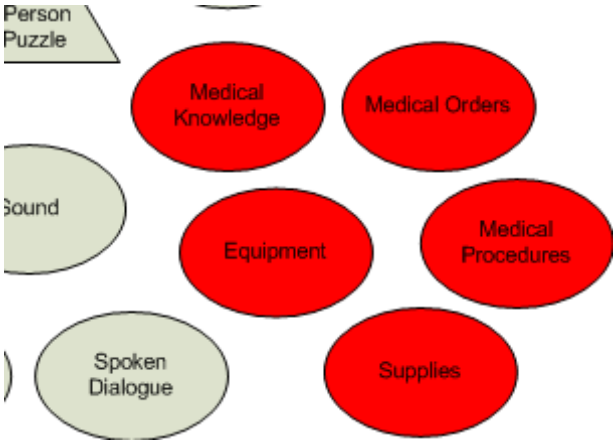

Figure 3-3Lower Levels of Functionality

Section 3.2.2.2: Games versions

For its initial release, I-CARE offers a single game version referred to as a Module. In this case, the Upper Respiratory Module educates a player on the process of diagnosing upper respiratory problems and administering an Albuterol treatment as a solution. This Challenge module was selected since Upper respiratory illnesses are the leading cause of pediatric fatalities.

This module starts with patient triage and virtual classroom instruction. It continues with medication and equipment selection, and ends with actual patient interaction. Patient interaction includes a discourse directly with the patient and even taking vital signs along with assessing the patients' lung function. The ultimate goal is to describe a framework which allows the player to learn the correct thought-process and execute the proper nursing protocols to carry out any prescribed medical order.

The Upper Respiratory Module also allows the player to navigate the virtual game world Pediatric Nursing symbolizes. For starters, the player is able to receive actual classroom instruction through pre-recorded laboratory exercises, explore various rooms, and even explore objects within (i.e. triage information, labs, supplies, medication worksheets, etc.). Moreover, the player is able to practice with a patient within a room not only in terms of scripted dialogue, but also with the administration of a medical order -- physical assessment included. The module also allows for the practice of washing hands and documenting findings in the Medical Record. Finally, the player can evaluate the module content and provide any feedback to the I-CARE Development Team.

Section 3.2.2.3: Define the Game

In the development of a game, it is important to identify the Game Genre that it belongs to. This will make it easier to identify the expectations of the target audience. Pediatric Nursing has already been compared to the game Clue that can be viewed as an adventure style game. That in itself provides some connotation of room exploration and clue gathering. There is additional information in regard to the rooms themselves as well as information gathering / tasks that can occur within. To this end, a sample description of game play follows.

Welcome to Pediatric Nursing – Upper Respiratory Module. Meet Zori. She's having some trouble breathing and was admitted into Children's Hospital this afternoon. According to the triage report, she's 10 years old with an acute asthmatic exacerbation of unknown origin. You should start by reading the rest of the report to obtain other information such as any pertinent medical history, her current physical examination results, and determine what medical orders you should execute as part of the medical treatment prescribed by Dr. Sara Jones.

A Narrator guides the game play as the Pediatric Nursing Student explores this virtual world. For example, "*Introduce yourself to Zori*" at the game opening. You can hear some of Zori's responses to questions about her current condition. One of Zori's dialogued scripts includes such phrases such as *"I got a new puppy, and now I don't feel so good."* Moreover, you can hear about any environmental conditions that might be a contributing factor(s) for that condition. Now let's begin our journey toward providing medical treatment.

"Being a Nursing Student, you should get some formal instruction on how to administer those prescribed medical orders. It might be helpful to enter the classroom. There you will be able to view any pre-recorded lecture materials that discuss Upper Respiratory problems for Asthmatics and even how to treat common problems. You will learn medical terminology, tips on medication, and about any equipment or supplies needed to treat such a patient. Finally, you can then show-off your new knowledge by taking some proficiency measuring quizzes that highlight the important concepts from the video(s).

You now have enough knowledge to put the module goals into play. You might want to enter the medical records room. Here you would be able to see any labs and get an idea of blood count differentials to watch for signs of infection or blood oxygen saturation. You could find

information from previous hospital admissions to find any pattern to this admission. Next you might enter the Equipment or even the Medications Rooms to pick-up the items required to perform the prescribed medical orders for our patient. Make sure that you fill out any worksheets to help with medication dosages. Finally, make sure to take items that you need – no more, and no less.

Finally, let's go back to Zori's room and perform the tasks at hand. Remember to follow Nursing Protocol Standards such as washing your hands, checking IV fluid levels, as well as monitoring current vital signs. You will also have a chance to show off your method towards proper lung function. Zori will be sure to give you any appropriate feedback while you are performing your task(s).

Section 3.2.2.4: Game Rendering

Pediatric Nursing is a game that takes place in a generic Children's Hospital Ward. In order to help immerse the player in the game, along the hospital corridors the player can see walls decorated with fresh, hand-painted artwork of its patients. In this fictional hospital, there are several rooms, each associated with different learning tasks or proficiency measuring opportunities. The rooms and their corresponding functions are summarized in the following table:

Room	Task
Reports Room	Player reviews data from triage for the current hospital visit. Player also receives the Medical Order(s) for the module.
Classroom	Player receives virtual classroom instruction. Player also measures proficiency through various quizzes which are Visual, Audio, and Textual in nature.
Medical Records Room	Player reviews data from previous hospital admissions.
Medications Room	Player gathers all Medications needed to perform Medical Orders Task(s). This includes filling out any corresponding dosage calculation worksheets.
Equipment / Supplies Room	Player gathers all equipment needed to perform Medical Orders Task(s).
Patient Room	Player provides patient care following Nursing Protocols.
Evaluation Room	Player evaluates various aspects of the game on a scale of 1 (poor) to 5 (excellent).
Feedback Room	Player creates / sends an email addressed to the Pediatric Nursing Development Team. The email body content is filled with the player's thoughts on game play, content, or any other suggestions.
Help Room	Player views help topics for the current room.

Table 3-2: Pediatric Nursing Room Inventory

Section 3.2.2.5: User Interactions

There are really two interactions for this game. One is player initiated (i.e. the Pediatric Nursing Student) and the other is patient initiated via the Patients Artificial Intelligence. The Pediatric Nursing Student interaction can be divided into three sections as shown in the UML diagram below:

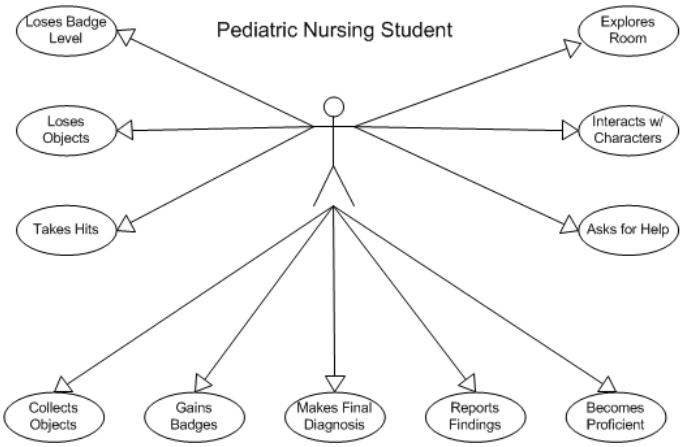

Figure 3-4: Student Interactions UML

In figure 3-4, Player Actions are listed to the right and include both learning and proficiency tasks. Positive player interactions are listed on the bottom and occur through successful room navigation. Negative player interactions are listed to the left and occur through non-compliant actions (based on Nursing Protocols).

Patient interaction is given in two forms. The first is scripted dialogue statements in response to Player questions (i.e. what's your name?) as well as in response to any treatment (i.e. responding to a cold stethoscope). The second is in regard to receiving treatment (i.e. visual clues for stethoscope placement). Please refer to the UML diagram below:

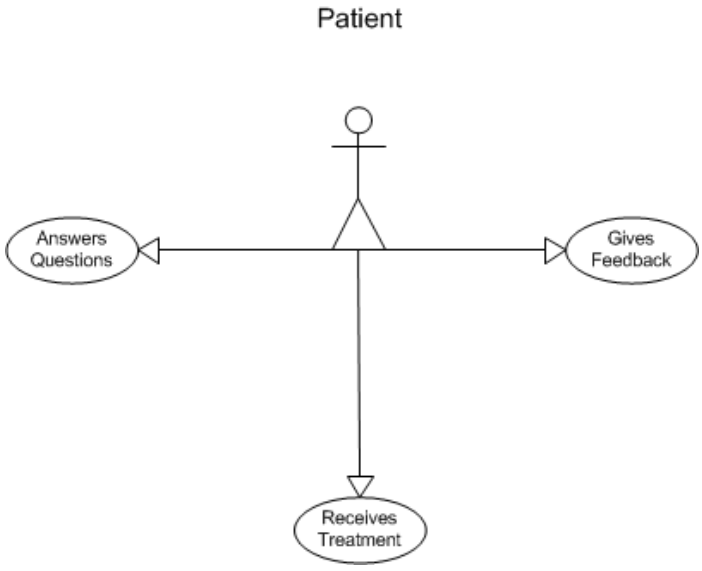

Figure 3-5: Patient Interactions UML

Section 3.2.2.6: Hierarchy of Challenges

For many games, the player faces several challenges at a time, which are organized in a hierarchy of challenges[38]. In order to win the game, the player must finish the challenges provided. Figure 3-6 shows all of the challenges that the I-CARE application provides.

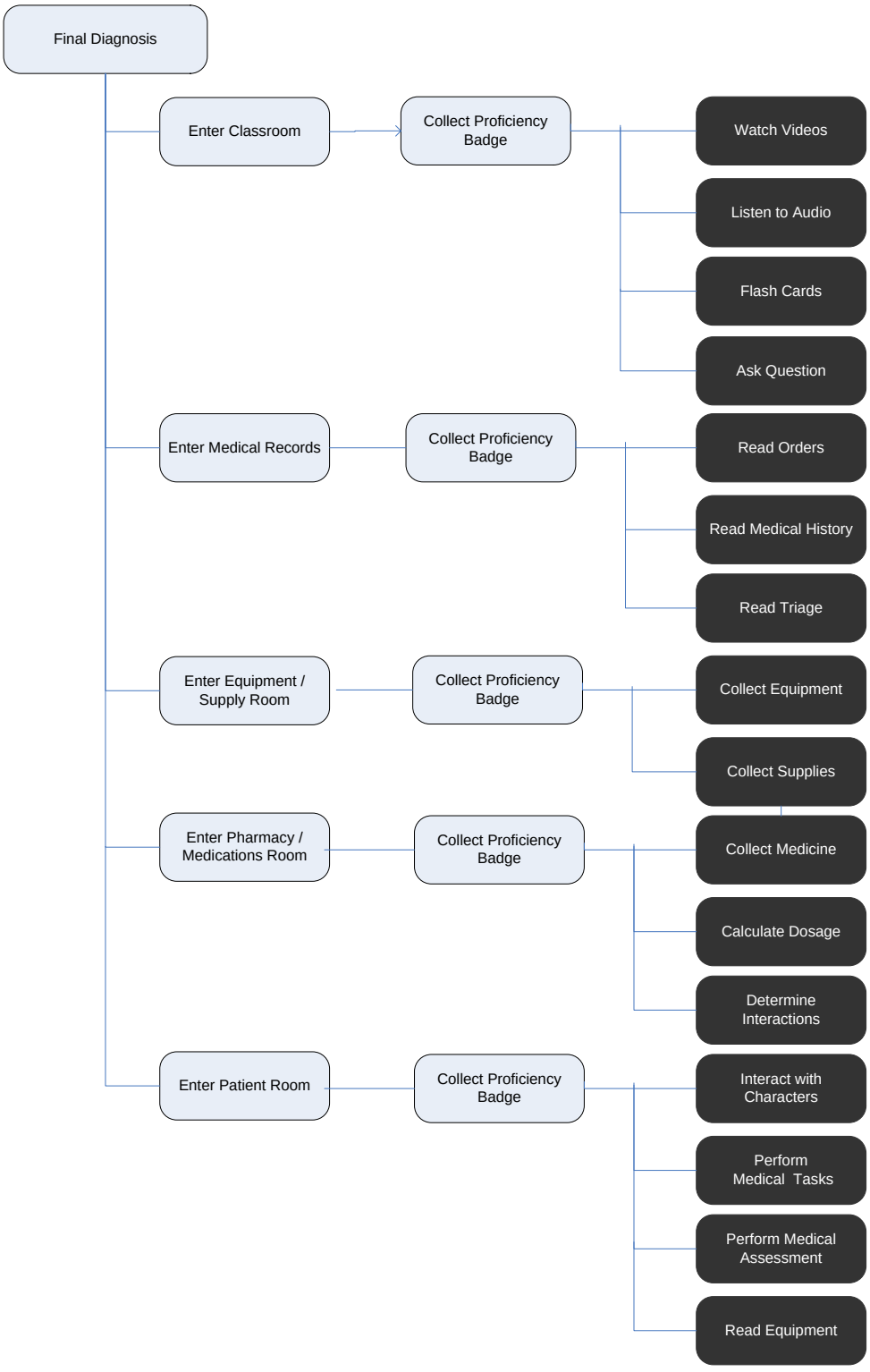

Figure 3-6 I-CARE Hierarchy of Challenges

Section 3.2.2.7: Controller

Windows Phones do not typically come with keyboard or mouse peripherals like those that come standard with a PC. There are "other" methods that are employed to achieve similar functionality, however. As a result, the controller for this game is the Windows Phone 7 gesture ensemble. The list of possible gesture movements are defined by Microsoft in the table 3-3.

Gesture Type	Description
Tap	A finger touches the screen and releases.
Double Tap	This gesture represents two taps in succession.
Hold	A finger touches the screen and holds it in place for a brief period of time.
Free Drag	A finger touches the screen and moves in any direction.
Vertical Drag	A finger touches the screen and moves in an up or down direction.
Horizontal Drag	A finger touches the screen and moves in a left or right direction.
Drag Complete	Marks the end of a Free Drag, Vertical Drag, or Horizontal Drag gesture.
Flick	A finger drags across the screen and is lifted up without stopping.
Pinch	Two fingers press on the screen and move around.
Pinch Complete	This gesture marks the end of a Pinch gesture.

Table 3-3: Windows Phone 7 Gesture Descriptions

It should be noted that NOT every Gesture Type is used in the I-CARE Game.

Section 3.3: Conclusions

In this chapter an overview of the software design of the game was presented. However, there are many ways by which to implement the design. The subsequent chapter gives a detailed description of the implementation developed here. One of the keys in the implementation here was to support the easy integration of social learning tools such as Cultural Algorithms and Social Media into the framework.

Chapter 4: I-CARE GAME IMPLEMENTATION MODULE

In Chapter 3, the blue prints to the Pediatric Nursing Game (I-CARE) were drawn up. The use of both structured and organic design processes together produced the Virtual Children's hospital I-CARE Game where Pediatric Nursing Students can practice providing quality medical care as they develop their critical thinking skills. The application has been accepted for demonstration in poster presentations[39, 40].

Section 4.1: Screen Shots and Descriptions

The goal of this section is to share glimpses of the Children's Hospital world by providing a virtual tour. Section 4.2 will then put these pieces into contextual perspective.

Section 4.1.1: Opening Screen

The Pediatric Nursing Opening Screen represents the warm feelings of "Welcome" and "Please Enter". Pediatric Nursing Students come from all walks of life and the image collage shown parallels that diversity.

Figure 4-1: Pediatric Nursing Opening Screen

Section 4.1.2: Splash Screen

The Splash screen to I-CARE depicts the entrance to the Children's Hospital. As can be seen, this fictional Children's Hospital has chosen to adorn its wall's with freshly-drawn patient art work. Imagine the doors sliding open while the Pediatric Nursing 5.0 theme song plays.

Figure 4-2: Pediatric Nursing Splash Screen

Section 4.1.3: Main Screen

This is the main menu to the Pediatric Nursing Application – it is the central hub of the game.

Figure 4-3: Pediatric Nursing Main Screen

This screen has several elements that come together to give this room a flair for realism. First, notice a focal point picture of the Patient (her name is Zori) that aims to remind the Student that this is a child in need – a very realistic admission wrist band just underneath reinforces that notion. Next, see an audio speaker button next to Zori where the Student can actually hear Zori's point of view on the whole ordeal. Finally, when this screen first appears, a narrator gives an audio description of this module as described earlier and asks the Student to begin by reading the triage report (top report button to the right of Zori).

At this juncture, it's up to the student to decide where to go and what to do next. For example, she/he can explore the various rooms (i.e. the top four icons to the right). She could decide to evaluate the Pediatric Nursing game (via the evaluation icon) or even to provide feedback to the game development team (via the Feedback icon at the very bottom right).

Finally, if there are any further questions, the Student can touch the '?' icon at the bottom of the screen to view a Help Screen.

Figure 4-4Main Menu Navigation Choices

Section 4.1.4: Report Room

This is the Report Room where triage information collected at admission can be reviewed. The main screen element is an actual .pdf image of a Triage Report. Even summarized, the information displayed is quite extensive. There could be additional content as time goes on – this leaves the problem of reading a report with tiny print on an already cramped phone screen. To this end, gestures touches come into play (see part on Controller in Chapter 3, Section 1). The Student has already gotten here using the 'Tap' Gesture. Now she can use the 'Pinch' gesture to expand the report and make the text larger. Afterwards, she can utilize either a Vertical or a Horizontal Drags in order to move the elongated report to zone in on other parts of the report.

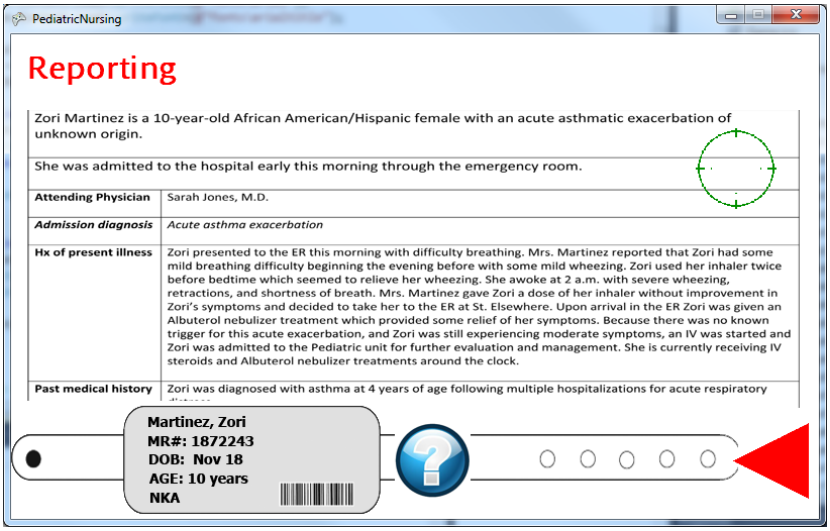

Figure 4-5: Pediatric Nursing Report Room

Finally, just like other rooms throughout the game world, this one has elements to assist the Student in keeping her bearings. A Title Bar shows the current location. There is also a Footer Bar that provides information about the current patient along with access to a Help room. The 'Red Left Arrow' button is used to return to the previous location.

Section 4.1.5: Classroom

This is the Classroom where Students receive Upper Respiratory Module material instruction. This is the main hub into all module content and supporting video, reading materials, as well as listening exercises for lung function diagnosis sounds.

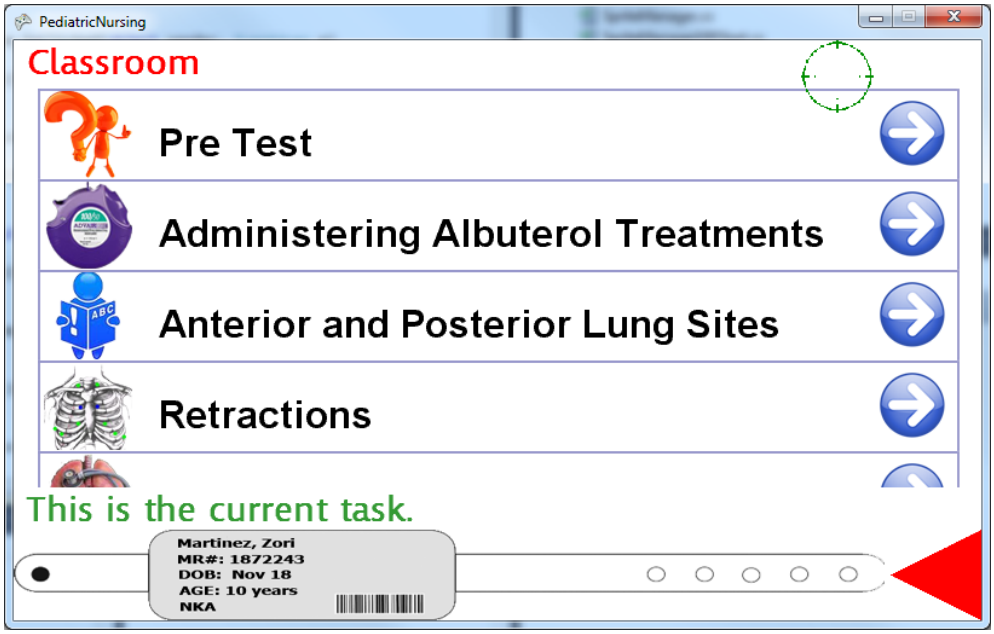

Figure 4-6: Pediatric Nursing Classroom

Section 4.1.5.1: Class Room Pre-Test

The Class Room Pre-Test screen provides a method to assess the Pediatric Nursing Student's existing knowledge of the Upper Respiratory Module content. The student simply uses the blue "right arrow" buttons to answer the pre-test questions. These answers are presented in the form of multiple choices. The available choices can be single- (i.e. 1 only) or multiple-choice (i.e. all that apply) in nature.

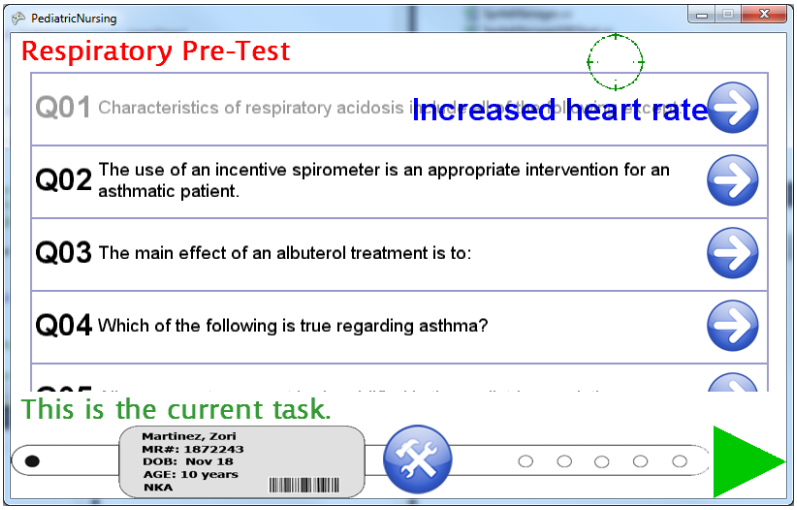

Figure 4-7Respiratory Pre-Test showing answer to Q01

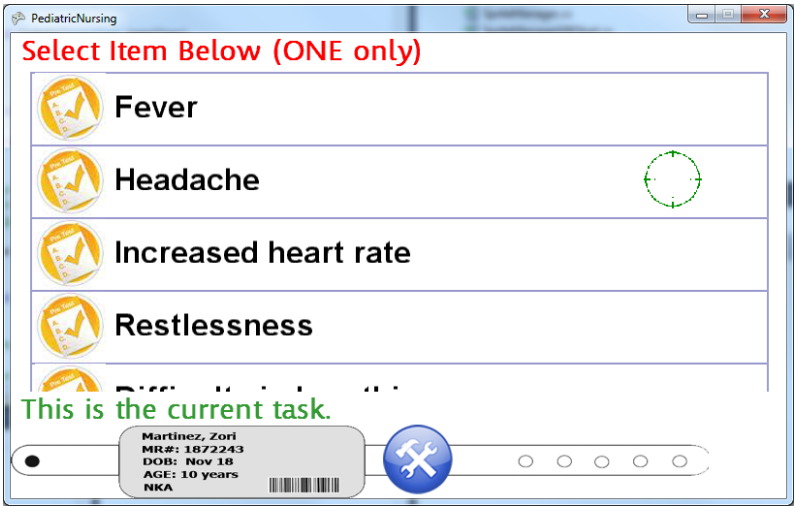

Figure 4-8Respiratory Pre-Test Q01 Multiple Choices

Section 4.1.5.2: Classroom Administering Albuterol Video

The Administering Albuterol section of the classroom has two components. The first is a video of an actual laboratory instructional session on administering albuterol treatments. The presented video provides a demo of the tasks required, but also showcases the critical thinking that supports each of those steps. The second is a multiple-choice quiz that assesses retention of video content. Student answers to the quiz questions are securely stored on the mobile device for subsequent analysis.

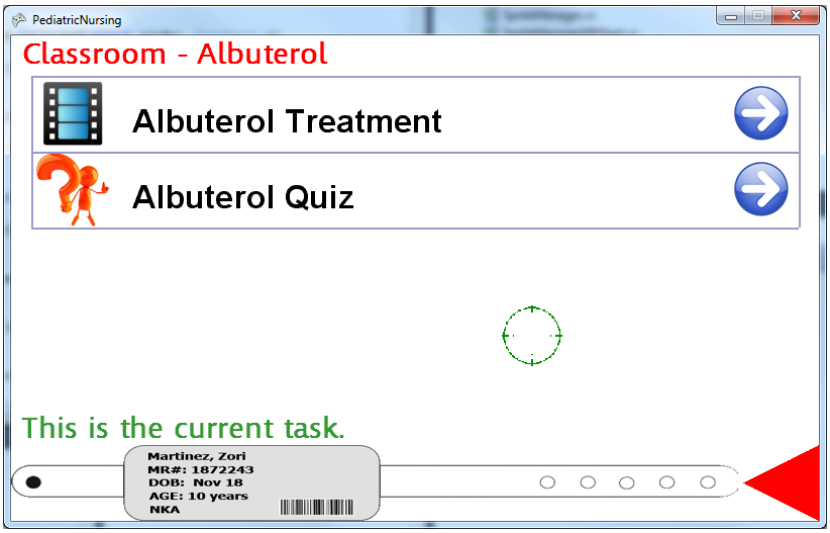

Figure 4-9Administering Albuterol Component List

While watching the video, the Student is presented with standard control buttons that allow for 'Pause', 'Stop', and 'Rewind' features (note: the Windows version shown here does not have this functionality). This allows the student to recover from any interruptions as well as to utilize instant replay of a segment as many times as necessary for her to understand. See Figure 4-10 below for an illustration showing the first frame of that video.

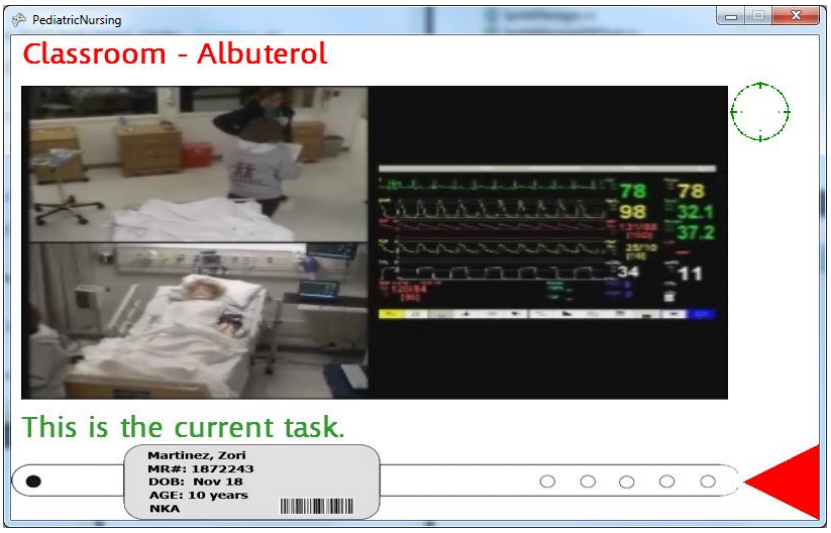

Figure 4-10: Administering Albuterol Video

The Albuterol Treatment True/False Quiz provides a method to assess just how much knowledge that the student was able to absorb from watching the corresponding video. The Student is presented several questions that are true or false in nature. The student simply clicks on the blue "Check" button to indicate "True". Conversely, the student clicks on the blue "X" button to indicate "False."

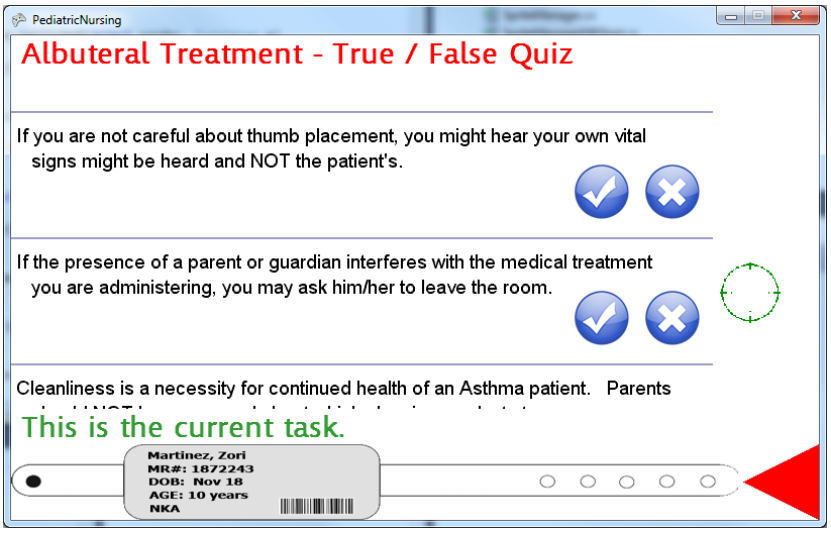

Figure 4-11Administering Albuterol Video Quiz

Section 4.1.5.3: Classroom Retractions

The Classroom-Retractions section has three components. The first is a visual flash card that provides the physical imagery of where one might find retractions. The second is a set of videos that showcase live demonstrations of not only what these retractions look like, but how they sound. Finally, the third is a flash card quiz to stimulate memorization of the retraction locations.

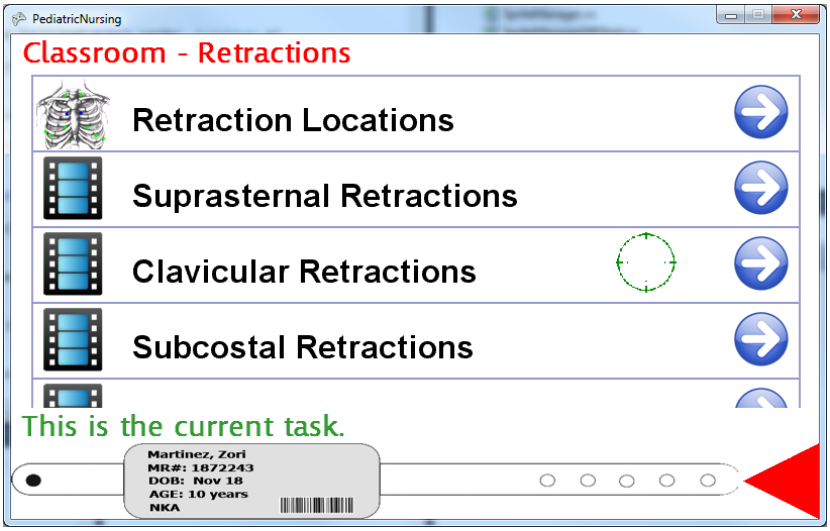

Figure 4-12Retractions Section Component List

When the student enters the visual flash card section, she is presented with an illustration of a human rib cage with the retraction location highlighted in blue. The name of the retraction location is highlighted in green text. To maneuver through all retraction locations, the student uses the "vertical drag" haptic gesture. See figure 4-13 for how this looks.

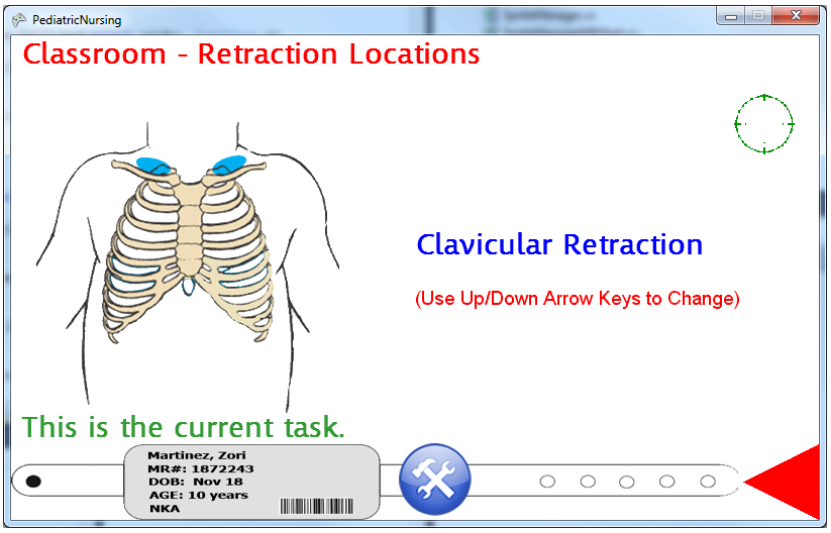

Figure 4-13Retraction Location Visual Flash Cards

Simply knowing the locations of retraction is not enough. Live videos of each type of retraction are also provided. Just like with the Administering Albuterol vide, the Student is presented with standard control buttons that allow for 'Pause', 'Stop', and 'Rewind' features (note: the Windows version shown here does not have this functionality). This allows the student to utilize instant replay of a segment as many times as necessary for her to understand.

Figure 4-14Suprasternal Retractions in Action

Section 4.1.5.4: Classroom Retractions - Visual Quiz

Here the Student is quizzed using a flash card paradigm. A randomly highlighted retraction location structure is displayed and the student must identify. The student uses a vertical drag gesture to switch between the available structures. She then taps on the blue arrow button to make her suggestion (See figure down below).

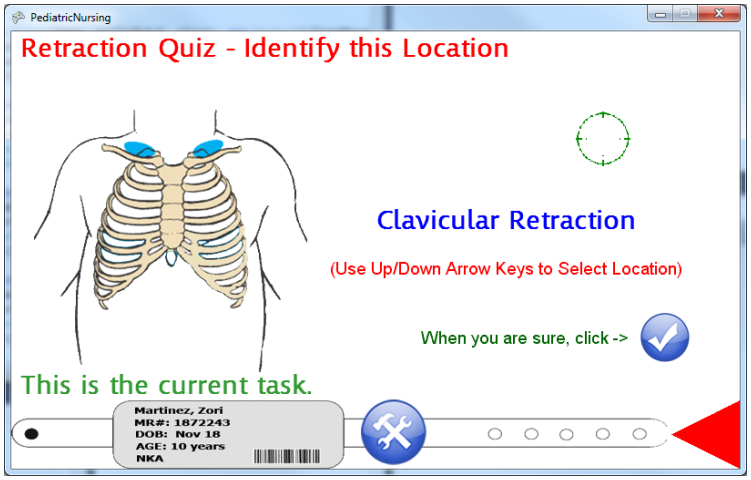

Figure 4-15: Retractions - Visual Quiz

Afterwards, a blinking notification is displayed indicated "Correct" or "Incorrect". See figure 4-16 for an example of a correct identification.

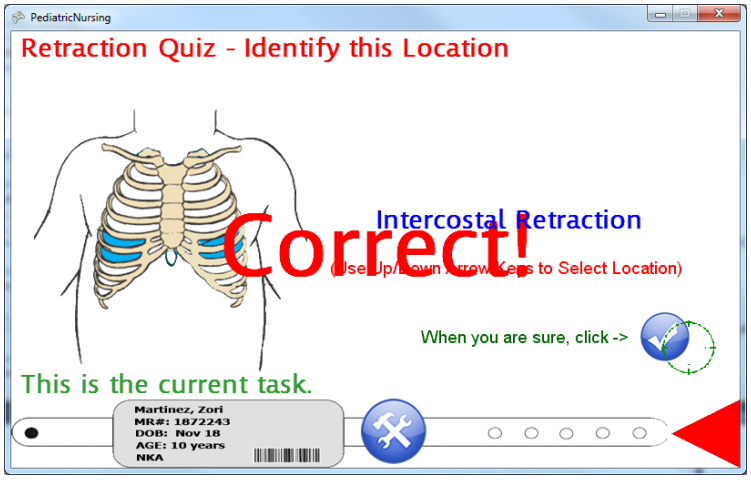

Figure 4-16Pediatric Nursing Classroom - Visual Quiz Answer

Section 4.1.5.5: Classroom Lung Sounds

The Classroom Lung Sounds section has two components. The first is an audio flash card that provides sound clips of various lung sounds. There is also reading material describing the lung sounds. The second is a set of audio flash cards to help retain this auditory information.

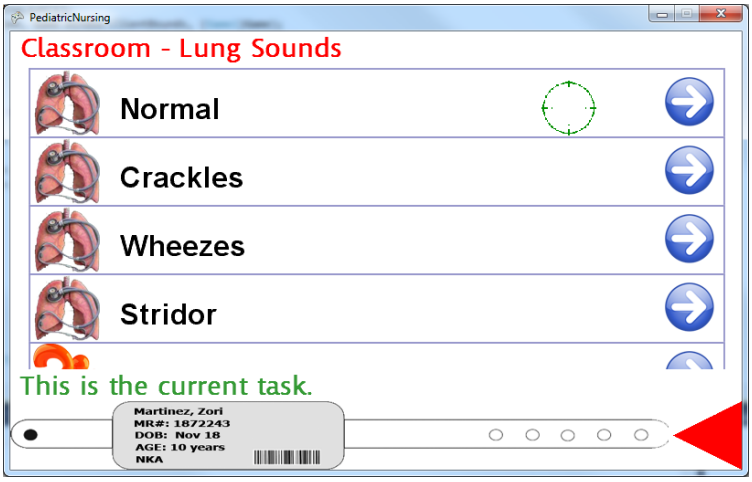

Figure 4-17Lung Sounds component list

The student is able to use pinch and vertical drag gestures to maneuver the reading material. See figure 4-13 for how this looks.

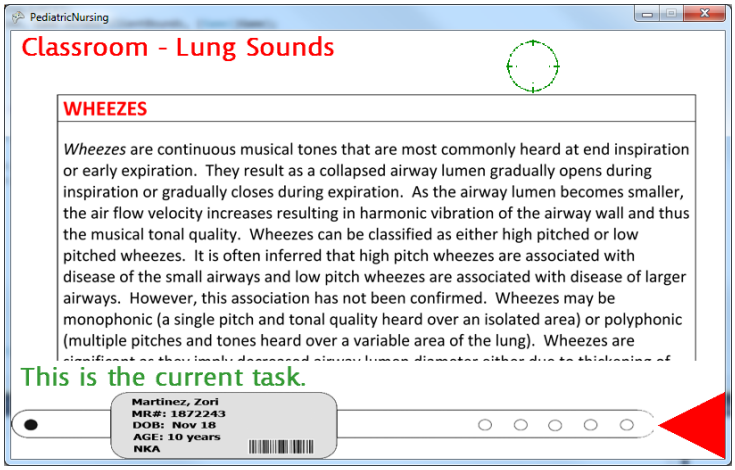

Figure 4-18Lung Sounds Reading Materials

Section 4.1.5.6: Classroom Lung Sounds - Audio Quiz

This where the Student is quizzed using a flash card paradigm. A randomly selected lung sound is played and the student must identify that sound using a drag gesture. The student uses a vertical drag gesture to switch between the available lung sound choices. She then taps on the blue arrow button to make her suggestion (See figure down below).

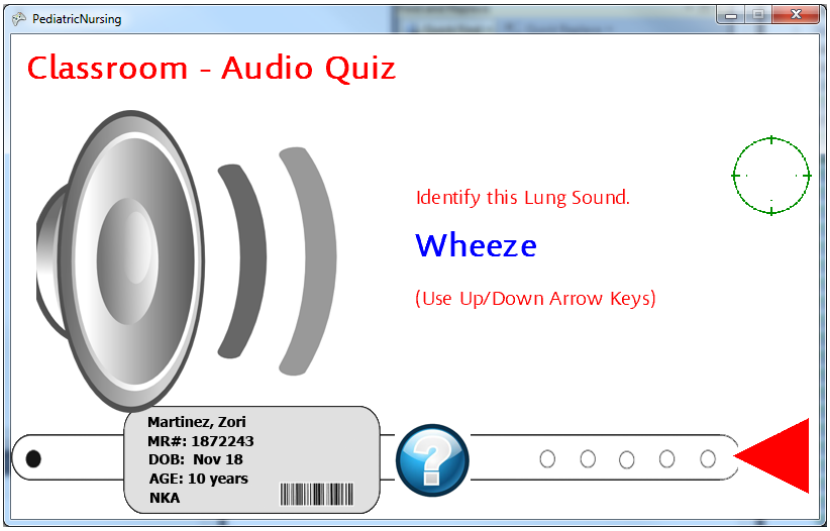

Figure 4-19: Pediatric Nursing Classroom - Audio Quiz

Section 4.1.6: Medical Records Room

This is where a Student goes in order to review detailed patient history from previous visits / admissions. Teacher Narration is heard the first time this room is entered. The Student is informed about the list of Medical Records Sections (i.e. the list starts with the "Labs" section). The Student is then directed to use the 'Tap' gesture on the 'Right Blue Arrow' buttons to drill-in to the Medical Records area of interest. See figure 4-21 below for a screen shot of this room.

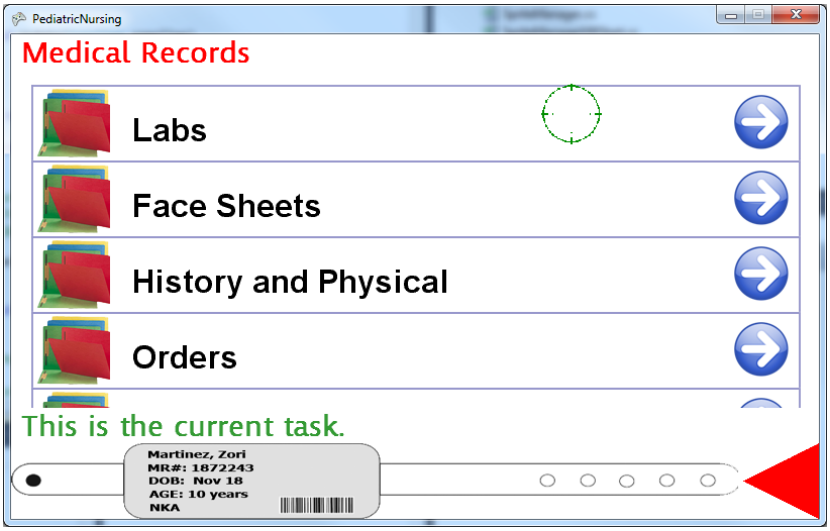

Figure 4-20: Medical Records Room List Components

For this module, the only area that is currently functional is the Labs section (see the next section for information on that section). Provisions have been made for the additional of many areas other including: Face Sheets, History and Physical, Orders, Progress Notes, Nursing Data, Consultation, Nursing Assessment, and finally Discharge Planning or Patient Education. To view the rest of the list, the Student can utilize the Vertical Drag Gesture (see part on Controller in Chapter 3, Section1) to scroll up/down the list.

Section 4.1.7: Medical Records Room - Lab Section

This is where a Student can go to read Laboratory Test Results -- in this case, blood differentials. See figure 4-22 below.

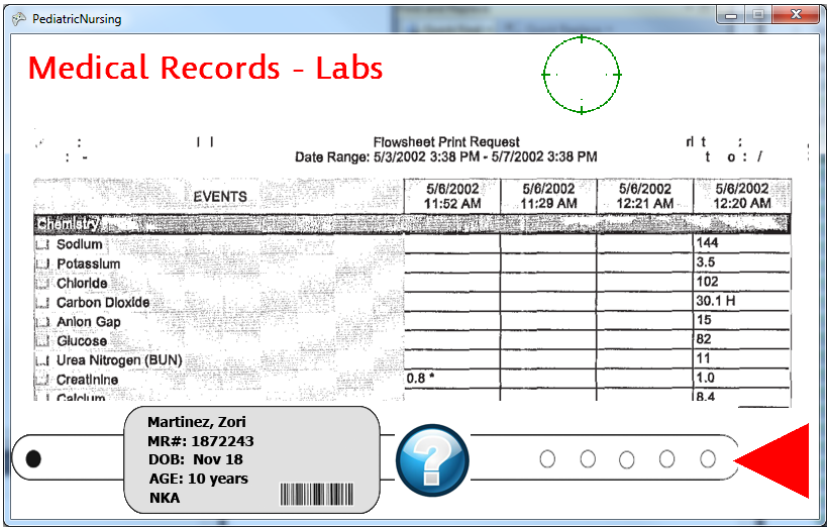

Figure 4-21: Pediatric Nursing Medical Records Room - Lab Section

The main screen element is an actual .pdf image of a Lab Results Report – it's very similar to those in the Report Room. Although presented in summarized form the information that is displayed is quite extensive. There can be additional content as time goes on – this leaves the problem of reading test results with tiny print on an already cramped phone screen. To this end, gestures touches come into play. The Student has already gotten here using the 'Tap' Gesture. Now she can use the 'Pinch' gesture to expand the test results report and make the text larger. Afterwards, she can utilize either a Vertical or a Horizontal Drags in order to move the elongated report to zone in on other parts of the report.

Section 4.1.8: Equipment Room

This is the room where Students come to get equipment / supplies needed to carry out the Medical Orders specified in the Reports Triage Room. See figure below for a sample of what this room looks like.

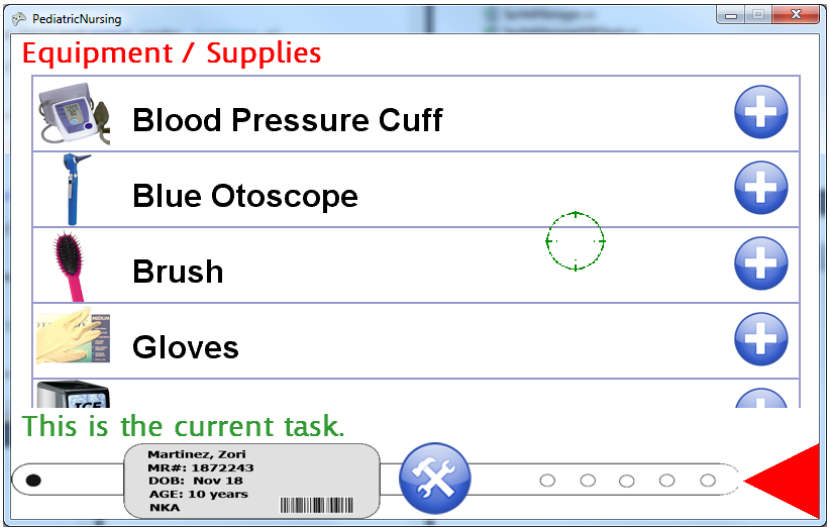

Figure 4-22: Pediatric Nursing Equipment Room

A Teacher Narration is heard the first time this room is entered. Students are directed to scroll through the list of items and then tap on the plus icon to add that item to her Nursing Back Pack. The student is warned to only take items that are needed. For this module, the stethoscope is the item that should be added to the Nursing Back Pack. To do this, the Student must use the Vertical Drag Gesture to scroll up/down through the list. Once there, the Student should tap on the Selection Icon. At this point the Student can tap on the 'Red Left Arrow' button to return to the Main Menu.

Section 4.1.9: Medications Room

This is the room where Students go to get the medications needed to carry out the Medical Orders specified in the Reports Triage Room.

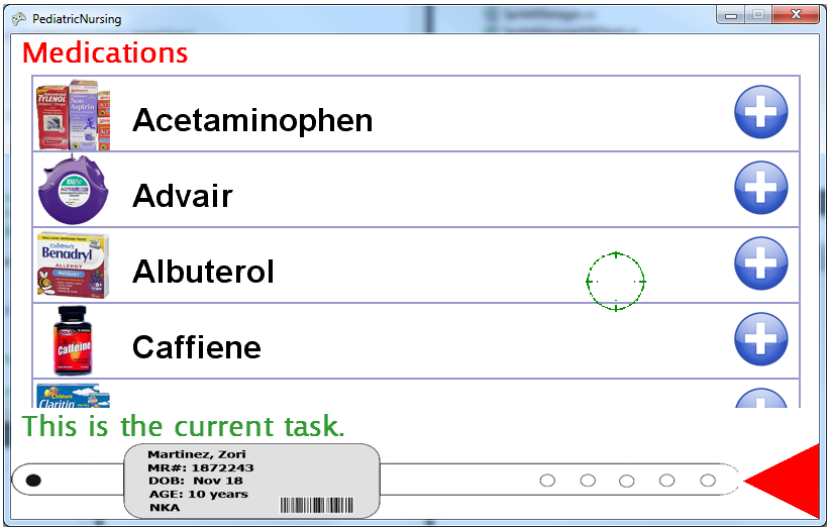

Figure 4-23: Pediatric Nursing Medications Room

Again, a Teacher Narration is heard the first time this room is entered. Students are directed to scroll through the list of medications and then tap on the plus icon to add that medication to her Nursing Back Pack. The student is warned to only take items that are needed. For this module, Ibuprofen is the item that should be added to the Nursing Back Pack. To do this, the Student must use the Vertical Drag Gesture (see part on Controller in Chapter 3, Section1) to scroll up/down through the list. Once there, the Student should tap on the Selection Icon. At this point the Student should tap on the Worksheet Room to fill out the dosage calculation worksheet for this medication. The student will lose evaluation points if extra items are taken.

Section 4.1.9.1: Medications – Worksheets

This is the room where Students come to fill out dosage requirements and adverse effect checklists for a medication.

Figure 4-24: Pediatric Nursing Medications - Worksheets

As before, a Teacher Narration is heard the first time this room is entered. Students are directed to scroll through the list of medications and then tap on the plus icon to fill out a worksheet for any medications in her Nursing Back Pack. For this module, the Ibuprofen Worksheet is the item that should be selected. To do this, the Student must use the Vertical Drag Gesture (see part on Controller in Chapter 3, Section1) to scroll up/down through the list. Once there, the Student should tap on the Selection Icon. At this point the Student should tap on the Worksheet Room to fill out the dosage calculation worksheet for this medication.

Section 4.1.9.2: Medications – Worksheets - Ibuprofen

This is where the student fill-out medication worksheets for dosage amounts which also serve as a checklist for any potential adverse reactions. See figure below for an example of what this room looks like.

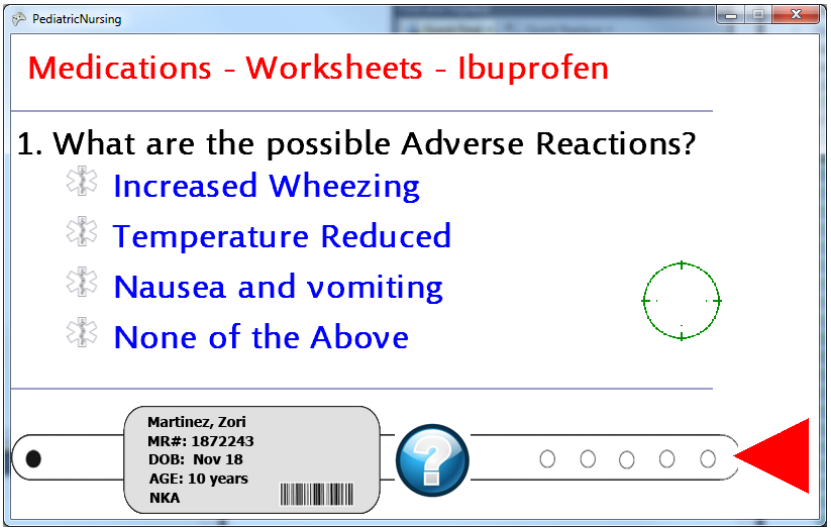

Figure 4-25: Pediatric Nursing Medications - Worksheets - Ibuprofen

Section 4.1.10: Evaluation Room

The Evaluation Room provides a method to assess the effectiveness of the I-CARE Upper Respiratory Module. The student simply uses the blue "right arrow" buttons to answer the evaluation questions. These answers are presented in the form of multiple choices. The multiple choices can be single- (i.e. 1 only) or multi-choice (i.e. all that apply) in nature.

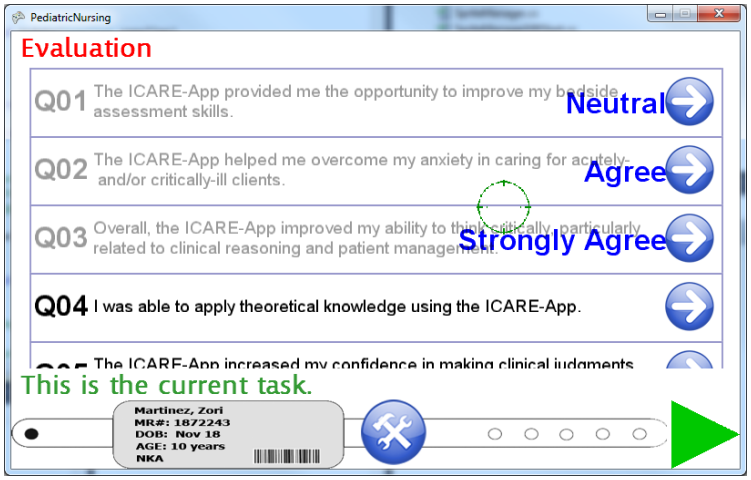

Figure 4-26: Pediatric Nursing Evaluation Room

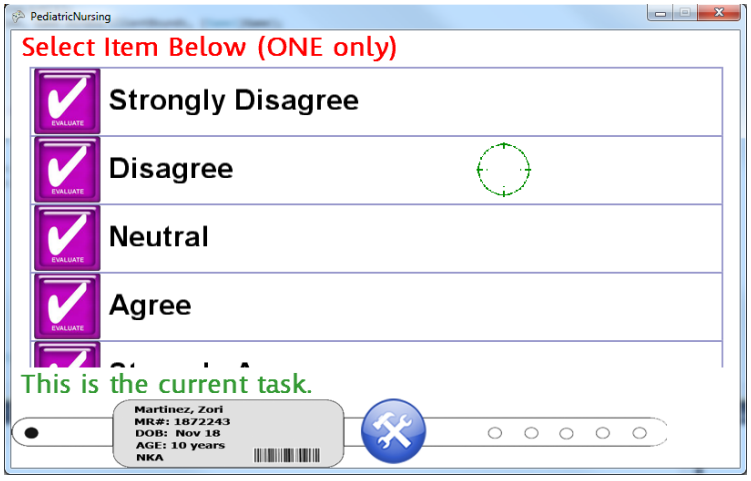

Figure 4-278EvaluationQ01 Multiple Choices

Section 4.1.11: Patient Room

This is the Patient Room. This is the place where the student has the opportunity to practice administering an albuterol treatment to the Patient. This is the place where the student can practice delivering quality medical care. See figure below.

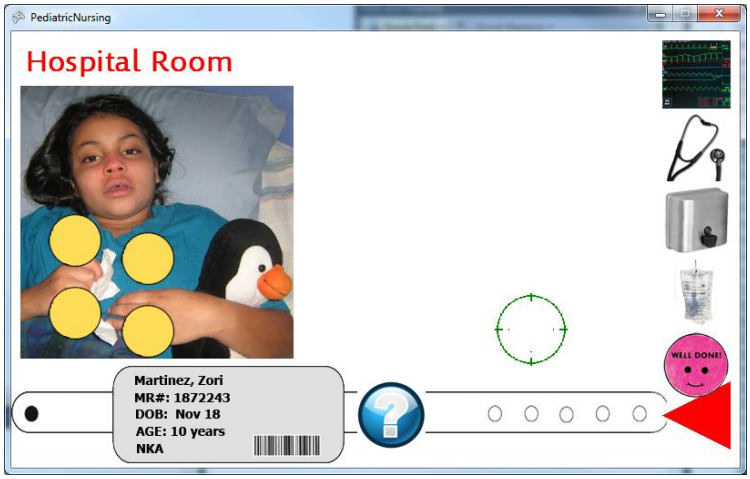

Figure 4-28I-CARE Patient Room

Section 4.1.11.1: Patient Room - Vital Signs

To view Zori's vital signs, the student simply clicks on "monitor" icon to the top right.

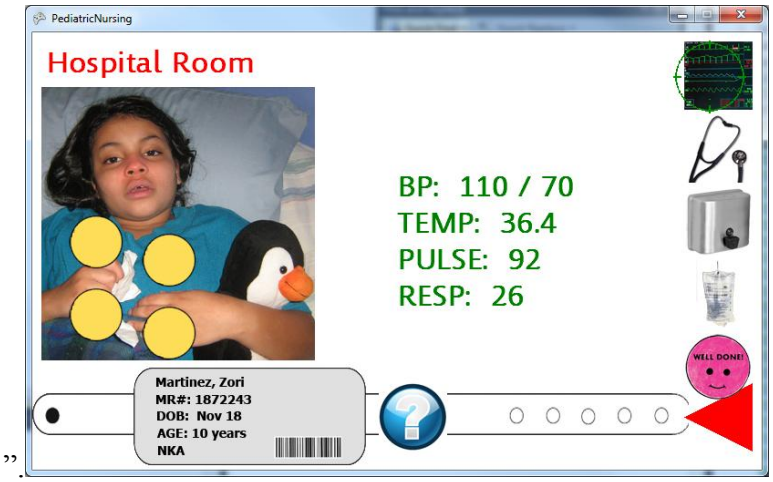

Figure 4-29I-CARE view Zori's Vital Signs

Section 4.1.11.2: Patient Room – Wash Hands

To wash hands, the student clicks on the soap dispenser icon to the right. Failure to wash hands during the procedure can lead to a loss of evaluation points as we will see.

Figure 4-30I-CARE application washing hands

Section 4.1.11.3: Patient Room – Check IV Bag

To check on the status of the IV Bag, the student clicks on IV Bag icon.

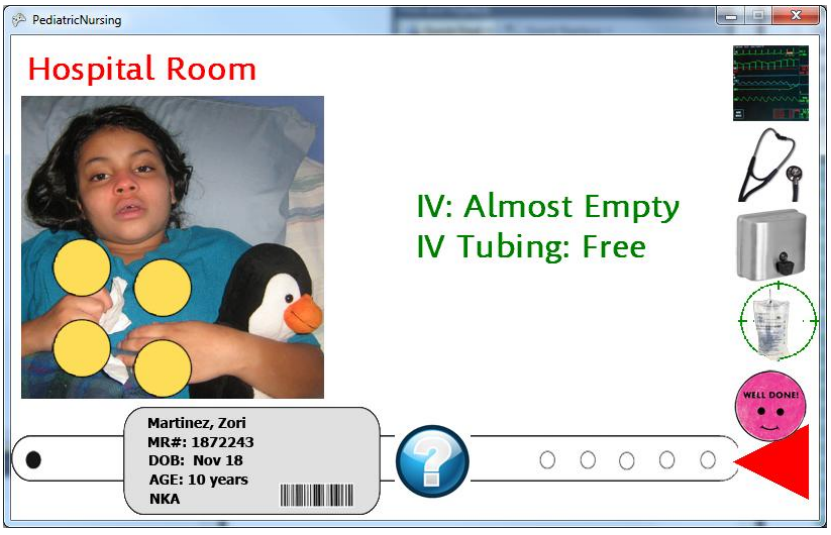

Figure 4-31*I-CARE application gauging IV Bag*

Section 4.1.11.4: Patient Room – Lung Function

In order too perform a Lung Function assessment, the student first clicks on the stethoscope icon. At that point, the virtual stethoscope appears and the student must then position it on the designated lung function locations. If done in the correct order, "Happy Face" icons appear.

Figure 4-32ICARE Application using the Stethoscope

Figure 4-33ICARE Application Assessing Lung Function in Correct Order

Section 4.1.12: Good Bye Screen

The I-CARE Application closing Screen leaves the student with warm feelings of "Thank You" and "You helped me feel better". Pediatric patients come from all walks of like and the image collage shown parallels that diversity.

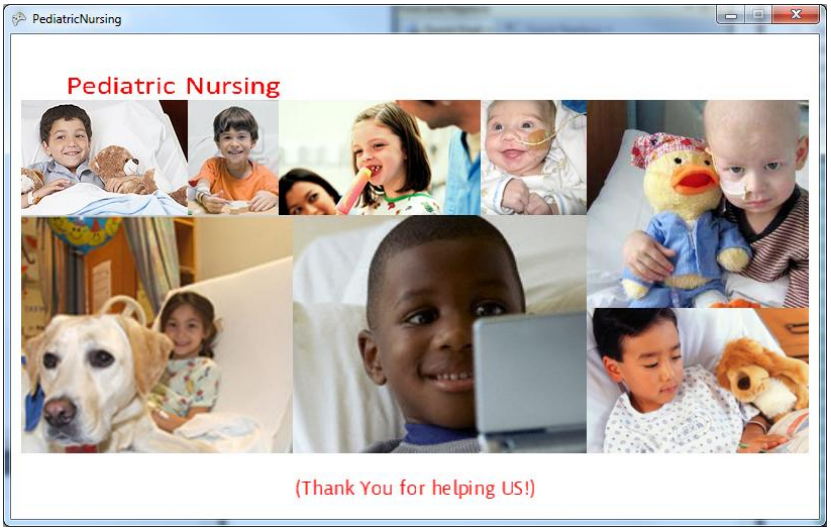

Figure 4-34I-CARE Application Closing Screen

Section 4.2: Security Model

Security is especially critical for mobile devices (i.e. smart phones, I Pads as well as other tablets). In part, their small sizes increase their mobility – but as a result, they are more prone to being lost or misplaced. This could result in potential security breaches that include the compromising of sensitive data. To this end, the I-Care application will have multiple security layers to protect participant information.

The first layer will involve PIN access to the I-Care application. The goal here is to prevent any unauthorized access to I-Care Application, itself. If the device were lost or left unattended, only someone knowing the pin number would be able to access the application.

At enrollment, the participant will be asked to designate a 4-digit pin number that will serve as a security key for the I-Care application. The participant will be required to enter that pin at application start in order to gain access to the application. Moreover, any time the application has been tombstoned (i.e. another application brought to the forefront or the device has been locked), that pin must be entered to regain access into the application. In fact, the I-Care application will lock itself after a period of inactivity as well. Finally, if at any time a pin is lost or needs to be re-issued, an I-Care Team Member must assist.

The second layer will involve encryption of any data that resides in the isolated storage of the mobile device. The goal here is to prevent any unauthorized access to data stored by the I-Care application about a research participant. If the device were lost or left unattended, an intruder would not be able to read any sensitive I-Care data about the research participant stored in the device's isolated storage area.

Sensitive data would include participant demographics, answers to quiz questions, and the responses to application evaluation and/or feedback data. Other data would include an ordered listing of all I-Care module tasks performed within the application (i.e. rooms entered, equipment collected, learning spaces visited, etc.). This data will be encrypted using the Cryptographic API's provided by the Windows Phone platform.

The third layer will involve encryption of any data transmitted to or from the mobile device. The goal here is to prevent any port listeners and or sniffers from accessing sensitive information. There are two occasions where the I-Care application will have a need to transmit data.

In the first scenario, the I-Care application will facilitate a collaborative learning environment. This collaboration can be student-to-student or student-to-teacher collaboration. It could be in the form of secured instant messages via a dedicated host server. Moreover, it could be in the form of secured blog communication where various topics of interest are started and a board-style of dialogue ensues. Either way, this communication will be encrypted between the mobile devices and the I-Care host server using a SSL certificate.

In the second scenario, the I-Care application will upload the encrypted data saved in its isolated storage area to a host server. Just like in the previous scenario, this communication will be encrypted between the mobile device and the I-Care host server using a SSL certificate.

Section 4.3: Conclusions

In this chapter an overview of the actual implementation of the I_CARE virtual world is presented. In the next section the evaluation of a students' performance within the virtual world will be discussed. As suggested in the description here certain sequences of activities must be performed in order to receive full credit for an application. In other words, the students must navigate through the rooms while satisfying certain activity sequencing constraints in order to receive full credit for the exercise. In the next section the basic constraints on navigation will be described. These constraints will be used to score the learning process for a Cultural Algorithms based learner that attempts to generate a benchmark plan upon which the Nurses performance can be evaluated.

Chapter 5: FINDING THE OPTIMAL SOLUTION PATH: AUTOMATING CRITICAL THINKING WITH CULTURAL AGLORITHMS

One of the key issues is assessing the impact that the software has on student learning. In order to do this benchmark solutions must be generated that can be compared with those generated by the students. In order to do this the Cultural Algorithm is employed to generate benchmark plans that reflect positive examples of the learned concept. This is done by first extracting a set of constraints on sequence of activities that the RN can. The violation of these constraints will result in the loss of performance points. As such, the Cultural Algorithm is used to generate optimal paths plans for the solution of the given problem. Section 1 gives the set of possible actions that the user can take. Section 2 gives the constraints on those actions that need to be satisfied. Sections 5.3 through 5.5 present the configuration of the Cultural Algorithm that is used for the learning task here. Section 5.6 presents the conclusions.

Section 5.1: Statement of Problem

We have a virtual world with 71 different procedural tasks that can be performed therein. A Pediatric Nursing Student is charged with not only choosing the appropriate tasks, but also the order in which they are executed in order to administer an Albuterol treatment. This includes gathering the correct equipment, interacting with the patient, assessing physical condition, and ultimately documenting their findings. The end result is the delivery of quality medical care per established Nursing Community guiding principles. Quality is defined in terms of decisions as to which tasks to perform, and in which order to perform them. Medical Care decision is whether to administer the albuterol treatment or not. Finally, if the decision was to administer

the treatment, the medical care also includes an assessment of the treatment – did the treatment work.

Section 5.1.1: Available Procedural Tasks

There are 71 procedural tasks that a virtual Pediatric Nursing Student has to choose from. These virtual tasks represent real-world tasks and compose the physical system in the experimental framework. These tasks are grouped by the virtual room in which they are performed. The tasks performed in each room are given in the following tables.

Section 5.1.1.1: Medical Report Room Procedural Tasks

Task	Object	Value
Read	Medical Triage Report	Yes, No

Table 5-1Medical Report Room Procedural Tasks

Section 5.1.1.2: Medical Records Room

Task	Object	Value
Read	Labs	Yes, No
Read	Face Sheets	Yes, No
Read	History and Physical	Yes, No
Read	Orders	Yes, No
Read	Progress Notes	Yes, No
Read	Nursing Data	Yes, No
Read	Consultation	Yes, No
Read	Nursing Assessment	Yes, No
Read	Discharge Planing or Patient Education	Yes, No

Table 5-2 Medical Records Room Procedural Tasks

Section 5.1.1.3: Medications Room Procedural Tasks

Task	Object	Value
Collect	Acetaminophen	Yes, No
Collect	Advair	Yes, No
Collect	Albuterol	Yes, No
Collect	Benadryl	Yes, No
Collect	Caffiene	Yes, No
Collect	Claritin	Yes, No
Collect	Flonase	Yes, No
Collect	Ibuprofen	Yes, No
Collect	Xolair	Yes, No

Table 5-3Medications Room Procedural Tasks

Section 5.1.1.4: Medications Worksheets Room Procedural Tasks

Task	Object	Value
Complete	Acetaminophen Worksheet	Yes, No
Complete	Advair Worksheet	Yes, No
Complete	Albuterol Worksheet	Yes, No
Complete	Benadryl	Yes, No
Complete	Caffiene Worksheet	Yes, No
Complete	Claritin Worksheet	Yes, No
Complete	Flonase Worksheet	Yes, No
Complete	Ibuprofen Worksheet	Yes, No
Complete	Xolair Worksheet	Yes, No
Determine	Safe to Administer Medication	Yes, No

Table 5-4Medications Worksheets Room Procedural Tasks

Section 5.1.1.5: Equipment Room Procedural Tasks

Task	Object	Value
Collect	Blood Pressure Cuff	Yes, No
Collect	Blue Otoscope	Yes, No
Collect	Brush	Yes, No
Collect	Comb	Yes, No
Collect	Gloves	Yes, No
Collect	Ice	Yes, No
Collect	Isolation Gown	Yes, No
Collect	Lotion	Yes, No
Collect	Mask	Yes, No
Collect	Mouthwash	Yes, No
Collect	Pajamas	Yes, No
Collect	Scale	Yes, No
Collect	Slippers	Yes, No
Collect	Specimen Cup	Yes, No
Collect	Sterile Gloves	Yes, No
Collect	Stethoscope	Yes, No
Collect	Styrofoam Cup	Yes, No
Collect	Thermometer	Yes, No
Collect	Tissues	Yes, No
Collect	Toothbrush	Yes, No
Collect	Toothpaste	Yes, No
Collect	Wireless on Wheels	Yes, No

Table 5-5Equipment Room Procedural Tasks

Section 5.1.1.6: Patient Room Procedural Tasks

Task	Object	Value
Knock	Door	Yes, No
Introduce	Self	Yes, No
Wash	Hands	Yes, No
Pre Medication Assess	Lung Sound	Normal, Crackles, Wheezes, Stridor, Rhonci, Coughing
Post Medication Assess	Lung Sound	Normal, Crackles, Wheezes, Stridor, Rhonci, Coughing
Elevate	Bed 0 Degrees (Flat)	Flat, Midway, Upright
Administer	Albuterol	Yes, No
Document	Findings	Yes, No
Gauge	IV Bag	Empty, Low, Half, Full
Pre Medication Gauge	Temperature	High, Low
Pre Medication Gauge	Blood Pressure Normal	Normal, Low, High
Pre Medication Gauge	Respiratory Rate	Normal, Fast, Slow
Pre Medication Gauge	Heart Rate	Normal, Fast, Slow, Irregular
Post Medication Gauge	Temperature	High, Low
Post Medication Gauge	Blood Pressure Normal	Normal, Low, High
Post Medication Gauge	Respiratory Rate	Normal, Fast, Slow
Post Medication Gauge	Heart Rate	Normal, Fast, Slow, Irregular
Determine	Ready to Enter Patient Room	Yes, No
Determine	Conditions Right to Administer	Yes, No
Determine	Medication Worked	Yes, No

Table 5-6 Patient Room Procedural Tasks

Section 5.2: Cultural Algorithms Set Up

The Cultural Algorithm (CAs) was introduced in its general form in Chapter 2. It is composed of two primary components: *Population Space* and *Belief Space*. The two form a symbiotic relationship where learning takes place in parallel as each continually updates and refines the other in an iterative fashion. The two components interact via the interaction protocol that consists of an *Influence* channel and *Acceptance* communication channel. See figure 5-1 below for a high-level view of the two components within this framework. See table 5-7 for the CA pseudo-code.

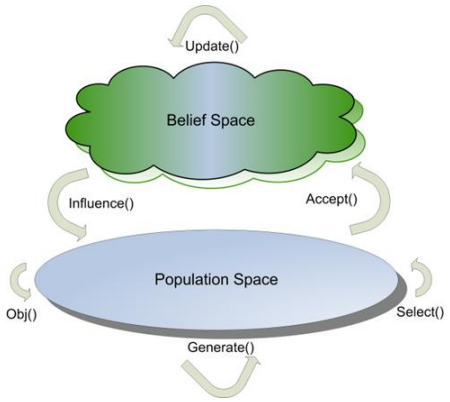

Figure 5-1Cultural Algorithm Framework

Pseudo-code of a Cultural Algorithm
Generate the initial population
Initialize the belief space
Evaluate the initial population
Repeat
Update the belief space via the Accept() function
Evaluate each Agent in the current population with Fitness Function
Select top agents based on Fitness
Until End Criteria

Table 5-7Cultural Algorithm Pseudo Code

Section 5.3: Population Space

In the I-CARE experimental framework, the Population Space is a group of virtual Nursing Students. Collectively, they are given a Medical Order to complete. Each determines which tasks are required to complete the given Medical Order, and in which order. The Population Space embodies a collection of nursing plans for carrying out the medical Order..

Section 5.3.1: Population Space Representation

The Population Space will be composed of 100 Virtual Pediatric Nursing Students, each with their own evolving plan. Each determines a progression of 30 possible tasks that represent individual choices for how to solve the problem of administering an Albuterol treatment. See an example progression in Table 5-8.

A Virtual Pediatric Nursing Student's Choice on Administering Albuterol Treatment	
01-Read Triage Report	16-Take Pre-Medication Temperature
02-Read Medical Orders	17-Take Pre-Medication Blood Pressure
03-Read Medical Records Physical and History	18-Take Pre-Medication Respiratory Rate
04-Read Medical Records Progress Notes	19-Take Pre-Medication Heart Rate
05-Collect Stethoscope	20-Administer Albuterol Treatment
06-Collect Blood Pressure Cuff	21-Take Post-Medication Lung Assessment
07-Collect Sterile Gloves	22-Take Post-Medication Temperature
08-Collect Wireless on Wheels	23-Take Post-Medication Blood Pressure
09-Collect Albuterol Medication	24-Take Post-Medication Respiratory Rate
10-Completed Albuterol Medication Worksheet	25-Take Post-Medication Heart Rate
11-Knock on Patient Door	26-Evaluate Response
12-Introduce Myself	27-Adjust Bed Elevation to 40^{o}
13-Wash My Hands	28-Check IV Bag
14-Take Pre-Medication Lung Assessment	29-Say Good Bye
15-Adjust Bed Elevation to 20^{o}	30-Document all in Wireless on Wheels

Table 5-8 Example Progression of Tasks to administer Albuterol Treatment

Section 5.4: Belief Space

For this experimental framework, the Belief Space is a virtual Nursing Community. The Nursing Community has an established set of guiding principles that influence a Nurse's critical thinking skills. In the real world, critical thinking has been identified as the basis for quality patient care. Quality patient care includes a multitude of standard operating procedures such as those for patient assessment, proper diagnosis and the correct course of treatment. Within the I-CARE virtual world, the Belief Space guides the critical thinking of the virtual Nursing Student.

There are five types of knowledge: Normative (i.e. best range of values), Domain (i.e. best rules), Situational (i.e. best solutions so far), Historical (i.e. best solutions) and Topographical (i.e. best locations for solutions). As indicated in Chapter 2's introduction to Cultural Algorithms (CAs), all of those five types may be used as part of the Belief Space.

Section 5.4.1: Knowledge Source Selection

Only those knowledge sources applicable to the problem are necessary. This particular problem entails finding the best sequence of tasks for administering Albuterol. Historical knowledge is not selected here. It would be more applicable in cases where these experiments were run for a certain age group and incorporated for comparison to another age group in the current set of experiments. Topographical knowledge is not appropriate to the problem as there are defined areas in which to perform tasks – tasks have assigned rooms in which they can be performed. Thus, the three that have been chosen for these experiments are Domain, Situational, and Normative knowledge.

Section 5.4.2: Domain Knowledge

Domain Knowledge in this case is the set of operating procedures for providing quality patient care. It consists of a set of rules that govern the order of task progressions that a virtual Nursing Student (i.e. agent) should follow for the given Medical Order. For example, one rule might be that all task progressions start with the task "Read Triage Report." Another rule example might be that all task progressions end with the task "Document A." There are even rules on task pairing. It is important to note that Domain Knowledge does not give the exact steps needed to complete the Medical Order. It instead gives characteristics of how those steps should take place.

Section 5.4.2.1: Content

Content Rules define which steps must be present within a task progression. For example, one such rule might state that "All task progressions must contain a Lung Assessment task." Another rule might state that "All task progressions must contain an Administer Albuterol Treatment Task." See the table 5-9 below for a list of content rules used in this experimental framework.

Content and Structural Rule Descriptions	Value
All Task Progressions must start with the "Read the Triage Report" task.	400
All Task Progressions must end with "Document Findings in the EMR" task.	400
There must be a "Collect Stethescope" task near the beginning of the tasks.	10
There must be a "Collect Thermomteter" task near the beginning of all the tasks.	10
There must be a "Collect Blood Pressure Cuff" task near the beginning of all tasks.	10
There must be a "Determine Ready To Enter Patient Room" task near the beginning of all task.	20
There must be a "Collect Albuterol" task somewhere in the middle of tasks.	10
There must be a "Complete Albuterol" task somewhere in the middle of the tasks.	10
There must be a "Knock At Door" task somewhere in the middle of the tasks.	10
There must be a "Introduce Self" task somewhere in the middle of the tasks.	10
There must be a "Wash Hands" task somewhere in the middle of the tasks.	10
There must be a "Pre-Medication Assess Lung Sound" task somewhere in the middle of the tasks.	10
There must be a "Pre-Medication Gauge Blood Pressure" task somewhere in the middle of the tasks.	10
There must be a "Pre-Medication Gauge Temperature" task somewhere in the middle of the tasks.	10
There must be a "Pre-Medication Gauge Heart Rate" task somewhere in the middle of the tasks.	10
There must be a "Pre-Medication Gauge Respiratory Rate" task somewhere in the middle of the tasks.	10
There must be a "Gauge IV Bag" task somewhere in the middle of the tasks.	10
There must be a "Determine Safe to Administer Medication" task somewherein the middle of the tasks.	10
There must be a "Determine Medication Worked" task at the end of the tasks.	10
Therre must be a "Determine Conditions Right to Administer Medication" near the end of the tasks.	10
There must be a "Post Mediciation Assess Lung Sound" task near the end of all tasks	10
There must be a "Post Medication Gauge Respiratory Rate" task near the end of all tasks.	10
There must be a "Post Mediciation Gauge Heart Rate" task near the end of all tasks	10
There must be a "Read Medical Triage Report", "Administer Abluterol", and "Document Findings" task	100
There must be a "AdministerAlbuterol = "Yes", "Determine Safe to Administer Medication" = "Yes" "Determine Conditions Right To Administer Medication" = "Yes", and a "DetermineMedicationWorked" = "Yes" tasks	100

Table 5-9 Content Rules for Experiments

Section 5.4.2.2: Structural Rules

Structural Rules describe fixed tasks and their absolute position within a task progression. For example, such a rule might state that “All task progressions must start with the Read Triage Report task”. Another rule might state that “All task progressions must end with a Document Findings in Wireless on Wheels task.” See the table 5-10 below for a listing of structure rules used in this experimental framework.

Content and Structural Rule Descriptions	Value
All Task Progressions must start with the "Read the Triage Report" task.	400
All Task Progressions must end with "Document Findings in the EMR" task.	400
There must be a "Collect Stethescope" task near the beginning of the tasks.	10
There must be a "Collect Thermomteter" task near the beginning of all the tasks.	10
There must be a "Collect Blood Pressure Cuff" task near the beginning of all tasks.	10
There must be a "Determine Ready To Enter Patient Room" task near the beginning of all task.	20
There must be a "Collect Albuterol" task somewhere in the middle of tasks.	10
There must be a "Complete Albuterol" task somewhere in the middle of the tasks.	10
There must be a "Knock At Door" task somewhere in the middle of the tasks.	10
There must be a "Introduce Self" task somewhere in the middle of the tasks.	10
There must be a "Wash Hands" task somewhere in the middle of the tasks.	10
There must be a "Pre-Medication Assess Lung Sound" task somewhere in the middle of the tasks.	10
There must be a "Pre-Medication Gauge Blood Pressure" task somewhere in the middle of the tasks.	10
There must be a "Pre-Medication Gauge Temperature" task somewhere in the middle of the tasks.	10
There must be a "Pre-Medication Gauge Heart Rate" task somewhere in the middle of the tasks.	10
There must be a "Pre-Medication Gauge Respiratory Rate" task somewhere in the middle of the tasks.	10
There must be a "Gauge IV Bag" task somewhere in the middle of the tasks.	10
There must be a "Determine Safe to Administer Medication" task somewherein the middle of the tasks.	10
There must be a "Determine Medication Worked" task at the end of the tasks.	10
Therre must be a "Determine Conditions Right to Administer Medication" near the end of the tasks.	10
There must be a "Post Mediciation Assess Lung Sound" task near the end of all tasks	10
There must be a "Post Medication Gauge Respiratory Rate" task near the end of all tasks.	10
There must be a "Post Mediciation Gauge Heart Rate" task near the end of all tasks	10
There must be a "Read Medical Triage Report", "Administer Abluterol", and "Document Findings" task	100
There must be a "AdministerAlbuterol = "Yes", "Determine Safe to Administer Medication" = "Yes" "Determine Conditions Right To Administer Medication" = "Yes", and a "DetermineMedicationWorked" = "Yes" tasks	100

Table 5-10 Structural Rules for Experiments

Section 5.4.2.3: Contextual Rules

Contextual Rules describe semantic positioning of related tasks and in what order they should occur in a task progression. For example, such a rule might state that “In Order to assess patient lung function, the stethoscope must be present.” Another might state that “In Order to take a blood pressure, the blood pressure cuff must be present.” See the following two tables for a listing of the Contextual Rules used in this experimental framework.

Contextual Rule Descriptions	Value
If there is a "Determine Ready To Enter Patient Room" tasks then the "Collect Stethoscope" task must have already occurred.	15
If there is a "Determine Ready To Enter Patient Room" tasks then the "Collect Thermometer" task must have already occurred.	15
If there is a "Determine Ready To Enter Patient Room" tasks then the "Collect Blood Pressure Cuff" task must have already occurred.	15
If there is a "Complete Albuterol Worksheet Task" then a "Collect Albuterol" task must have already happened.	50
If there is a "Post Medication Assess Lung Sound Task" then the "Administer Abluterol" task must have already happened.	20
If there is a "Post Medication Gauge Blood Pressure" task then the "Administer Abluterol" task must have already happened.	20
If there is a "Post Medication Gauge Temeperature" task" then the "Administer Abluterol" task must have already happened.	20
If there is a "Post Medication Gauge Respiratory Rate" task then the "Administer Abluterol" task must have already happened.	20
If there is a "Post Medication Gauge Heart Rate" task, then the "Administer Abluterol" task must have already happened.	20
If there is a "Administer Albuterol" task then a "Pre-Medication Assess Lung Sound" task must have already happened.	20
If there is a "Administer Albuterol" task then a "Pre-Medication Gauge Blood Pressure" task must have already happened.	20
If there is a "Administer Albuterol" task then a "Pre-Medication Gauge Temperature" task must have already happened.	20
If there is a "Administer Albuterol" task then a "Pre-Medication Gauge Respiratory Rate" task must have already happened	20
If there is a "Administer Albuterol" task, a "Pre-Medication Gauge Heart Rate" task must have already happened.	20
If there is a "Gauge IV Bag" task, then a "Knock at Door" task must have already happened.	50
If there is a "Introduce Self" task, then a "Knock at Door" task must have already happened.	50
If there is a "Pre-Medication AssessLung Sound" task then a "Knock at Door" task must have already happened.	20
If there is a "Pre-Medication Gaguge Blood Pressure" task then a "Knock at Door" task must have already happened.	20
If there is a "Pre-Medication Gaguge Heart Rate" task then a "Knock at Door" task must have already happened.	20
If there is a "Pre-Medication Gaguge Respiratory" task then a "Knock at Door" task must have already happened.	20
If there is a "Pre-Medication Gaguge Temperature" task then a "Knock at Door" task must have already happened.	20
If there is a "Determine Medication Worked" = "Yes" task then a "Administer Albuterol" = "Yes" must have already happened.	50
If there is a "Determine Medication Worked" = "Yes" task then a "Post Medication Assess Lung Sound" = "Normal" task must have happened.	50

Table 5-11 Contextual Rules for Experiments (1 of 2)

Contextual Rule Descriptions Continued		Value
If there is a "Determine Medication Worked" = "No" task, then		50
	a "Post Medication Assess Lung Sound" = "Irregular" task must have happened.	
If there is a "Determine Medication Worked" = "No" task then		50
	a "Post Medication Gauge Temperature" = "High" task must have happened.	
If there is a "Determine Safe to Administer Medication" = "Yes" tasks		100
	a "Complete Albuterol Worksheet " must have already happened.	
	AND a "CollectAlbuterol" task must have already happened.	
If there is a "Determine Ready To Enter Patient Room" then		100
	a "CollectStethoscope" task must have already happened.	
	AND a "Collect Thermometer" task must have already happened.	
	AND a "Collect Blood Pressure Cuff" task must have already happened.	
If there is a "DetermineMedicationWorked" = "Yes" task then		15
	a "Post Medication Assess LungSound" = "Normal" task must have happened.	
If there is a "DetermineMedicationWorked" = "Yes" task then		15
	a "Post Medication Gaugue Respiratory Rate" = "Normal" task happened.	
If there is a "DetermineMedicationWorked" = "Yes" task then		15
	a "Post Medication Gaugue Heart Rate" = "Normal" task must have happened.	
If there is a "DetermineMedicationWorked" = "Yes" task then		100
	a "Post Medication Assess LungSound" = "Normal" task must have happened.	
	AND a "Post Medication Gaugue Respiratory Rate" = "Normal" task happened.	
	AND a "Post Medication Gaugue Heart Rate" = "Normal" task must have	

Table 5-12 Contextual Rules for Experiments (2 of 2)

Section 5.4.3: Situational Knowledge

Figure 5-2 illustrates Situational Knowledge. The Situational Knowledge is a collection of the 20 best Pediatric Nurse solutions generated. This list is compiled at the end of each generation. See Table 5-16 for the pseudo-code of how this list is compiled. The figure below is a 5x4 matrix with each cell representing a single solution like the one shown in Table 5-8.

Figure 5-2 Situational Knowledge Representation

Section 5.4.4: Normative Knowledge

Normative Knowledge is an array of values that represent segments of "goodness" in a progression of tasks. To illustrate this point, think of a progression of tasks as a progression or list of 30 tasks. The figure below is an example of this thought process.

Task 1	Task 2	Task 3	…	…	…	…	Task 28	Task 29	Task 30

Figure 5-3 A task progression thought of as a progression of cells instead of a list.

The "goodness" of a task progression can be thought of as those tasks which contributed to the overall fitness score for an agent. Figure 5-4 shows those tasks in an agent's task progression that contributed to its fitness score. In this example, Task1 and Task 28 are not only correct tasks for quality care, but are also in the correct order to provide medical care. The same can be said for Task 3 and Task 24. Task 30 provides that quality medical care all on its own.

Task 1	Task 2	Task 3	…	…	Task 24	…	Task 28	Task 29	Task 30

Figure 5-4 Good segments for Task Progression

For this example experiment, Normative Knowledge is the source for all good task segments from the top 5 members of the Situational Knowledge. Figure 5-5 below illustrates this.

Task 1	Task 2	Task 3	…	…	Task 24	…	Task 28	Task 29	Task 30
Task 1	Task 2	Task 3	…	…	…	…	Task 28	Task 29	Task 30
Task 1	Task 2	Task 3	…	…	…	…	Task 28	Task 29	Task 30
Task 1	Task 2	Task 3	…	Task 15	…	…	Task 28	Task 29	Task 30
Task 1	Task 2	Task 3	…	…	…	…	Task 28	Task 29	Task 30

Figure 5-5 Normative Knowledge as a listing of good segment for top 5 agents.

Section 5.5: Knowledge Source Evolution

Each knowledge source updates the others via a communication channel. Cultural Algorithms uses this communication channel as the basis for its evolutionary process. The Belief Space updates the Population Space. This process is called micro-evolution and is implemented through an Influence Function. The Population also updates the Belief Space. This process is called macro-evolution and is executed through an Acceptance Function. Both processes begin with a scoring mechanism called the Fitness Function.

Section 5.5.1: Population Space Evolution

Population Space Evolution is the method by which each generation of virtual Pediatric Nursing Students (a.k.a. agents) is created. The initial population is created by assigning a random list of 30 possible tasks to each agent. Each subsequent generation is created using a Fitness Function as a scoring mechanism to guide that evolution with the rules contained within the Belief Spaces Domain Knowledge Source.

Section 5.5.1.1: Fitness Function

The Fitness Function is the scoring mechanism used to identify the best agents in the Population Space. This function utilizes the rules that reside in the Domain Knowledge. Suffice it to say that each virtual Pediatric Nurse's choices are measured up against each of those rules in terms of content (i.e. which tasks were selected), structure (i.e. the order in which the tasks were executed), and context (i.e. the decision to select a task based on prior task execution). The fitness score for each agent increases as the number of matching rules from the Domain Knowledge is determined. See Table 5-13 for the pseudo-code for how this is calculated for each agent in the Population Space.

Pseudo-code Calculate Fitness Scores

```
InializeFitnessScoreForCurrentGenerationToZero()

For each Agent in PopulationSpace
    For each Rule in (ContentStructureRules AND ContextRules)
        If RuleApplies(Rule, Agent) == True THEN
            Agent.FitnessScore += Rule.Value
        End If
    Loop /* Rule */
Loop /* Agent */
```

Table 5-13Pseudo-code for Fitness Function

Section 5.5.1.2: Influence Function

The Influence Function guides the micro-evolution of Population Space with the next generation of virtual Pediatric Nursing Students. It guides the evolution with the 2 Belief Space Knowledge Sources (i.e. Situational Knowledge and Normative Knowledge) plus an additional random component (i.e. same as the one used for the creation of generation 0) to do this. See Table 5-14 for the pseudo code.

Pseudo-code Influence Function to Create Next Generation

```
Copy CurrentSituationalKnowledge to PopulationSpace to create next generation.
Create 40RandomVirtualPedatricNursingStudents.
Copy 40RandomVirtualPedatricNursingStudents to PopulationSpace
Create 40RandomVirtualPedatricNursingStudents.
Use NormativeKnowledge to inject goodness into 40RandomVirtualPedatricNursingStudents
Copy 40RandomVirtualPedatricNursingStudents to PopulationSpace
```

Table 5-14 Pseudo-code for Influence Function

Section 5.5.2: Belief Space Evolution

The Acceptance Function updates the Belief Space based on the current generation's fitness scores – this is called macro-evolution. It updates two knowledge sources: the Situational Knowledge and the Normative Knowledge. See Table 5-15 for the high-level pseudo-code. See Tables 5-16 and 5-17 for the detail-level pseudo-code.

Pseudo-code Acceptance Function to update Belief Space
UpdateSituationalKnowledge()
UpdateNormativeKnowledge()

Table 5-15Pseudo-code for Acceptance Function

Section 5.5.2.1: Domain Knowledge Evolution

Domain Knowledge is a listing of all the rules that govern the Nursing Guiding Principles for quality medical care. To simplify the experimental framework, this knowledge source remains static at each generation level.

Section 5.5.2.2: Situational Knowledge Evolution

Situational Knowledge is a listing of the current best virtual Pediatric Nurse plans from the previous generation in the Population Space. This list is updated just before the creation of the next generation of agents. The Influence Function determines the next "best" list from the union of the existing list and the best from the current generation. See Table 5-5 for the pseudo code on how this takes place.

Pseudo-code Update Situational Knowledge
Create *ListOfTop20* candidates from the current generation based on fitness score.
UnionList = ExistingSituationalKnowledge ∪ *ListOfTotalTop20*
Create *NewListOfTop20* from UnionList based on fitness scores
CurrentSituationalKnowledge = NewListOfTop20

Table 5-16 Situational Knowledge Evolutionary Process

Section 5.5.2.3: Normative Knowledge Evolution

Normative Knowledge is the array of tasks that have given prior success in fitness score evaluation. This list is updated just before the creation of the next generation of agents. The Influence Function updates these ranges based on the top 5 of the agents in the Situational Knowledge source. See Table 5-4 for the pseudo code on this process.

Pseudo-code Update Normative Knowledge
Determine *Top5Agents* from *CurrentSituationalKnowledge*
Determine *RulesHits* (i.e. task combinations) that contributed each *Top5Agents FitnessScore*
Update CelluarRanges using RuleHits from Top5Agents

Table 5-17 Normative Knowledge Evolutionary Process

Chapter 6: EXPERIMENTAL RESULTS

In the previous Chapter the configuration of Cultural Algorithms needed to generate benchmark problem solving plans in order to assess student nurse performance was discussed. In this chapter the results of running the Cultural Algorithm learning component for the Upper Respiratory Module will be discussed.

Section 6.1: Experimental Framework

In the last section, Cultural Algorithms was put in the context as a learning component for the module exercise of the I-CARE application. There is some additional configuration that must be addressed before moving on. First, see an updated version of the pseudo code from section 5-2. In it, additional variables are incorporated into the code to allow for a number of runs to execute. Other variables are added to quantify not only the population size, but also the stopping criteria for each run.

Pseudo-code of a Cultural Algorithm

```
For NumberRuns = 1 to 10
    Generate the initial population of 100 agents
    Initialize the belief space
    Evaluate the initial population with Fitness Function
    Repeat
        Update the belief space via the Accept() function
        Evaluate each Agent in the current population with Fitness Function
        Select top agents based on Fitness
    Until 1000 Generations Created
Loop /* NumberRuns */
```

Table 6-1Updated CA for Experimental Framework

For each run, Cultural Algorithms was allowed to run 1000 generations. A top agent from each was identified based on its fitness score. The fitness score was determined based on domain knowledge "rule" hits. More rule hits are equated to more optimal solutions. These hits can be plotted as a maximum fitness score over each generation. The "perfect" agent score is 2260 (i.e. 80% ~ 1800).

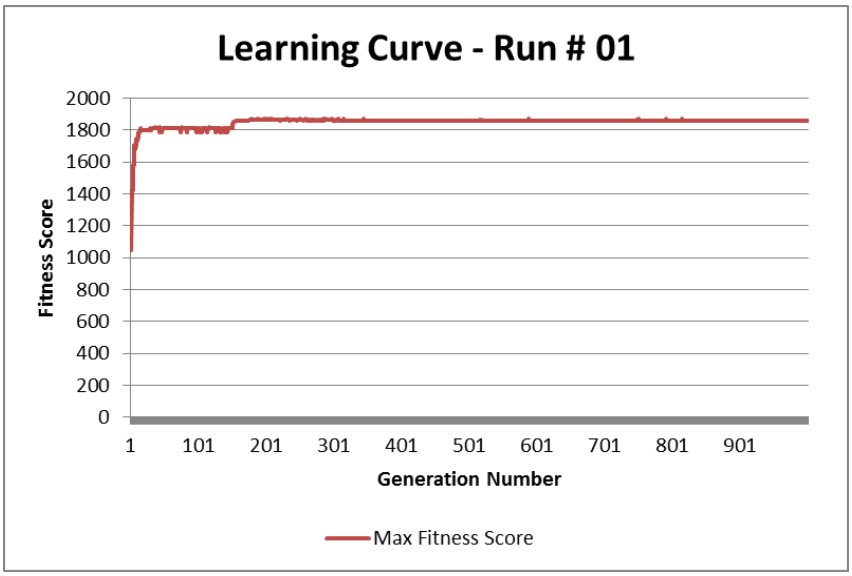

Figure 6-1Run #01 Max Fitness Score over 1000 generations

For these experiments, those agents' solutions with at least 80% of the perfect agent score are considered a good progression of tasks for Albuterol administration. Based on the Learning Curve for Run #01, that threshold is met relatively quickly. In fact, after that threshold is reached, the fitness score does not improve any further during the rest of the 1000 generations. This appeared to be the case for the other 9 runs as well. To get a better idea of that transition, the plot scale was reduced to show only fitness scores for the first 30 generation. See the figure 6-2 below for Run # 01 for that plot.

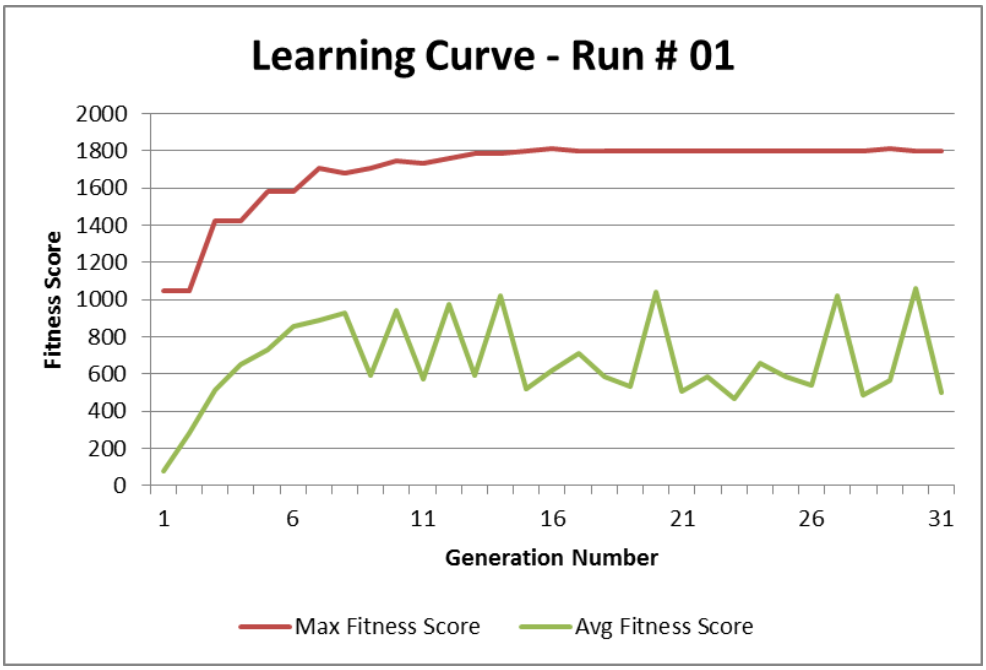

Figure 6-2Run # 01 Max Fitness Score over 30 Generations

When analyzing CA plots, plateaus and inclines are important as they indicate segments of "learning". For example, the plateaus represent segments where learning has leveled off. Conversely, inclines identify where learning has transcended to the next level. See figures 6-3 and 6-4 for illustrations of these in the learning curve for Run # 01. Please note that all learning curves for each run can be seen in Sections 6.1.1 to 6.1.9.

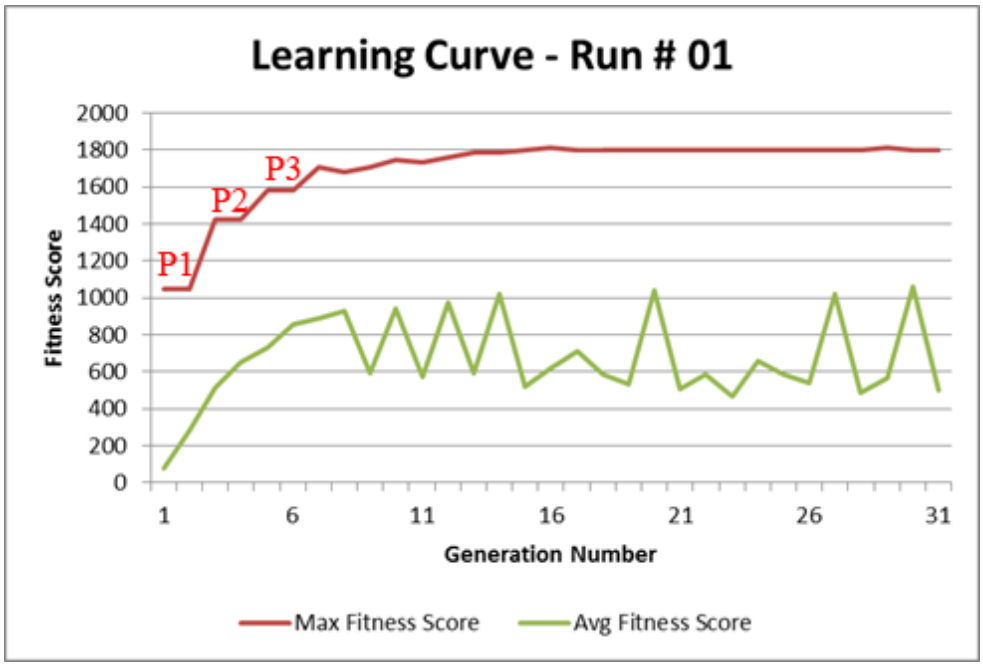

Figure 6-3Run # 01 with Plateaus shown at P1, P2, and P3

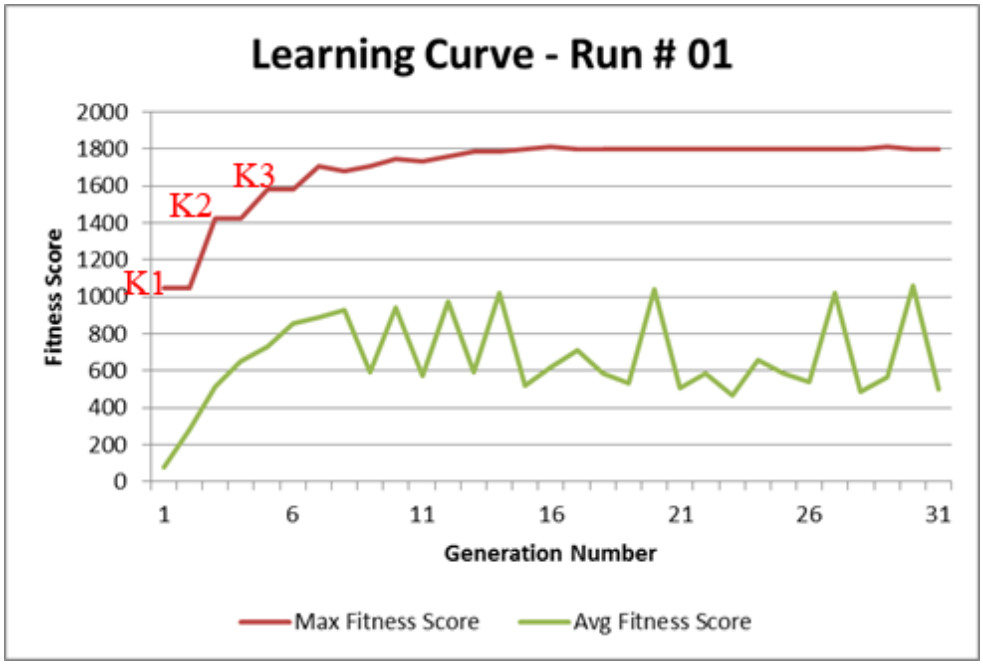

Figure 6-4Run # 01 with Inclines shown at K1, K2, and K3

Section 6.2: Learning Curves

In the last section it was noted that learning curves are in themselves a progression of inclines and plateaus. Sections 6.21 through 6.2.10 illustrate the learning curves from each of the 10 runs for these experiments. Finally, in section 6.2.11, the "best" run is pointed out, which will be the focus of a comparison to a Human Optimal Task Progression solution.

Section 6.2.1: Learning Curve – Run # 01

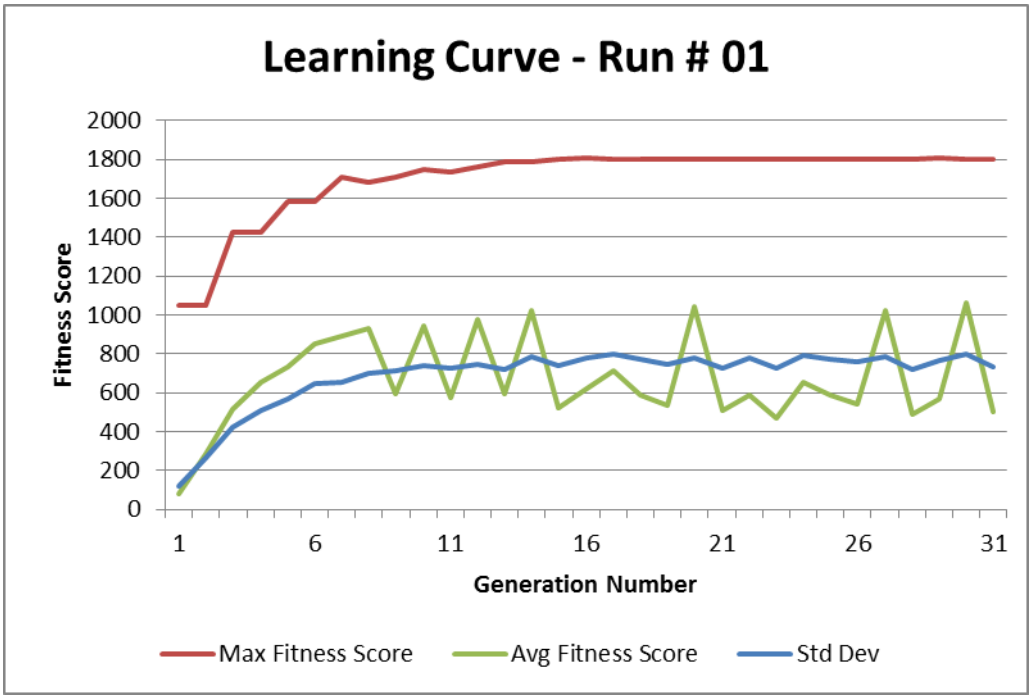

Figure 6-5 Learning Curve for Run 1

Section 6.2.2: Learning Curve – Run # 02

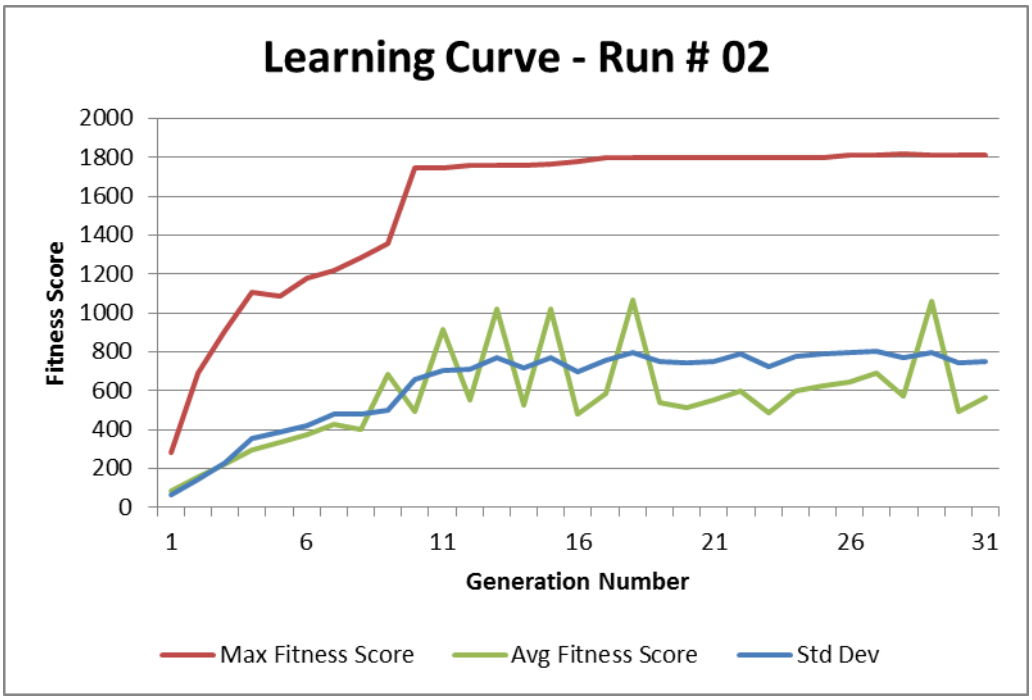

Figure 6-6 Learning Curve for Run 2

Section 6.2.3: Learning Curve – Run # 03

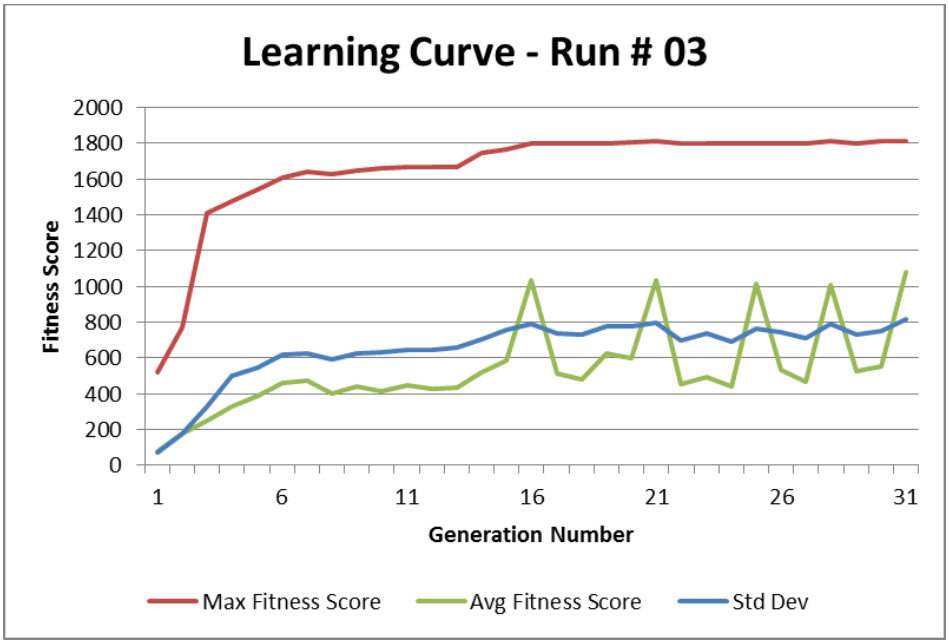

Figure 6-7 Learning Curve for Run 3

Section 6.2.4: Learning Curve – Run # 04

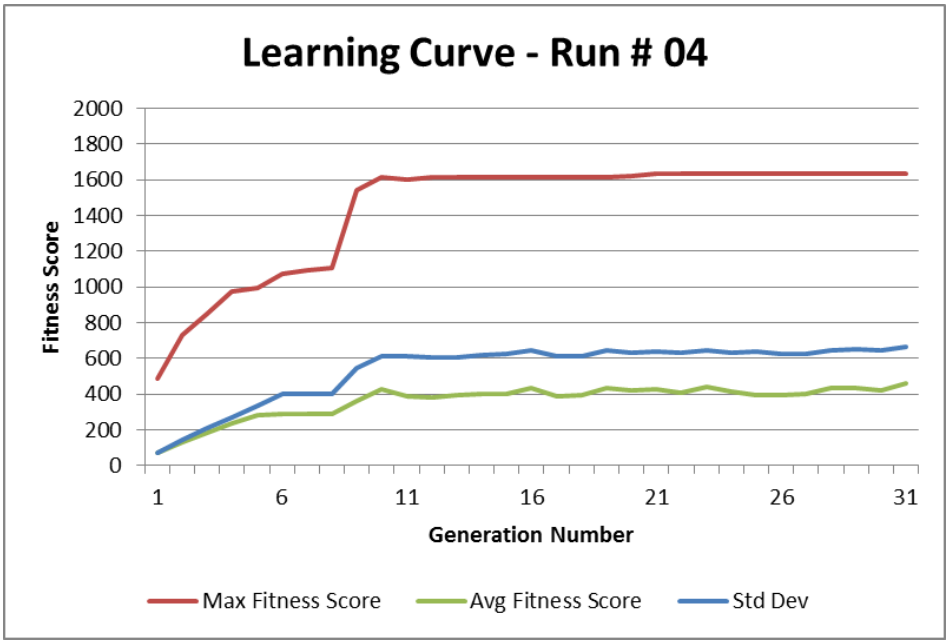

Figure 6-8 Learning Curve for Run 4

Section 6.2.5: Learning Curve – Run # 05

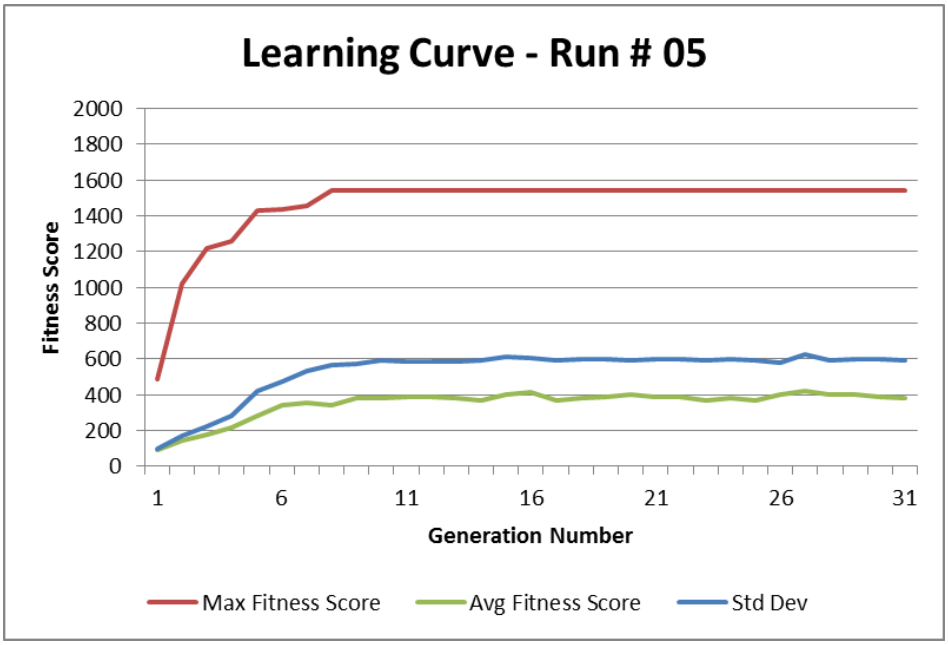

Figure 6-9 Learning Curve for Run 5

Section 6.2.6: Learning Curve – Run # 06

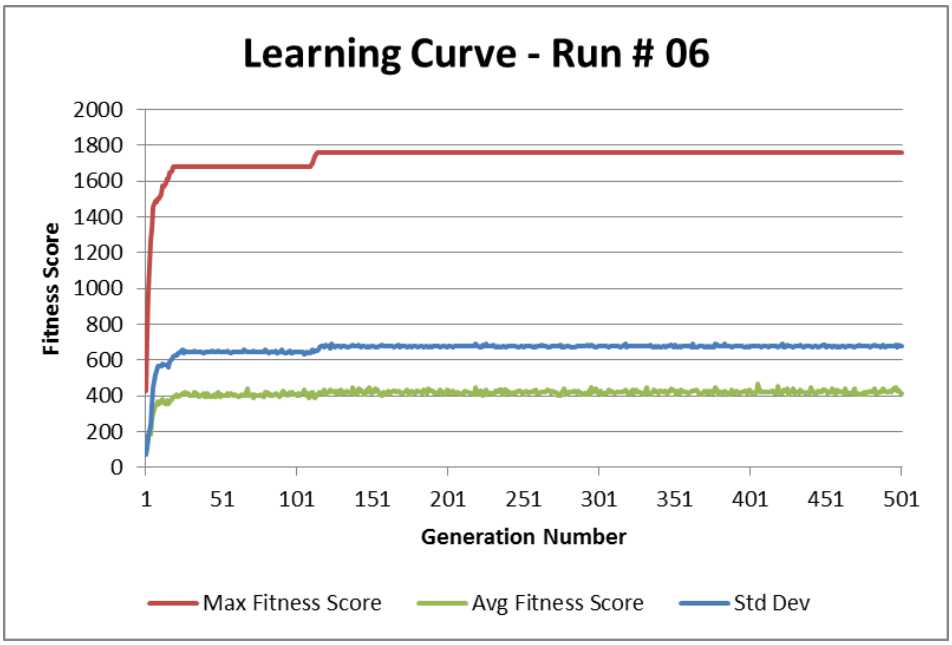

Figure 6-10 Learning Curve for Run 6

Section 6.2.7: Learning Curve – Run # 07

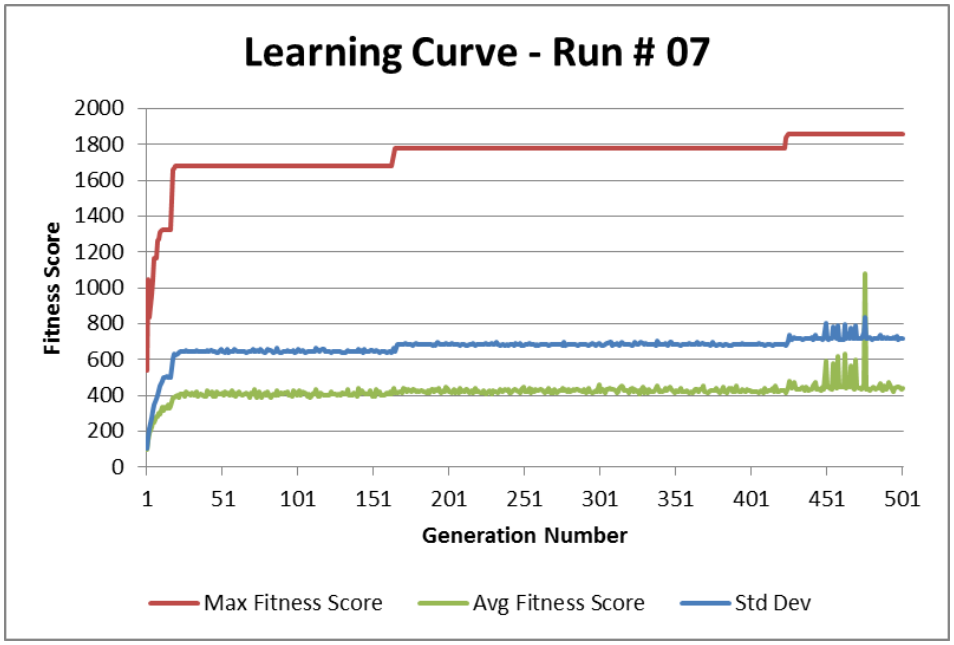

Figure 6-11 Learning Curve for Rune 7

Section 6.2.8: Learning Curve – Run # 08

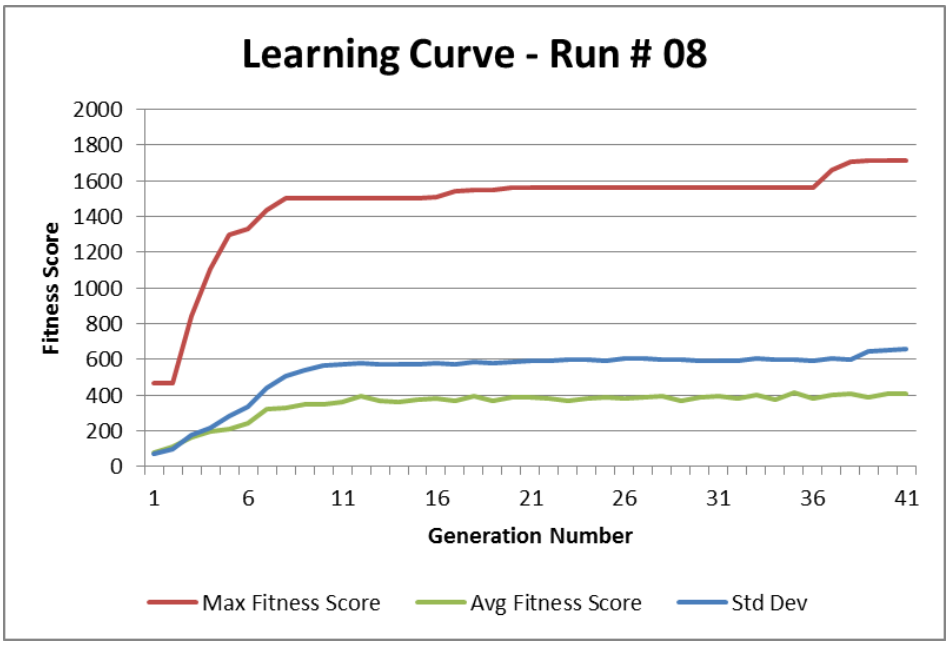

Figure 6-12 Learning Curve for Run 8

Section 6.2.9: Learning Curve – Run # 09

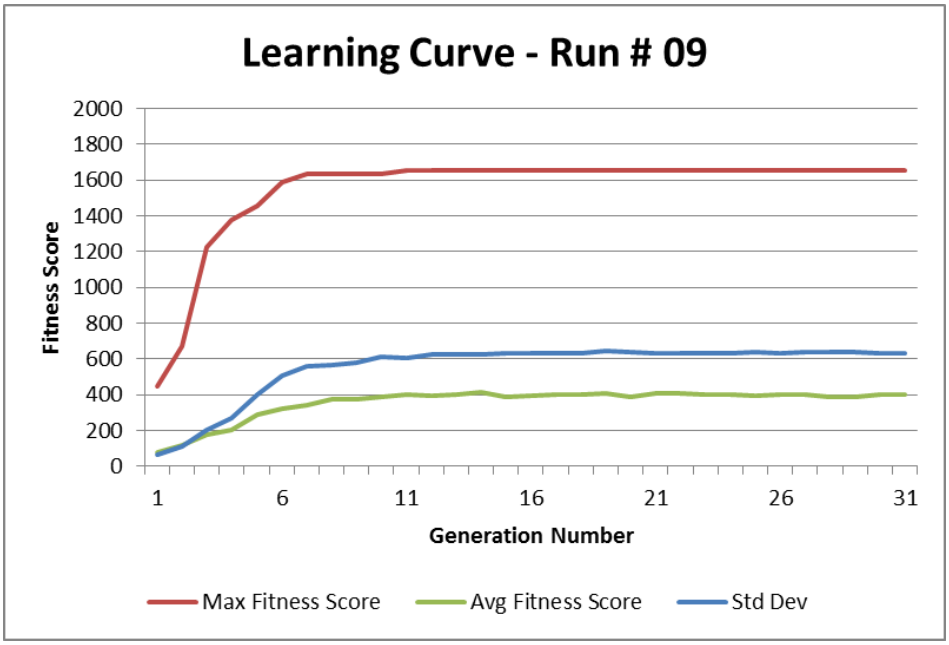

Figure 6-13 Learning Curve for Run 9

Section 6.2.10: Learning Curve – Run # 10

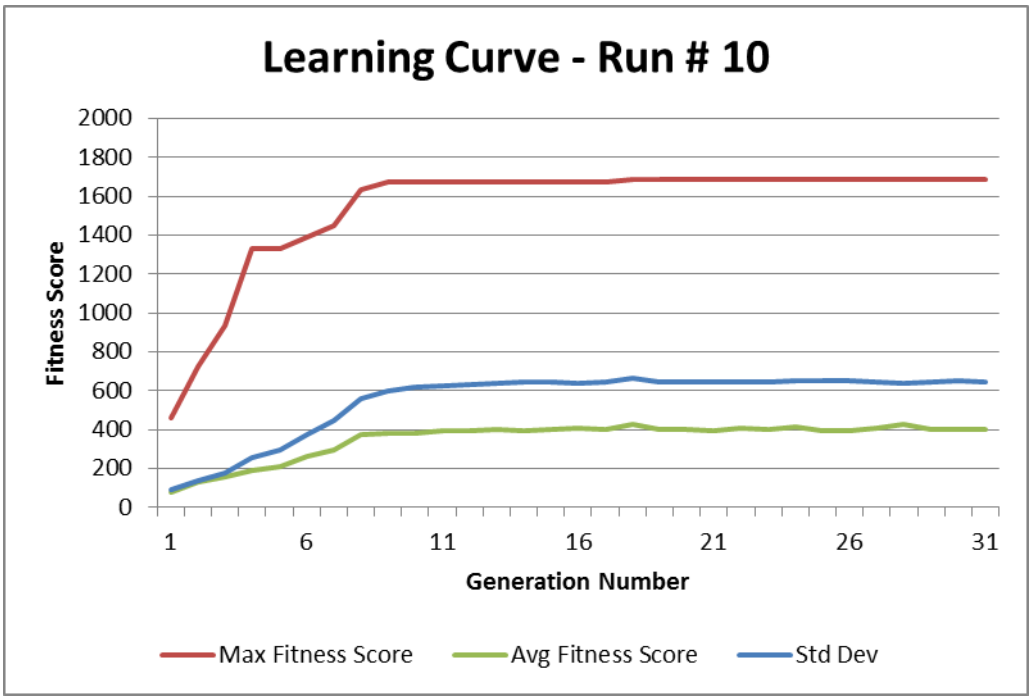

Figure 6-14 Learning Curve for Run 10

Section 6.2.11: Choosing the Best Computational Run

The Plateaus are not necessarily as pronounced as they are in the Run #01 example. Even for that example, the distinction between the two blurs as generations' progress. One observation is that the more defined presence of such characteristics translates to better solutions – these learning curves exceeded the 80% threshold of 1800. This observation will be tested in the following sections when the computational optimal task progressions are compared to a human-accepted task progression for Albuterol delivery. The run that had the most defined plateaus and inclines was Run #07.

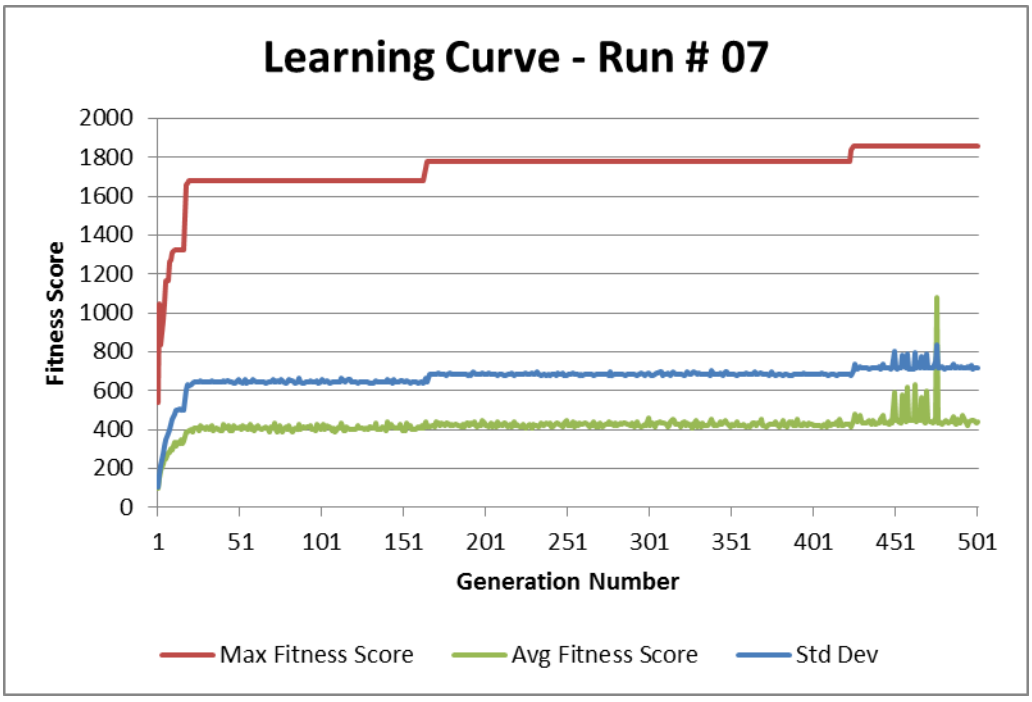

Figure 6-15Run #07 Fitness Score over 500 generations.

Despite having the best learning segments, Run #07 differs from the other Runs in that the learning curve occurs over 500 generations instead of 30. Five (5) Inclines have been identified at Generations 4, 10, 17, 163, and 423.

Section 6.3: Human Optimal Task Progression

Each computation best solution will be compared to a human optimal task progression. Moreover, an attempt will be made to determine those elements which are learned at each of the identified plateau and incline combinations. The human optimal solution is presented in table 6-1. Its fitness score was evaluated to be 1840 (~ 81.4%). Please note that not all 30 tasks have been allocated for the human-optimal task progressions. For the sake of comparison, Task 29 and 30 are defaulted to the "Document Findings" task.

A Human Optimal Task Progression for Administering an Albuterol Treatment	
01-Read Triage Report	16- Take Pre-Medication Blood Pressure
02-Read Medical Orders	17- Take Pre-Medication Respiratory Rate
03-Read Medical Records Physical and History	18- Take Pre-Medication Heart Rate
04-Read Medical Records Progress Notes	19-Determine Safe to Administer Albuterol Y
05-Collect Stethoscope	20- Take Post-Medication Lung Assessment
06-Collect Blood Pressure Cuff	21- Take Post-Medication Temperature
07-Collecte Wireless on Wheels	22- Take Post-Medication Blood Pressure
08- Collect Albuterol Medication	23- Take Post-Medication Respiratory Rate
09-Completed Albuterol Medication Worksheet	24- Take Post-Medication Heart Rate
10- Determine Ready to Enter Patient Room	25- Determine Medication Worked
11- Knock on Patient Door	26- Adjust Bed Elevation to 40^{o}
12- Introduce Myself	27- Check IV Bag
13- Wash My Hands.	28- Document Findings
14- Take Pre-Medication Lung Assessment	29-
15- Take Pre-Medication Temperature	30-

Table 6-2 Human Optimal Task Progression as a solution to the Albuterol Treatment Problem

Section 6.4: Computational Versus Human Optimal Paths

Section 6.4.1.1: Run #07 Generation 0

This is the initial randomly generation task progression at generation 0 for Run #07. This is the initial incline, and has already learned that task 1 should be the "Read Medical Triage Report" task. It has a maximum at fitness score 540.

Run 7 Generation 0 Solution to Administering Albuterol	
01 - Read Medical Triage Report	16 - Collect Acetaminophen
02 - Complete Caffiene Worksheet	17 - Collect Wireless on Wheels
03 - Determine Safe to Administer Medication Yes	18 - Complete Claritin Worksheet
04 - Read Consultation	19 - Post Medication Gauge Blood Pressure Normal Normal
05 - Complete Xolair Worksheet	20 - Document Findings
06 - Introduce Self	21 - Read Face Sheets
07 - Collect Caffiene	22 - Complete Flonase Worksheet
08 - Read Labs	23 - Collect Claritin
09 - Administer Albuterol Yes	24 - Collect Wireless on Wheels
10 - Post Medication Gauge Respiratory Rate Fast	25 - Complete Xolair Worksheet
11 - Complete Claritin Worksheet	26 - Collect Isolation Gown
12 - Complete Flonase Worksheet	27 - Read Medical Triage Report
13 - Collect Stethoscope	28 - Wash Hands
14 - Complete Ibuprofen Worksheet	29 - Collect Blue Otoscope
15 - Collect Toothpaste	30 - Read Nursing Assessment

Table 6-3Run #07 Generation 0 Best Solution

Section 6.4.1.2: Run #07 Generation 4

Generation 4 is the next incline for Run #07's learning curve. During the learning segment between the last incline and this one, it can be seen that the CA has learned that the last task should be to "Document Findings" at the end of all the tasks. It has a max fitness score at 1170.

Run 7 Generation 4 Solution to Administering Albuterol	
01 - Read Medical Triage Report	16 - Collect Thermometer
02 - Determine Ready to Enter Patient Room	17 - Collect Sterile Gloves
03 - Complete Claritin Worksheet	18 - Collect Wireless on Wheels
04 - Pre Medication Gauge Temperature Normal	19 - Collect Advair
05 - Collect Acetaminophen	20 - Document Findings
06 - Complete Flonase Worksheet	21 - Determine Ready to Enter Patient Room
07 - Post Medication Gauge Blood Pressure Normal Normal	22 - Pre Medication Gauge Temperature Normal
08 - Collect Stethoscope	23 - Collect Blood Pressure Cuff
09 - Administer Albuterol Yes	24 - Collect Blood Pressure Cuff
10 - Complete Claritin Worksheet	25 - Collect Brush
11 - Post Medication Gauge Temperature High	26 - Collect Mask
12 - Determine Conditions Right to Administer Yes	27 - Collect Albuterol
13 - Collect Claritin	28 - Post Medication Gauge Respiratory Rate Normal
14 - Collect Styrofoam Cup	29 - Determine Ready to Enter Patient Room
15 - Complete Xolair Worksheet	30 - Document Findings

Table 6-4 Run #07 Generation 4 Best Solution

Section 6.4.1.3: Run #07 Generation 10

Generation 10 is the next incline for Run #07's learning curve. During the learning segment between the last incline and this one, it can be seen that the CA has learned several things. First, the accumulation of the correct equipment along with the readiness to enter the patient room has been learned. Next, the general ordering of how to enter the patient room with the "Knock Door" and "Introduce Self" tasks. Finally, a post patient interaction task of "Gauge IV Bag Low" was discovered. It has a max fitness score at 1325.

Run 7 Generation 10 Solution to Administering Albuterol	
01 - Read Medical Triage Report	16 - Post Medication Gauge Temperature High
02 - Post Medication Gauge Respiratory Rate Normal	17 - Post Medication Assess Lung Sound Stridor
03 - Collect Blood Pressure Cuff	18 - Knock Door
04 - Collect Thermometer	19 - Pre Medication Gauge Blood Pressure Normal High
05 - Collect Blood Pressure Cuff	20 - Pre Medication Gauge Respiratory Rate Normal
06 - Determine Ready to Enter Patient Room	21 - Collect Albuterol
07 - Administer Albuterol Yes	22 - Post Medication Gauge Heart Rate Normal
08 - Collect Blood Pressure Cuff	23 - Document Findings
09 - Administer Albuterol Yes	24 - Determine Medication Worked Yes
10 - Knock Door	25 - Determine Medication Worked Yes
11 - Administer Albuterol Yes	26 - Complete Albuterol Worksheet
12 - Pre Medication Gauge Respiratory Rate Fast	27 - Gauge IV Bag Low
13 - Introduce Self	28 - Post Medication Gauge Respiratory Rate Fast
14 - Pre Medication Gauge Temperature Normal	29 - Determine Safe to Administer Medication Yes
15 - Complete Albuterol Worksheet	30 - Document Findings

Table 6-5 Run #07 Generation 10 Best Solution

Section 6.4.1.4: Run #07 Generation 17

Generation 17 is the next incline for Run #07's learning curve. During the learning segment between the last incline and this one, it can be seen that the CA has learned several things. First, the "Determine Safe to Administer Medication Yes" task emerges after entering the patient room. Next, the "Pre-"and "Post-"Medication vital signs have appeared and in the correct order. Finally, the relative position of the "Determine Medication Worked Yes" task is discovered. It has a max fitness score at 1680

Run 7 Generation 17 Solution to Administering Albuterol	
01 - Read Medical Triage Report	16 - Post Medication Gauge Temperature High
02 - Collect Stethoscope	17 - Post Medication Assess Lung Sound Stridor
03 - Collect Blood Pressure Cuff	18 - Post Medication Gauge Temperature High
04 - Collect Thermometer	19 - Pre Medication Gauge Blood Pressure Normal High
05 - Administer Albuterol Yes	20 - Pre Medication Gauge Respiratory Rate Normal
06 - Determine Ready to Enter Patient Room	21 - Post Medication Assess Lung Sound Crackles
07 - Administer Albuterol Yes	22 - Post Medication Gauge Heart Rate Normal
08 - Pre Medication Gauge Temperature High	23 - Document Findings
09 - Administer Albuterol Yes	24 - Determine Medication Worked Yes
10 - Knock Door	25 - Determine Medication Worked Yes
11 - Determine Safe to Administer Medication Yes	26 - Complete Albuterol Worksheet
12 - Pre Medication Gauge Respiratory Rate Fast	27 - Gauge IV Bag Low
13 - Introduce Self	28 - Post Medication Gauge Respiratory Rate Fast
14 - Pre Medication Gauge Temperature Normal	29 - Determine Safe to Administer Medication Yes
15 - Complete Albuterol Worksheet	30 - Document Findings

Table 6-6 Run #07 Generation 17 Best Solution

Section 6.4.1.5: Run #07 Generation 163

Generation 163 is the next incline for Run #07's learning curve. During the learning segment between the last incline and this one, not much more was learned from the last incline. Tasks are simply ordered differently. The max fitness score here was 1780.

Run 7 Generation 163 Solution to Administering Albuterol	
01 - Read Medical Triage Report	16 - Complete Albuterol Worksheet
02 - Collect Stethoscope	17 - Post Medication Assess Lung Sound Stridor
03 - Collect Blood Pressure Cuff	18 - Post Medication Gauge Temperature High
04 - Collect Thermometer	19 - Pre Medication Gauge Blood Pressure Normal High
05 - Administer Albuterol Yes	20 - Pre Medication Gauge Respiratory Rate Normal
06 - Determine Ready to Enter Patient Room	21 - Post Medication Assess Lung Sound Crackles
07 - Administer Albuterol Yes	22 - Administer Albuterol Yes
08 - Collect Stethoscope	23 - Pre Medication Gauge Respiratory Rate Normal
09 - Post Medication Gauge Blood Pressure Normal High	24 - Determine Medication Worked Yes
10 - Knock Door	25 - Determine Medication Worked Yes
11 - Administer Albuterol Yes	26 - Complete Albuterol Worksheet
12 - Gauge IV Bag Low	27 - Gauge IV Bag Low
13 - Pre Medication Gauge Heart Rate Fast	28 - Post Medication Gauge Respiratory Rate Fast
14 - Pre Medication Gauge Temperature Normal	29 - Determine Safe to Administer Medication Yes
15 - Collect Albuterol	30 - Document Findings

Table 6-7 Run #07 Generation 163 Best Solution

Section 6.4.1.6: Run #07 Generation 423

Generation 163 is the next incline for Run #07's learning curve. During the learning segment between the last incline and this one, not much more was learned from the last incline. Tasks are simply ordered differently. The max fitness score here was 1860.

Run 7 Generation 423 Solution to Administering Albuterol	
01 - Read Medical Triage Report	16 - Complete Albuterol Worksheet
02 - Collect Stethoscope	17 - Post Medication Assess Lung Sound Stridor
03 - Collect Blood Pressure Cuff	18 - Post Medication Gauge Temperature High
04 - Collect Thermometer	19 - Pre Medication Gauge Blood Pressure Normal High
05 - Administer Albuterol Yes	20 - Pre Medication Gauge Respiratory Rate Normal
06 - Determine Ready to Enter Patient Room	21 - Post Medication Assess Lung Sound Crackles
07 - Knock Door	22 - Post Medication Gauge Heart Rate Normal
08 - Collect Stethoscope	23 - Pre Medication Gauge Respiratory Rate Normal
09 - Administer Albuterol Yes	24 - Determine Medication Worked Yes
10 - Knock Door	25 - Pre Medication Gauge Heart Rate Fast
11 - Pre Medication Assess Lung Sound Wheezes	26 - Complete Albuterol Worksheet
12 - Wash Hands	27 - Determine Medication Worked Yes
13 - Introduce Self	28 - Post Medication Gauge Respiratory Rate Fast
14 - Pre Medication Gauge Temperature Normal	29 - Determine Safe to Administer Medication Yes
15 - Collect Albuterol	30 - Document Findings

Table 6-8 Run #07 Generation 423 Best Solution

Section 6.5: Best Solutions

For this chapter, Run #07 was the focus of discussion. This was done due to the well-defined inclines and plateaus of its corresponding learning curve. The incline / plateau combinations presented therein were classified as learning segments. For the sake of completeness, the remaining best solutions for the other 9 runs are included in this section.

Section 6.5.1: Best Solutions - Run # 01

Run 1 Generation 0 Solution to Administering Albuterol	
01 - Read Medical Triage Report	16 - Pre Medication Assess Lung Sound Wheezes
02 - Collect Xolair	17 - Determine Medication Worked Yes
03 - Collect Xolair	18 - Read Consultation
04 - Gauge IV Bag Half	19 - Collect Specimen Cup
05 - Read Discharge Planing or Patient Education	20 - Collect Advair
06 - Gauge IV Bag Half	21 - Collect Flonase
07 - Collect Claritin	22 - Determine Conditions Right to Administer Yes
08 - Pre Medication Assess Lung Sound Wheezes	23 - Complete Advair Worksheet
09 - Collect Claritin	24 - Complete Claritin Worksheet
10 - Post Medication Assess Lung Sound Wheezes	25 - Collect Thermometer
11 - Read Labs	26 - Post Medication Gauge Blood Pressure Normal High
12 - Collect Albuterol	27 - Collect Toothpaste
13 - Pre Medication Gauge Blood Pressure Normal High	28 - Pre Medication Gauge Temperature High
14 - Read Consultation	29 - Complete Albuterol Worksheet
15 - Post Medication Gauge Heart Rate Slow	30 - Document Findings

Figure 6-16 Run 1 Generation 0 Solution to Administering Albuterol

Run 1 Generation 5 Solution to Administering Albuterol	
01 - Read Medical Triage Report	16 - Pre Medication Assess Lung Sound Wheezes
02 - Administer Albuterol Yes	17 - Determine Medication Worked Yes
03 - Gauge IV Bag Low	18 - Pre Medication Gauge Temperature High
04 - Pre Medication Assess Lung Sound Wheezes	19 - Collect Pajamas
05 - Collect Tissues	20 - Collect Stethoscope
06 - Administer Albuterol Yes	21 - Collect Albuterol
07 - Post Medication Assess Lung Sound Wheezes	22 - Collect Toothbrush
08 - Post Medication Gauge Temperature Normal	23 - Post Medication Gauge Heart Rate Slow
09 - Collect Stethoscope	24 - Pre Medication Assess Lung Sound Wheezes
10 - Elevate Bed 0 Degrees (Flat) Flat	25 - Determine Ready to Enter Patient Room
11 - Post Medication Gauge Respiratory Rate Normal	26 - Collect Claritin
12 - Collect Albuterol	27 - Gauge IV Bag Low
13 - Complete Albuterol Worksheet	28 - Determine Medication Worked Yes
14 - Knock Door	29 - Determine Safe to Administer Medication Yes
15 - Introduce Self	30 - Document Findings

Figure 6-17 Run 1 Generation 5 Solution to Administering Albuterol

Run 1 Generation 10 Solution to Administering Albuterol	
01 - Read Medical Triage Report	16 - Pre Medication Gauge Heart Rate Slow
02 - Collect Blood Pressure Cuff	17 - Post Medication Gauge Temperature High
03 - Knock Door	18 - Gauge IV Bag Half
04 - Pre Medication Assess Lung Sound Crackles	19 - Complete Albuterol Worksheet
05 - Knock Door	20 - Introduce Self
06 - Pre Medication Gauge Temperature High	21 - Administer Albuterol Yes
07 - Pre Medication Gauge Respiratory Rate Fast	22 - Determine Safe to Administer Medication Yes
08 - Pre Medication Gauge Heart Rate Normal	23 - Post Medication Assess Lung Sound Rhonci
09 - Administer Albuterol Yes	24 - Determine Medication Worked Yes
10 - Post Medication Gauge Heart Rate Normal	25 - Determine Ready to Enter Patient Room
11 - Complete Albuterol Worksheet	26 - Post Medication Gauge Respiratory Rate Fast
12 - Collect Albuterol	27 - Determine Medication Worked Yes
13 - Post Medication Assess Lung Sound Rhonci	28 - Determine Medication Worked Yes
14 - Determine Ready to Enter Patient Room	29 - Determine Safe to Administer Medication Yes
15 - Pre Medication Gauge Blood Pressure Normal High	30 - Document Findings

Figure 6-18 Run 1 Generation 10 Solution to Administering Albuterol

Run 1 Generation 15 Solution to Administering Albuterol	
01 - Read Medical Triage Report	16 - Pre Medication Gauge Respiratory Rate Normal
02 - Collect Thermometer	17 - Post Medication Gauge Temperature High
03 - Post Medication Assess Lung Sound Normal	18 - Pre Medication Gauge Heart Rate Normal
04 - Collect Blood Pressure Cuff	19 - Complete Albuterol Worksheet
05 - Knock Door	20 - Introduce Self
06 - Knock Door	21 - Post Medication Gauge Respiratory Rate Fast
07 - Collect Blood Pressure Cuff	22 - Determine Safe to Administer Medication Yes
08 - Pre Medication Gauge RespiratoryRate Normal	23 - Post Medication Assess Lung Sound Rhonci
09 - Collect Stethoscope	24 - Determine Medication Worked Yes
10 - Determine Ready to Enter Patient Room	25 - Administer Albuterol Yes
11 - Complete Albuterol Worksheet	26 - Post Medication Assess Lung Sound Normal
12 - Collect Albuterol	27 - Determine Medication Worked Yes
13 - Administer Albuterol Yes	28 - Post Medication Gauge Heart Rate Fast
14 - Post Medication Gauge Heart Rate Slow	29 - Introduce Self
15 - Determine Medication Worked Yes	30 - Document Findings

Figure 6-19 Run 1 Generation 15 Solution to Administering Albuterol

Run 1 Generation 20 Solution to Administering Albuterol	
01 - Read Medical Triage Report	16 - Pre Medication Gauge Respiratory Rate Normal
02 - Collect Blood Pressure Cuff	17 - Post Medication Assess Lung Sound Normal
03 - Post Medication Assess Lung Sound Normal	18 - Pre Medication Gauge Heart Rate Normal
04 - Pre Medication Assess Lung Sound Crackles	19 - Complete Albuterol Worksheet
05 - Knock Door	20 - Gauge IV Bag Half
06 - Knock Door	21 - Post Medication Gauge Respiratory Rate Fast
07 - Collect Blood Pressure Cuff	22 - Determine Safe to Administer Medication Yes
08 - Gauge IV Bag Half	23 - Post Medication Assess Lung Sound Rhonci
09 - Collect Stethoscope	24 - Determine Medication Worked Yes
10 - Determine Ready to Enter Patient Room	25 - Administer Albuterol Yes
11 - Pre Medication Gauge Blood Pressure NormalNormal	26 - Post Medication Gauge Respiratory Rate Fast
12 - Determine Safe to Administer Medication Yes	27 - Determine Medication Worked Yes
13 - Administer Albuterol Yes	28 - Post Medication Gauge Heart Rate Fast
14 - Post Medication Gauge Heart Rate Slow	29 - Introduce Self
15 - Determine Medication Worked Yes	30 - Document Findings

Figure 6-20 Run 1 Generation 20 Solution to Administering Albuterol

Run 1 Generation 25 Solution to Administering Albuterol	
01 - Read Medical Triage Report	16 - Pre Medication Gauge Heart Rate Slow
02 - Collect Blood Pressure Cuff	17 - Post Medication Gauge Temperature High
03 - Knock Door	18 - Gauge IV Bag Half
04 - Pre Medication Assess Lung Sound Crackles	19 - Complete Albuterol Worksheet
05 - Knock Door	20 - Introduce Self
06 - Pre Medication Gauge Temperature High	21 - Administer Albuterol Yes
07 - Collect Thermometer	22 - Determine Safe to Administer Medication Yes
08 - Pre Medication Gauge RespiratoryRate Normal	23 - Post Medication Assess Lung Sound Rhonci
09 - Administer Albuterol Yes	24 - Determine Medication Worked Yes
10 - Post Medication Gauge Heart Rate Normal	25 - Determine Ready to Enter Patient Room
11 - Complete Albuterol Worksheet	26 - Post Medication Gauge Respiratory Rate Fast
12 - Collect Albuterol	27 - Determine Medication Worked Yes
13 - Post Medication Assess Lung Sound Rhonci	28 - Post Medication Gauge Heart Rate Normal
14 - Knock Door	29 - Post Medication Gauge Blood Pressure Normal Normal
15 - Pre Medication Gauge Blood Pressure Normal High	30 - Document Findings

Figure 6-21 Run 1 Generation 25 Solution to Administering Albuterol

Run 1 Generation 30 Solution to Administering Albuterol	
01 - Read Medical Triage Report	16 - Pre Medication Gauge Heart Rate Slow
02 - Collect Blood Pressure Cuff	17 - Post Medication Gauge Temperature High
03 - Knock Door	18 - Gauge IV Bag Half
04 - Pre Medication Assess Lung Sound Crackles	19 - Complete Albuterol Worksheet
05 - Knock Door	20 - Introduce Self
06 - Pre Medication Gauge Temperature High	21 - Administer Albuterol Yes
07 - Collect Thermometer	22 - Determine Safe to Administer Medication Yes
08 - Pre Medication Gauge RespiratoryRate Normal	23 - Post Medication Assess Lung Sound Rhonci
09 - Administer Albuterol Yes	24 - Determine Medication Worked Yes
10 - Post Medication Gauge Heart Rate Normal	25 - Determine Ready to Enter Patient Room
11 - Complete Albuterol Worksheet	26 - Post Medication Gauge Respiratory Rate Fast
12 - Collect Albuterol	27 - Determine Medication Worked Yes
13 - Pre Medication Gauge Blood Pressure Normal High	28 - Post Medication Gauge Heart Rate Normal
14 - Knock Door	29 - Post Medication Gauge Blood Pressure Normal Normal
15 - Pre Medication Gauge Blood Pressure Normal High	30 - Document Findings

Figure 6-22 Run 1 Generation 30 Solution to Administering Albuterol

Section 6.5.2: Best Solutions - Run # 02

Run 2 Generation 0 Solution to Administering Albuterol	
01 - Gauge IV Bag Half	16 - Read Nursing Assessment
02 - Complete Xolair Worksheet	17 - Post Medication Gauge Temperature High
03 - Collect Toothbrush	18 - Collect Blood Pressure Cuff
04 - Pre Medication Assess Lung Sound Crackles	19 - Collect Tissues
05 - Complete Advair Worksheet	20 - Collect Wireless on Wheels
06 - Read History and Physical	21 - Read Medical Triage Report
07 - Collect Thermometer	22 - Collect Acetaminophen
08 - Determine Conditions Right to Administer Yes	23 - Post Medication Assess Lung Sound Rhonci
09 - Administer Albuterol Yes	24 - Collect Advair
10 - Collect Mask	25 - Collect Acetaminophen
11 - Read Face Sheets	26 - Post Medication Gauge Respiratory Rate Fast
12 - Collect Tissues	27 - Collect Pajamas
13 - Post Medication Assess Lung Sound Rhonci	28 - Determine Medication Worked Yes
14 - Collect Sterile Gloves	29 - Collect Gloves
15 - Collect Lotion	30 - Administer Albuterol Yes

Figure 6-23 Run 2 Generation 0 Solution to Administering Albuterol

Run 2 Generation 5 Solution to Administering Albuterol	
01 - Read Medical Triage Report	16 - Post Medication Gauge Heart Rate Fast
02 - Collect Brush	17 - Post Medication Gauge Temperature High
03 - Administer Albuterol Yes	18 - Gauge IV Bag Half
04 - Pre Medication Assess Lung Sound Crackles	19 - Complete Albuterol Worksheet
05 - Knock Door	20 - Introduce Self
06 - Pre Medication Gauge Temperature High	21 - Administer Albuterol Yes
07 - Collect Thermometer	22 - Determine Safe to Administer Medication Yes
08 - Pre Medication Gauge Respiratory Rate Normal	23 - Determine Safe to Administer Medication Yes
09 - Administer Albuterol Yes	24 - Pre Medication Gauge Temperature High
10 - Post Medication Gauge Heart Rate Normal	25 - Post Medication Assess Lung Sound Rhonci
11 - Complete Albuterol Worksheet	26 - Post Medication Gauge Respiratory Rate Fast
12 - Collect Albuterol	27 - Determine Medication Worked Yes
13 - Collect Blood Pressure Cuff	28 - Introduce Self
14 - Determine Ready to Enter Patient Room	29 - Read Medical Triage Report
15 - Pre Medication Gauge Blood Pressure Normal High	30 - Administer Albuterol Yes

Figure 6-24Run 2 Generation 5 Solution to Administering Albuterol

Run 2 Generation 10 Solution to Administering Albuterol	
01 - Read Medical Triage Report	16 - Pre Medication Gauge Heart Rate Slow
02 - Read Discharge Planing or Patient Education	17 - Post Medication Gauge Temperature High
03 - Knock Door	18 - Gauge IV Bag Half
04 - Pre Medication Assess Lung Sound Crackles	19 - Complete Albuterol Worksheet
05 - Knock Door	20 - Introduce Self
06 - Pre Medication Gauge Temperature High	21 - Administer Albuterol Yes
07 - Pre Medication Gauge RespiratoryRate Fast	22 - Determine Safe to Administer Medication Yes
08 - Pre Medication Gauge RespiratoryRate Normal	23 - Post Medication Assess Lung Sound Rhonci
09 - Administer Albuterol Yes	24 - Determine Medication Worked Yes
10 - Post Medication Gauge Heart Rate Normal	25 - Post Medication Assess Lung Sound Rhonci
11 - Complete Albuterol Worksheet	26 - Post Medication Gauge Respiratory Rate Fast
12 - Collect Albuterol	27 - Determine Medication Worked Yes
13 - Post Medication Assess Lung Sound Rhonci	28 - Post Medication Gauge Heart Rate Normal
14 - Knock Door	29 - Post Medication Gauge Blood Pressure Normal High
15 - Pre Medication Gauge Blood Pressure Normal High	30 - Document Findings

Figure 6-25 Run 2 Generation 10 Solution to Administering Albuterol

Run 2 Generation 15 Solution to Administering Albuterol	
01 - Read Medical Triage Report	16 - Pre Medication Gauge Respiratory Rate Normal
02 - Collect Thermometer	17 - Post Medication Assess Lung Sound Stridor
03 - Post Medication Assess Lung Sound Normal	18 - Pre Medication Gauge Heart Rate Normal
04 - Collect Blood Pressure Cuff	19 - Complete Albuterol Worksheet
05 - Knock Door	20 - Gauge IV Bag Half
06 - Knock Door	21 - Post Medication Gauge Respiratory Rate Fast
07 - Collect Thermometer	22 - Determine Safe to Administer Medication Yes
08 - Gauge IV Bag Half	23 - Pre Medication Gauge Temperature High
09 - Collect Thermometer	24 - Determine Medication Worked Yes
10 - Determine Ready to Enter Patient Room	25 - Administer Albuterol Yes
11 - Pre Medication Gauge Blood Pressure NormalNormal	26 - Post Medication Assess Lung Sound Normal
12 - Collect Albuterol	27 - Post Medication Gauge Blood Pressure Normal High
13 - Administer Albuterol Yes	28 - Post Medication Gauge Heart Rate Normal
14 - Post Medication Gauge Heart Rate Slow	29 - Introduce Self
15 - Determine Medication Worked Yes	30 - Document Findings

Figure 6-26Run 2 Generation150 Solution to Administering Albuterol

Run 2 Generation 20 Solution to Administering Albuterol	
01 - Read Medical Triage Report	16 - Pre Medication Gauge Heart Rate Slow
02 - Collect Blood Pressure Cuff	17 - Post Medication Gauge Temperature High
03 - Knock Door	18 - Gauge IV Bag Half
04 - Pre Medication Assess Lung Sound Wheezes	19 - Complete Albuterol Worksheet
05 - Knock Door	20 - Post Medication Gauge Heart Rate Normal
06 - Pre Medication Gauge Temperature High	21 - Administer Albuterol Yes
07 - Collect Thermometer	22 - Determine Safe to Administer Medication Yes
08 - Pre Medication Gauge RespiratoryRate Normal	23 - Post Medication Assess Lung Sound Rhonci
09 - Administer Albuterol Yes	24 - Determine Medication Worked Yes
10 - Post Medication Gauge Heart Rate Normal	25 - Determine Ready to Enter Patient Room
11 - Introduce Self	26 - Post Medication Gauge Respiratory Rate Fast
12 - Collect Albuterol	27 - Determine Medication Worked Yes
13 - Post Medication Assess Lung Sound Rhonci	28 - Post Medication Gauge Heart Rate Normal
14 - Knock Door	29 - Post Medication Gauge Blood Pressure Normal Normal
15 - Pre Medication Gauge Blood Pressure Normal High	30 - Document Findings

Figure 6-27Run 2 Generation 20 Solution to Administering Albuterol

Run 2 Generation 25 Solution to Administering Albuterol	
01 - Read Medical Triage Report	16 - Pre Medication Gauge Heart Rate Slow
02 - Collect Blood Pressure Cuff	17 - Post Medication Gauge Temperature High
03 - Knock Door	18 - Gauge IV Bag Half
04 - Pre Medication Assess Lung Sound Crackles	19 - Complete Albuterol Worksheet
05 - Knock Door	20 - Introduce Self
06 - Pre Medication Gauge Temperature High	21 - Administer Albuterol Yes
07 - Collect Thermometer	22 - Determine Safe to Administer Medication Yes
08 - Pre Medication Gauge RespiratoryRate Normal	23 - Post Medication Assess Lung Sound Rhonci
09 - Administer Albuterol Yes	24 - Determine Medication Worked Yes
10 - Post Medication Gauge Heart Rate Normal	25 - Determine Ready to Enter Patient Room
11 - Introduce Self	26 - Post Medication Gauge Respiratory Rate Fast
12 - Collect Albuterol	27 - Determine Medication Worked Yes
13 - Pre Medication Gauge Blood Pressure Normal High	28 - Post Medication Gauge Heart Rate Normal
14 - Knock Door	29 - Post Medication Gauge Blood Pressure Normal Normal
15 - Pre Medication Gauge Blood Pressure Normal High	30 - Document Findings

Figure 6-28Run 2 Generation 25 Solution to Administering Albuterol

Run 2 Generation 30 Solution to Administering Albuterol	
01 - Read Medical Triage Report	16 - Pre Medication Gauge Heart Rate Slow
02 - Collect Blood Pressure Cuff	17 - Post Medication Gauge Temperature High
03 - Knock Door	18 - Gauge IV Bag Half
04 - Pre Medication Assess Lung Sound Wheezes	19 - Complete Albuterol Worksheet
05 - Knock Door	20 - Introduce Self
06 - Pre Medication Gauge Temperature High	21 - Administer Albuterol Yes
07 - Collect Thermometer	22 - Determine Safe to Administer Medication Yes
08 - Pre Medication Gauge RespiratoryRate Normal	23 - Post Medication Assess Lung Sound Rhonci
09 - Administer Albuterol Yes	24 - Determine Medication Worked Yes
10 - Post Medication Gauge Heart Rate Normal	25 - Determine Conditions Right to Administer Yes
11 - Introduce Self	26 - Post Medication Gauge Respiratory Rate Fast
12 - Collect Albuterol	27 - Determine Medication Worked Yes
13 - Post Medication Assess Lung Sound Rhonci	28 - Post Medication Gauge Heart Rate Normal
14 - Knock Door	29 - Post Medication Gauge Blood Pressure Normal Normal
15 - Pre Medication Gauge Blood Pressure Normal High	30 - Document Findings

Figure 6-29*Run 2 Generation 30 Solution to Administering Albuterol*

Section 6.5.3: Best Solutions - Run # 03

Run 3 Generation 0 Solution to Administering Albuterol	
01 - Gauge IV Bag Low	16 - Document Findings
02 - Introduce Self	17 - Pre Medication Gauge Respiratory Rate Fast
03 - Complete Benadryl	18 - Collect Benadryl
04 - Administer Albuterol Yes	19 - Determine Ready to Enter Patient Room
05 - Collect Claritin	20 - Pre Medication Gauge Respiratory Rate Fast
06 - Read History and Physical	21 - Post Medication Gauge Heart Rate Normal
07 - Collect Caffiene	22 - Determine Safe to Administer Medication Yes
08 - Read Medical Triage Report	23 - Collect Isolation Gown
09 - Knock Door	24 - Wash Hands
10 - Elevate Bed 0 Degrees (Flat) Flat	25 - Collect Scale
11 - Read Nursing Data	26 - Collect Claritin
12 - Pre Medication Gauge Heart Rate Slow	27 - Read Nursing Assessment
13 - Determine Medication Worked Yes	28 - Collect Sterile Gloves
14 - Collect Mouthwash	29 - Post Medication Gauge Respiratory Rate Normal
15 - Collect Toothpaste	30 - Document Findings

Figure 6-30Run 3 Generation 0 Solution to Administering Albuterol

Run 3 Generation 5 Solution to Administering Albuterol	
01 - Read Medical Triage Report	16 - Wash Hands
02 - Collect Stethoscope	17 - Post Medication Assess Lung Sound Stridor
03 - Knock Door	18 - Post Medication Gauge Temperature High
04 - Collect Thermometer	19 - Pre Medication Gauge Blood Pressure Normal High
05 - Collect Blood Pressure Cuff	20 - Pre Medication Gauge Respiratory Rate Normal
06 - Determine Ready to Enter Patient Room	21 - Collect Albuterol
07 - Collect Thermometer	22 - Administer Albuterol Yes
08 - Collect Blood Pressure Cuff	23 - Document Findings
09 - Administer Albuterol Yes	24 - Determine Medication Worked Yes
10 - Knock Door	25 - Determine Medication Worked Yes
11 - Administer Albuterol Yes	26 - Complete Albuterol Worksheet
12 - Determine Ready to Enter Patient Room	27 - Determine Medication Worked Yes
13 - Introduce Self	28 - Post Medication Gauge Respiratory Rate Fast
14 - Pre Medication Assess Lung Sound Rhonci	29 - Determine Medication Worked Yes
15 - Document Findings	30 - Document Findings

Figure 6-31Run 3 Generation 5 Solution to Administering Albuterol

Run 3 Generation 10 Solution to Administering Albuterol	
01 - Read Medical Triage Report	16 - Post Medication Gauge Temperature High
02 - Collect Stethoscope	17 - Post Medication Assess Lung Sound Stridor
03 - Collect Blood Pressure Cuff	18 - Post Medication Gauge Temperature High
04 - Collect Thermometer	19 - Pre Medication Gauge Blood Pressure Normal High
05 - Collect Blood Pressure Cuff	20 - Pre Medication Gauge Respiratory Rate Normal
06 - Determine Ready to Enter Patient Room	21 - Collect Albuterol
07 - Administer Albuterol Yes	22 - Post Medication Gauge Heart Rate Normal
08 - Collect Blood Pressure Cuff	23 - Introduce Self
09 - Administer Albuterol Yes	24 - Determine Medication Worked Yes
10 - Knock Door	25 - Determine Medication Worked Yes
11 - Determine Safe to Administer Medication Yes	26 - Complete Albuterol Worksheet
12 - Pre Medication Gauge RespiratoryRate Fast	27 - Gauge IV Bag Low
13 - Introduce Self	28 - Post Medication Gauge Respiratory Rate Fast
14 - Pre Medication Gauge Temperature Normal	29 - Determine Safe to Administer Medication Yes
15 - Complete Albuterol Worksheet	30 - Document Findings

Figure 6-32Run 3 Generation 10 Solution to Administering Albuterol

Run 3 Generation 15 Solution to Administering Albuterol	
01 - Read Medical Triage Report	16 - Pre Medication Gauge Heart Rate Slow
02 - Collect Blood Pressure Cuff	17 - Post Medication Gauge Temperature High
03 - Knock Door	18 - Gauge IV Bag Half
04 - Pre Medication Assess Lung Sound Crackles	19 - Complete Albuterol Worksheet
05 - Knock Door	20 - Introduce Self
06 - Pre Medication Gauge Temperature High	21 - Administer Albuterol Yes
07 - Collect Thermometer	22 - Determine Safe to Administer Medication Yes
08 - Pre Medication Gauge RespiratoryRate Normal	23 - Post Medication Assess Lung Sound Rhonci
09 - Administer Albuterol Yes	24 - Determine Medication Worked Yes
10 - Post Medication Gauge Heart Rate Normal	25 - Determine Ready to Enter Patient Room
11 - Complete Albuterol Worksheet	26 - Post Medication Gauge Respiratory Rate Fast
12 - Collect Albuterol	27 - Determine Medication Worked Yes
13 - Post Medication Assess Lung Sound Rhonci	28 - Post Medication Gauge Heart Rate Normal
14 - Knock Door	29 - Post Medication Gauge Blood Pressure Normal Normal
15 - Pre Medication Gauge Blood Pressure Normal High	30 - Document Findings

Figure 6-33Run 3 Generation 15 Solution to Administering Albuterol

Run 3 Generation 20 Solution to Administering Albuterol	
01 - Read Medical Triage Report	16 - Pre Medication Gauge Heart Rate Slow
02 - Collect Blood Pressure Cuff	17 - Post Medication Gauge Temperature High
03 - Knock Door	18 - Gauge IV Bag Half
04 - Pre Medication Assess Lung Sound Wheezes	19 - Complete Albuterol Worksheet
05 - Knock Door	20 - Post Medication Gauge Heart Rate Normal
06 - Pre Medication Gauge Temperature High	21 - Administer Albuterol Yes
07 - Collect Thermometer	22 - Determine Safe to Administer Medication Yes
08 - Pre Medication Gauge RespiratoryRate Normal	23 - Post Medication Assess Lung Sound Rhonci
09 - Administer Albuterol Yes	24 - Determine Medication Worked Yes
10 - Post Medication Gauge Heart Rate Normal	25 - Determine Ready to Enter Patient Room
11 - Introduce Self	26 - Post Medication Gauge Respiratory Rate Fast
12 - Collect Albuterol	27 - Determine Medication Worked Yes
13 - Post Medication Assess Lung Sound Rhonci	28 - Post Medication Gauge Heart Rate Normal
14 - Knock Door	29 - Post Medication Gauge Blood Pressure Normal Normal
15 - Pre Medication Gauge Blood Pressure Normal High	30 - Document Findings

Figure 6-34Run 3 Generation 20 Solution to Administering Albuterol

Run 3 Generation 25 Solution to Administering Albuterol	
01 - Read Medical Triage Report	16 - Pre Medication Gauge Respiratory Rate Normal
02 - Collect Thermometer	17 - Post Medication Assess Lung Sound Stridor
03 - Post Medication Assess Lung Sound Normal	18 - Pre Medication Gauge Heart Rate Normal
04 - Pre Medication Assess Lung Sound Crackles	19 - Complete Albuterol Worksheet
05 - Knock Door	20 - Gauge IV Bag Half
06 - Knock Door	21 - Post Medication Gauge Respiratory Rate Fast
07 - Collect Blood Pressure Cuff	22 - Determine Safe to Administer Medication Yes
08 - Gauge IV Bag Half	23 - Pre Medication Gauge Temperature High
09 - Collect Stethoscope	24 - Determine Medication Worked Yes
10 - Determine Ready to Enter Patient Room	25 - Administer Albuterol Yes
11 - Pre Medication Gauge Blood Pressure Normal Normal	26 - Post Medication Assess Lung Sound Crackles
12 - Determine Safe to Administer Medication Yes	27 - Post Medication Gauge Blood Pressure Normal High
13 - Administer Albuterol Yes	28 - Post Medication Gauge Heart Rate Fast
14 - Post Medication Gauge Heart Rate Slow	29 - Introduce Self
15 - Determine Medication Worked Yes	30 - Document Findings

Figure 6-35Run 3 Generation 25 Solution to Administering Albuterol

Run 3 Generation 30 Solution to Administering Albuterol	
01 - Read Medical Triage Report	16 - Pre Medication Gauge Heart Rate Slow
02 - Collect Blood Pressure Cuff	17 - Post Medication Gauge Temperature High
03 - Knock Door	18 - Gauge IV Bag Half
04 - Pre Medication Assess Lung Sound Wheezes	19 - Complete Albuterol Worksheet
05 - Knock Door	20 - Determine Safe to Administer Medication Yes
06 - Pre Medication Gauge Temperature High	21 - Administer Albuterol Yes
07 - Collect Thermometer	22 - Determine Safe to Administer Medication Yes
08 - Pre Medication Gauge Respiratory Rate Normal	23 - Post Medication Assess Lung Sound Rhonci
09 - Administer Albuterol Yes	24 - Determine Medication Worked Yes
10 - Post Medication Gauge Heart Rate Normal	25 - Determine Ready to Enter Patient Room
11 - Introduce Self	26 - Post Medication Gauge Respiratory Rate Fast
12 - Collect Albuterol	27 - Determine Medication Worked Yes
13 - Post Medication Assess Lung Sound Rhonci	28 - Post Medication Gauge Heart Rate Normal
14 - Knock Door	29 - Post Medication Gauge Blood Pressure Normal Normal
15 - Pre Medication Gauge Blood Pressure Normal High	30 - Document Findings

Figure 6-36Run 3 Generation 30 Solution to Administering Albuterol

Section 6.5.4: Best Solutions - Run # 04

Run 4 Generation 0 Solution to Administering Albuterol	
01 - Collect Tissues	16 - Complete Albuterol Worksheet
02 - Read Orders	17 - Collect Toothpaste
03 - Determine Safe to Administer Medication Yes	18 - Read Nursing Data
04 - Collect Gloves	19 - Collect Ibuprofen
05 - Knock Door	20 - Complete Caffiene Worksheet
06 - Collect Specimen Cup	21 - Pre Medication Gauge Temperature Normal
07 - Collect Thermometer	22 - Post Medication Gauge Heart Rate Normal
08 - Collect Blood Pressure Cuff	23 - Read Orders
09 - Collect Benadryl	24 - Complete Benadryl
10 - Collect Scale	25 - Complete Albuterol Worksheet
11 - Collect Styrofoam Cup	26 - Collect Benadryl
12 - Complete Caffiene Worksheet	27 - Collect Advair
13 - Complete Ibuprofen Worksheet	28 - Collect Toothbrush
14 - Pre Medication Gauge Heart Rate Fast	29 - Collect Pajamas
15 - Pre Medication Gauge Heart Rate Fast	30 - Document Findings

Figure 6-37Run 4 Generation 0 Solution to Administering Albuterol

Run 4 Generation 5 Solution to Administering Albuterol	
01 - Read Medical Triage Report	16 - Post Medication Gauge Temperature High
02 - Collect Stethoscope	17 - Post Medication Assess Lung Sound Stridor
03 - Determine Medication Worked Yes	18 - Post Medication Gauge Temperature High
04 - Collect Thermometer	19 - Pre Medication Gauge Blood Pressure Normal High
05 - Collect Blood Pressure Cuff	20 - Pre Medication Gauge Respiratory Rate Normal
06 - Determine Ready to Enter Patient Room	21 - Collect Albuterol
07 - Pre Medication Gauge Respiratory Rate Fast	22 - Post Medication Gauge Blood Pressure Normal Normal
08 - Collect Blood Pressure Cuff	23 - Pre Medication Gauge Respiratory Rate Normal
09 - Administer Albuterol Yes	24 - Determine Medication Worked Yes
10 - Knock Door	25 - Determine Medication Worked Yes
11 - Administer Albuterol Yes	26 - Complete Albuterol Worksheet
12 - Administer Albuterol Yes	27 - Gauge IV Bag Low
13 - Introduce Self	28 - Post Medication Gauge Respiratory Rate Fast
14 - Pre Medication Gauge Temperature Normal	29 - Determine Ready to Enter Patient Room
15 - Complete Albuterol Worksheet	30 - Document Findings

Figure 6-38Run 4 Generation 5 Solution to Administering Albuterol

Run 4 Generation 10 Solution to Administering Albuterol	
01 - Read Medical Triage Report	16 - Pre Medication Gauge Respiratory Rate Normal
02 - Collect Thermometer	17 - Post Medication Assess Lung Sound Stridor
03 - Post Medication Assess Lung Sound Normal	18 - Pre Medication Gauge Heart Rate Normal
04 - Collect Blood Pressure Cuff	19 - Read History and Physical
05 - Knock Door	20 - Gauge IV Bag Half
06 - Knock Door	21 - Post Medication Gauge Respiratory Rate Fast
07 - Pre Medication Gauge Respiratory Rate Fast	22 - Post Medication Gauge Heart Rate Normal
08 - Pre Medication Gauge Respiratory Rate Normal	23 - Pre Medication Gauge Temperature High
09 - Collect Stethoscope	24 - Determine Medication Worked Yes
10 - Determine Ready to Enter Patient Room	25 - Administer Albuterol Yes
11 - Pre Medication Gauge Blood Pressure Normal Normal	26 - Post Medication Assess Lung Sound Normal
12 - Pre Medication Gauge Blood Pressure Normal High	27 - Post Medication Gauge Blood Pressure Normal High
13 - Administer Albuterol Yes	28 - Post Medication Gauge Heart Rate Fast
14 - Post Medication Gauge Heart Rate Slow	29 - Introduce Self
15 - Determine Medication Worked Yes	30 - Document Findings

Figure 6-39Run 4 Generation 10 Solution to Administering Albuterol

Run 4 Generation 15 Solution to Administering Albuterol	
01 - Read Medical Triage Report	16 - Wash Hands
02 - Administer Albuterol Yes	17 - Administer Albuterol Yes
03 - Post Medication Gauge Heart Rate Normal	18 - Pre Medication Gauge Heart Rate Normal
04 - Knock Door	19 - Post Medication Gauge Blood Pressure Normal Normal
05 - Pre Medication Assess Lung Sound Stridor	20 - Gauge IV Bag Half
06 - Knock Door	21 - Determine Ready to Enter Patient Room
07 - Determine Ready to Enter Patient Room	22 - Post Medication Gauge Heart Rate Normal
08 - Collect Stethoscope	23 - Pre Medication Gauge Respiratory Rate Normal
09 - Pre Medication Gauge Heart Rate Normal	24 - Determine Medication Worked Yes
10 - Determine Ready to Enter Patient Room	25 - Post Medication Assess Lung Sound Rhonci
11 - Post Medication Gauge Respiratory Rate Normal	26 - Post Medication Gauge Heart Rate Fast
12 - Administer Albuterol Yes	27 - Determine Medication Worked Yes
13 - Introduce Self	28 - Post Medication Gauge Respiratory Rate Normal
14 - Post Medication Gauge Heart Rate Slow	29 - Introduce Self
15 - Determine Medication Worked Yes	30 - Document Findings

Figure 6-40Run 4 Generation 15 Solution to Administering Albuterol

Run 4 Generation 20 Solution to Administering Albuterol	
01 - Read Medical Triage Report	16 - Pre Medication Gauge Respiratory Rate Normal
02 - Collect Thermometer	17 - Collect Gloves
03 - Post Medication Assess Lung Sound Normal	18 - Pre Medication Gauge Heart Rate Normal
04 - Pre Medication Gauge Heart Rate Normal	19 - Post Medication Gauge Temperature High
05 - Collect Specimen Cup	20 - Gauge IV Bag Half
06 - Knock Door	21 - Post Medication Gauge Respiratory Rate Fast
07 - Collect Blood Pressure Cuff	22 - Collect Advair
08 - Pre Medication Gauge Respiratory Rate Normal	23 - Pre Medication Gauge Temperature High
09 - Collect Stethoscope	24 - Determine Medication Worked Yes
10 - Determine Ready to Enter Patient Room	25 - Administer Albuterol Yes
11 - Pre Medication Gauge Blood Pressure Normal Normal	26 - Post Medication Assess Lung Sound Crackles
12 - Determine Safe to Administer Medication Yes	27 - Post Medication Gauge Blood Pressure Normal High
13 - Administer Albuterol Yes	28 - Post Medication Gauge Heart Rate Fast
14 - Post Medication Gauge Heart Rate Slow	29 - Introduce Self
15 - Determine Medication Worked Yes	30 - Document Findings

Figure 6-41Run 4 Generation 20 Solution to Administering Albuterol

Run 4 Generation 25 Solution to Administering Albuterol	
01 - Read Medical Triage Report	16 - Pre Medication Gauge Respiratory Rate Normal
02 - Collect Thermometer	17 - Collect Gloves
03 - Post Medication Assess Lung Sound Normal	18 - Pre Medication Gauge Heart Rate Normal
04 - Pre Medication Gauge Heart Rate Normal	19 - Post Medication Gauge Temperature High
05 - Collect Specimen Cup	20 - Gauge IV Bag Half
06 - Knock Door	21 - Post Medication Gauge Respiratory Rate Fast
07 - Collect Blood Pressure Cuff	22 - Collect Advair
08 - Gauge IV Bag Half	23 - Pre Medication Gauge Temperature High
09 - Collect Stethoscope	24 - Determine Medication Worked Yes
10 - Determine Ready to Enter Patient Room	25 - Administer Albuterol Yes
11 - Pre Medication Gauge Blood Pressure Normal Normal	26 - Post Medication Assess Lung Sound Crackles
12 - Determine Safe to Administer Medication Yes	27 - Post Medication Gauge Blood Pressure Normal High
13 - Administer Albuterol Yes	28 - Post Medication Gauge Heart Rate Fast
14 - Post Medication Gauge Heart Rate Slow	29 - Introduce Self
15 - Determine Medication Worked Yes	30 - Document Findings

Figure 6-42Run 4 Generation 25 Solution to Administering Albuterol

Run 4 Generation 30 Solution to Administering Albuterol	
01 - Read Medical Triage Report	16 - Pre Medication Gauge Respiratory Rate Normal
02 - Collect Thermometer	17 - Post Medication Assess Lung Sound Stridor
03 - Post Medication Assess Lung Sound Normal	18 - Pre Medication Gauge Heart Rate Normal
04 - Pre Medication Gauge Heart Rate Normal	19 - Post Medication Gauge Temperature High
05 - Collect Specimen Cup	20 - Gauge IV Bag Half
06 - Knock Door	21 - Post Medication Gauge Respiratory Rate Fast
07 - Collect Blood Pressure Cuff	22 - Collect Advair
08 - Pre Medication Gauge RespiratoryRate Normal	23 - Pre Medication Gauge Temperature High
09 - Collect Stethoscope	24 - Determine Medication Worked Yes
10 - Determine Ready to Enter Patient Room	25 - Administer Albuterol Yes
11 - Pre Medication Gauge Blood Pressure Normal Normal	26 - Post Medication Assess Lung Sound Crackles
12 - Determine Safe to Administer Medication Yes	27 - Post Medication Gauge Blood Pressure Normal High
13 - Administer Albuterol Yes	28 - Post Medication Gauge Heart Rate Fast
14 - Post Medication Gauge Heart Rate Slow	29 - Introduce Self
15 - Determine Medication Worked Yes	30 - Document Findings

Figure 6-43Run 4 Generation 30 Solution to Administering Albuterol

Section 6.5.5: Best Solutions - Run # 05

Run 5 Generation 0 Solution to Administering Albuterol	
01 - Read Medical Triage Report	16 - Complete Benadryl
02 - Knock Door	17 - Post Medication Gauge Respiratory Rate Fast
03 - Complete Acetaminophen Worksheet	18 - Read Consultation
04 - Collect Advair	19 - Read Orders
05 - Complete Advair Worksheet	20 - Collect Advair
06 - Read Medical Triage Report	21 - Post Medication Gauge Respiratory Rate Fast
07 - Determine Safe to Administer Medication Yes	22 - Collect Lotion
08 - Complete Flonase Worksheet	23 - Read Labs
09 - Collect Thermometer	24 - Determine Medication Worked Yes
10 - Complete Acetaminophen Worksheet	25 - Read Orders
11 - Collect Mask	26 - Collect Isolation Gown
12 - Post Medication Gauge Heart Rate Slow	27 - Read Nursing Assessment
13 - Collect Xolair	28 - Collect Toothpaste
14 - Post Medication Gauge Heart Rate Slow	29 - Wash Hands
15 - Collect Specimen Cup	30 - Collect Flonase

Figure 6-44Run 5 Generation 0 Solution to Administering Albuterol

Run 5 Generation 5 Solution to Administering Albuterol	
01 - Read Medical Triage Report	16 - Pre Medication Gauge Respiratory Rate Normal
02 - Complete Flonase Worksheet	17 - Post Medication Assess Lung Sound Normal
03 - Post Medication Gauge Temperature Normal	18 - Pre Medication Gauge Heart Rate Normal
04 - Collect Tissues	19 - Complete Acetaminophen Worksheet
05 - Read Progress Notes	20 - Gauge IV Bag Half
06 - Knock Door	21 - Post Medication Gauge Respiratory Rate Fast
07 - Complete Caffiene Worksheet	22 - Collect Comb
08 - Pre Medication Gauge Respiratory Rate Normal	23 - Complete Advair Worksheet
09 - Collect Thermometer	24 - Determine Medication Worked Yes
10 - Complete Xolair Worksheet	25 - Administer Albuterol Yes
11 - Pre Medication Gauge Blood Pressure Normal Normal	26 - Knock Door
12 - Determine Safe to Administer Medication Yes	27 - Post Medication Gauge Blood Pressure Normal High
13 - Collect Caffiene	28 - Post Medication Gauge Heart Rate Fast
14 - Post Medication Gauge Heart Rate Slow	29 - Introduce Self
15 - Read Progress Notes	30 - Document Findings

Figure 6-45Run 5 Generation 5 Solution to Administering Albuterol

Run 5 Generation 10 Solution to Administering Albuterol	
01 - Read Medical Triage Report	16 - Pre Medication Gauge Respiratory Rate Normal
02 - Collect Thermometer	17 - Post Medication Assess Lung Sound Stridor
03 - Collect Ice	18 - Pre Medication Gauge Heart Rate Normal
04 - Collect Flonase	19 - Read Progress Notes
05 - Collect Comb	20 - Gauge IV Bag Half
06 - Knock Door	21 - Post Medication Gauge Respiratory Rate Fast
07 - Collect Blood Pressure Cuff	22 - Collect Wireless on Wheels
08 - Gauge IV Bag Half	23 - Pre Medication Gauge Temperature High
09 - Collect Thermometer	24 - Determine Medication Worked Yes
10 - Determine Ready to Enter Patient Room	25 - Administer Albuterol Yes
11 - Pre Medication Gauge Blood Pressure Normal Normal	26 - Wash Hands
12 - Determine Safe to Administer Medication Yes	27 - Post Medication Gauge Blood Pressure Normal High
13 - Complete Ibuprofen Worksheet	28 - Post Medication Gauge Heart Rate Fast
14 - Post Medication Gauge Heart Rate Slow	29 - Introduce Self
15 - Determine Medication Worked Yes	30 - Document Findings

Figure 6-46Run 5 Generation 10 Solution to Administering Albuterol

Run 5 Generation 15 Solution to Administering Albuterol	
01 - Read Medical Triage Report	16 - Pre Medication Gauge Respiratory Rate Normal
02 - Collect Thermometer	17 - Post Medication Assess Lung Sound Stridor
03 - Collect Ice	18 - Pre Medication Gauge Heart Rate Normal
04 - Collect Blood Pressure Cuff	19 - Read Progress Notes
05 - Collect Comb	20 - Gauge IV Bag Half
06 - Knock Door	21 - Post Medication Gauge Respiratory Rate Fast
07 - Collect Blood Pressure Cuff	22 - Collect Wireless on Wheels
08 - Gauge IV Bag Half	23 - Pre Medication Gauge Temperature High
09 - Collect Thermometer	24 - Determine Medication Worked Yes
10 - Determine Ready to Enter Patient Room	25 - Administer Albuterol Yes
11 - Pre Medication Gauge Blood Pressure Normal Normal	26 - Wash Hands
12 - Determine Safe to Administer Medication Yes	27 - Post Medication Gauge Blood Pressure Normal High
13 - Complete Ibuprofen Worksheet	28 - Post Medication Gauge Heart Rate Fast
14 - Post Medication Gauge Heart Rate Slow	29 - Introduce Self
15 - Determine Medication Worked Yes	30 - Document Findings

Figure 6-47Run 5 Generation 15 Solution to Administering Albuterol

Run 5 Generation 20 Solution to Administering Albuterol	
01 - Read Medical Triage Report	16 - Pre Medication Gauge Respiratory Rate Normal
02 - Collect Thermometer	17 - Post Medication Assess Lung Sound Normal
03 - Collect Ice	18 - Pre Medication Gauge Heart Rate Normal
04 - Collect Blood Pressure Cuff	19 - Read Progress Notes
05 - Collect Comb	20 - Gauge IV Bag Half
06 - Knock Door	21 - Post Medication Gauge Respiratory Rate Fast
07 - Collect Blood Pressure Cuff	22 - Collect Wireless on Wheels
08 - Gauge IV Bag Half	23 - Pre Medication Gauge Temperature High
09 - Collect Thermometer	24 - Determine Medication Worked Yes
10 - Determine Ready to Enter Patient Room	25 - Administer Albuterol Yes
11 - Pre Medication Gauge Blood Pressure Normal Normal	26 - Wash Hands
12 - Determine Safe to Administer Medication Yes	27 - Post Medication Gauge Blood Pressure Normal High
13 - Complete Ibuprofen Worksheet	28 - Post Medication Gauge Heart Rate Fast
14 - Post Medication Gauge Heart Rate Slow	29 - Introduce Self
15 - Determine Medication Worked Yes	30 - Document Findings

Figure 6-48Run 5 Generation 20 Solution to Administering Albuterol

Run 5 Generation 25 Solution to Administering Albuterol	
01 - Read Medical Triage Report	16 - Pre Medication Gauge Respiratory Rate Normal
02 - Collect Thermometer	17 - Post Medication Assess Lung Sound Normal
03 - Collect Ice	18 - Pre Medication Gauge Heart Rate Normal
04 - Collect Flonase	19 - Read Progress Notes
05 - Collect Comb	20 - Gauge IV Bag Half
06 - Knock Door	21 - Post Medication Gauge Respiratory Rate Fast
07 - Collect Blood Pressure Cuff	22 - Collect Wireless on Wheels
08 - Pre Medication Gauge RespiratoryRate Normal	23 - Pre Medication Gauge Temperature High
09 - Collect Thermometer	24 - Determine Medication Worked Yes
10 - Determine Ready to Enter Patient Room	25 - Administer Albuterol Yes
11 - Pre Medication Gauge Blood Pressure Normal Normal	26 - Wash Hands
12 - Determine Safe to Administer Medication Yes	27 - Post Medication Gauge Blood Pressure Normal High
13 - Complete Ibuprofen Worksheet	28 - Post Medication Gauge Heart Rate Fast
14 - Post Medication Gauge Heart Rate Slow	29 - Introduce Self
15 - Determine Medication Worked Yes	30 - Document Findings

Figure 6-49Run 5 Generation 25 Solution to Administering Albuterol

Run 5 Generation 30 Solution to Administering Albuterol	
01 - Read Medical Triage Report	16 - Pre Medication Gauge Respiratory Rate Normal
02 - Collect Thermometer	17 - Post Medication Assess Lung Sound Normal
03 - Collect Ice	18 - Pre Medication Gauge Heart Rate Normal
04 - Collect Flonase	19 - Read Progress Notes
05 - Collect Comb	20 - Gauge IV Bag Half
06 - Knock Door	21 - Post Medication Gauge Respiratory Rate Fast
07 - Collect Blood Pressure Cuff	22 - Collect Wireless on Wheels
08 - Pre Medication Gauge RespiratoryRate Normal	23 - Pre Medication Gauge Temperature High
09 - Collect Thermometer	24 - Determine Medication Worked Yes
10 - Determine Ready to Enter Patient Room	25 - Administer Albuterol Yes
11 - Pre Medication Gauge Blood Pressure Normal Normal	26 - Wash Hands
12 - Determine Safe to Administer Medication Yes	27 - Post Medication Gauge Blood Pressure Normal High
13 - Complete Ibuprofen Worksheet	28 - Post Medication Gauge Heart Rate Fast
14 - Post Medication Gauge Heart Rate Slow	29 - Introduce Self
15 - Determine Medication Worked Yes	30 - Document Findings

Figure 6-50Run 5 Generation 30 Solution to Administering Albuterol

Section 6.5.6: Best Solutions - Run # 06

Run 6 Generation 0 Solution to Administering Albuterol	
01 - Read Medical Triage Report	16 - Determine Conditions Right to Administer Yes
02 - Pre Medication Gauge Temperature High	17 - Collect Lotion
03 - Read Orders	18 - Pre Medication Gauge Heart Rate Fast
04 - Read History and Physical	19 - Collect Wireless on Wheels
05 - Complete Xolair Worksheet	20 - Complete Ibuprofen Worksheet
06 - Collect Acetaminophen	21 - Post Medication Gauge Heart Rate Fast
07 - Complete Ibuprofen Worksheet	22 - Gauge IV Bag Empty
08 - Collect Toothpaste	23 - Pre Medication Assess Lung Sound Normal
09 - Determine Conditions Right to Administer Yes	24 - Complete Claritin Worksheet
10 - Read Progress Notes	25 - Complete Claritin Worksheet
11 - Collect Pajamas	26 - Pre Medication Gauge Heart Rate Fast
12 - Collect Caffiene	27 - Post Medication Gauge Respiratory Rate Normal
13 - Collect Flonase	28 - Collect Advair
14 - Complete Caffiene Worksheet	29 - Collect Mask
15 - Complete Acetaminophen Worksheet	30 - Collect Slippers

Figure 6-51Run 6 Generation 0 Solution to Administering Albuterol

Run 6 Generation 5 Solution to Administering Albuterol	
01 - Read Medical Triage Report	16 - Post Medication Assess Lung Sound Rhonci
02 - Collect Stethoscope	17 - Post Medication Assess Lung Sound Stridor
03 - Knock Door	18 - Post Medication Gauge Temperature High
04 - Collect Thermometer	19 - Pre Medication Gauge Blood Pressure Normal High
05 - Collect Thermometer	20 - Pre Medication Gauge Respiratory Rate Normal
06 - Determine Ready to Enter Patient Room	21 - Post Medication Assess Lung Sound Crackles
07 - Administer Albuterol Yes	22 - Administer Albuterol Yes
08 - Collect Blood Pressure Cuff	23 - Introduce Self
09 - Administer Albuterol Yes	24 - Determine Medication Worked Yes
10 - Knock Door	25 - Determine Medication Worked Yes
11 - Gauge IV Bag Empty	26 - Administer Albuterol Yes
12 - Determine Ready to Enter Patient Room	27 - Gauge IV Bag Low
13 - Introduce Self	28 - Post Medication Gauge Respiratory Rate Fast
14 - Pre Medication Gauge Temperature Normal	29 - Determine Medication Worked Yes
15 - Complete Albuterol Worksheet	30 - Document Findings

Figure 6-52Run 6 Generation 5 Solution to Administering Albuterol

Run 6 Generation 10 Solution to Administering Albuterol	
01 - Read Medical Triage Report	16 - Wash Hands
02 - Determine Ready to Enter Patient Room	17 - Administer Albuterol Yes
03 - Knock Door	18 - Pre Medication Gauge Heart Rate Normal
04 - Pre Medication Gauge Temperature Normal	19 - Post Medication Gauge Blood Pressure Normal Normal
05 - Gauge IV Bag Low	20 - Collect Styrofoam Cup
06 - Collect Albuterol	21 - Determine Ready to Enter Patient Room
07 - Knock Door	22 - Post Medication Gauge Temperature Normal
08 - Collect Stethoscope	23 - Pre Medication Gauge Respiratory Rate Normal
09 - Administer Albuterol Yes	24 - Collect Toothpaste
10 - Pre Medication Gauge Blood Pressure Normal Normal	25 - Post Medication Assess Lung Sound Rhonci
11 - Post Medication Gauge Respiratory Rate Normal	26 - Post Medication Gauge Heart Rate Fast
12 - Gauge IV Bag Low	27 - Determine Medication Worked Yes
13 - Introduce Self	28 - Post Medication Gauge Respiratory Rate Normal
14 - Complete Albuterol Worksheet	29 - Post Medication Assess Lung Sound Crackles
15 - Document Findings	30 - Document Findings

Figure 6-53Run 6 Generation 10 Solution to Administering Albuterol

Run 6 Generation 15 Solution to Administering Albuterol	
01 - Read Medical Triage Report	16 - Complete Albuterol Worksheet
02 - Collect Stethoscope	17 - Post Medication Assess Lung Sound Stridor
03 - Collect Blood Pressure Cuff	18 - Post Medication Gauge Temperature High
04 - Collect Thermometer	19 - Pre Medication Gauge Blood Pressure Normal High
05 - Administer Albuterol Yes	20 - Pre Medication Gauge Respiratory Rate Normal
06 - Determine Ready to Enter Patient Room	21 - Post Medication Assess Lung Sound Crackles
07 - Administer Albuterol Yes	22 - Administer Albuterol Yes
08 - Collect Blood Pressure Cuff	23 - Introduce Self
09 - Administer Albuterol Yes	24 - Determine Medication Worked Yes
10 - Knock Door	25 - Determine Medication Worked Yes
11 - Administer Albuterol Yes	26 - Complete Albuterol Worksheet
12 - Pre Medication Gauge Respiratory Rate Fast	27 - Gauge IV Bag Low
13 - Pre Medication Gauge Heart Rate Fast	28 - Post Medication Gauge Respiratory Rate Normal
14 - Pre Medication Gauge Temperature Normal	29 - Determine Safe to Administer Medication Yes
15 - Collect Albuterol	30 - Document Findings

Figure 6-54Run 6 Generation 15 Solution to Administering Albuterol

Run 6 Generation 20 Solution to Administering Albuterol	
01 - Read Medical Triage Report	16 - Pre Medication Assess Lung Sound Crackles
02 - Determine Ready to Enter Patient Room	17 - Administer Albuterol Yes
03 - Knock Door	18 - Pre Medication Gauge Heart Rate Normal
04 - Pre Medication Gauge Temperature Normal	19 - Post Medication Gauge Blood Pressure Normal Normal
05 - Collect Blood Pressure Cuff	20 - Collect Styrofoam Cup
06 - Collect Albuterol	21 - Determine Ready to Enter Patient Room
07 - Knock Door	22 - Post Medication Gauge Temperature Normal
08 - Collect Stethoscope	23 - Pre Medication Gauge Respiratory Rate Normal
09 - Pre Medication Gauge Heart Rate Normal	24 - Collect Toothpaste
10 - Pre Medication Gauge Blood Pressure Normal Normal	25 - Post Medication Assess Lung Sound Rhonci
11 - Post Medication Gauge Respiratory Rate Normal	26 - Post Medication Gauge Heart Rate Fast
12 - Gauge IV Bag Low	27 - Determine Medication Worked Yes
13 - Introduce Self	28 - Post Medication Gauge Respiratory Rate Normal
14 - Complete Albuterol Worksheet	29 - Post Medication Assess Lung Sound Crackles
15 - Determine Medication Worked Yes	30 - Document Findings

Figure 6-55Run 6 Generation 20 Solution to Administering Albuterol

Run 6 Generation 25 Solution to Administering Albuterol	
01 - Read Medical Triage Report	16 - Pre Medication Assess Lung Sound Crackles
02 - Determine Ready to Enter Patient Room	17 - Administer Albuterol Yes
03 - Knock Door	18 - Pre Medication Gauge Heart Rate Normal
04 - Pre Medication Gauge Temperature Normal	19 - Post Medication Gauge Blood Pressure Normal Normal
05 - Collect Blood Pressure Cuff	20 - Collect Styrofoam Cup
06 - Collect Albuterol	21 - Determine Ready to Enter Patient Room
07 - Knock Door	22 - Post Medication Gauge Temperature Normal
08 - Collect Stethoscope	23 - Pre Medication Gauge Respiratory Rate Normal
09 - Pre Medication Gauge Heart Rate Normal	24 - Collect Toothpaste
10 - Pre Medication Gauge Blood Pressure Normal Normal	25 - Post Medication Assess Lung Sound Rhonci
11 - Post Medication Gauge Respiratory Rate Normal	26 - Post Medication Gauge Heart Rate Fast
12 - Gauge IV Bag Low	27 - Determine Medication Worked Yes
13 - Introduce Self	28 - Post Medication Gauge Respiratory Rate Normal
14 - Complete Albuterol Worksheet	29 - Post Medication Assess Lung Sound Crackles
15 - Determine Medication Worked Yes	30 - Document Findings

Figure 6-56Run 6 Generation 25 Solution to Administering Albuterol

Run 6 Generation 30 Solution to Administering Albuterol	
01 - Read Medical Triage Report	16 - Pre Medication Assess Lung Sound Crackles
02 - Determine Ready to Enter Patient Room	17 - Administer Albuterol Yes
03 - Knock Door	18 - Pre Medication Gauge Heart Rate Normal
04 - Pre Medication Gauge Temperature Normal	19 - Post Medication Gauge Blood Pressure Normal Normal
05 - Collect Blood Pressure Cuff	20 - Collect Styrofoam Cup
06 - Collect Albuterol	21 - Determine Ready to Enter Patient Room
07 - Knock Door	22 - Post Medication Gauge Temperature Normal
08 - Collect Stethoscope	23 - Pre Medication Gauge Respiratory Rate Normal
09 - Pre Medication Gauge Heart Rate Normal	24 - Collect Toothpaste
10 - Pre Medication Gauge Blood Pressure Normal Normal	25 - Post Medication Assess Lung Sound Rhonci
11 - Post Medication Gauge Respiratory Rate Normal	26 - Post Medication Gauge Heart Rate Fast
12 - Gauge IV Bag Low	27 - Determine Medication Worked Yes
13 - Introduce Self	28 - Post Medication Gauge Respiratory Rate Normal
14 - Complete Albuterol Worksheet	29 - Post Medication Assess Lung Sound Crackles
15 - Determine Medication Worked Yes	30 - Document Findings

Figure 6-57Run 6 Generation 30 Solution to Administering Albuterol

Section 6.5.7: Best Solutions - Run # 07

Run 7 Generation 0 Solution to Administering Albuterol	
01 - Read Medical Triage Report	16 - Collect Acetaminophen
02 - Complete Caffiene Worksheet	17 - Collect Wireless on Wheels
03 - Determine Safe to Administer Medication Yes	18 - Complete Claritin Worksheet
04 - Read Consultation	19 - Post Medication Gauge Blood Pressure Normal Normal
05 - Complete Xolair Worksheet	20 - Document Findings
06 - Introduce Self	21 - Read Face Sheets
07 - Collect Caffiene	22 - Complete Flonase Worksheet
08 - Read Labs	23 - Collect Claritin
09 - Administer Albuterol Yes	24 - Collect Wireless on Wheels
10 - Post Medication Gauge Respiratory Rate Fast	25 - Complete Xolair Worksheet
11 - Complete Claritin Worksheet	26 - Collect Isolation Gown
12 - Complete Flonase Worksheet	27 - Read Medical Triage Report
13 - Collect Stethoscope	28 - Wash Hands
14 - Complete Ibuprofen Worksheet	29 - Collect Blue Otoscope
15 - Collect Toothpaste	30 - Read Nursing Assessment

Section 6.5.8: Best Solutions - Run # 08

Run 8 Generation 0 Solution to Administering Albuterol	
01 - Read Medical Triage Report	16 - Post Medication Assess Lung Sound Rhonci
02 - Collect Stethoscope	17 - Collect Blue Otoscope
03 - Collect Comb	18 - Collect Ibuprofen
04 - Collect Brush	19 - Collect Specimen Cup
05 - Pre Medication Gauge Temperature High	20 - Post Medication Gauge Respiratory Rate Fast
06 - Complete Ibuprofen Worksheet	21 - Read Nursing Assessment
07 - Administer Albuterol Yes	22 - Collect Stethoscope
08 - Collect Benadryl	23 - Collect Tissues
09 - Collect Caffiene	24 - Collect Acetaminophen
10 - Collect Styrofoam Cup	25 - Pre Medication Gauge Heart Rate Fast
11 - Collect Caffiene	26 - Read Consultation
12 - Post Medication Gauge Respiratory Rate Fast	27 - Collect Blood Pressure Cuff
13 - Complete Acetaminophen Worksheet	28 - Collect Brush
14 - Collect Specimen Cup	29 - Collect Specimen Cup
15 - Read History and Physical	30 - Complete Xolair Worksheet

Figure 6-58Run 8 Generation 0 Solution to Administering Albuterol

Run 8 Generation 5 Solution to Administering Albuterol	
01 - Read Medical Triage Report	16 - Post Medication Assess Lung Sound Rhonci
02 - Collect Stethoscope	17 - Post Medication Assess Lung Sound Stridor
03 - Determine Medication Worked Yes	18 - Knock Door
04 - Collect Thermometer	19 - Pre Medication Gauge Blood Pressure Normal High
05 - Collect Thermometer	20 - Collect Stethoscope
06 - Determine Ready to Enter Patient Room	21 - Collect Albuterol
07 - Administer Albuterol Yes	22 - Administer Albuterol Yes
08 - Collect Blood Pressure Cuff	23 - Document Findings
09 - Administer Albuterol Yes	24 - Determine Medication Worked Yes
10 - Knock Door	25 - Determine Medication Worked Yes
11 - Administer Albuterol Yes	26 - Complete Albuterol Worksheet
12 - Determine Ready to Enter Patient Room	27 - Gauge IV Bag Low
13 - Pre Medication Assess Lung Sound Crackles	28 - Post Medication Gauge Respiratory Rate Fast
14 - Pre Medication Assess Lung Sound Rhonci	29 - Post Medication Gauge Heart Rate Normal
15 - Complete Albuterol Worksheet	30 - Document Findings

Figure 6-59Run 8 Generation 5 Solution to Administering Albuterol

Run 8 Generation 10 Solution to Administering Albuterol	
01 - Read Medical Triage Report	16 - Pre Medication Gauge Blood Pressure Normal High
02 - Post Medication Gauge Respiratory Rate Normal	17 - Introduce Self
03 - Determine Medication Worked Yes	18 - Knock Door
04 - Collect Stethoscope	19 - Pre Medication Gauge Temperature High
05 - Collect Thermometer	20 - Gauge IV Bag Half
06 - Knock Door	21 - Post Medication Assess Lung Sound Crackles
07 - Administer Albuterol Yes	22 - Pre Medication Gauge Heart Rate Slow
08 - Collect Blood Pressure Cuff	23 - Document Findings
09 - Post Medication Gauge Blood Pressure Normal High	24 - Collect Sterile Gloves
10 - Read Progress Notes	25 - Determine Medication Worked Yes
11 - Wash Hands	26 - Administer Albuterol Yes
12 - Pre Medication Gauge Respiratory Rate Fast	27 - Determine Conditions Right to Administer Yes
13 - Pre Medication Gauge Temperature High	28 - Pre Medication Gauge Blood Pressure Normal High
14 - Determine Safe to Administer Medication Yes	29 - Determine Medication Worked Yes
15 - Knock Door	30 - Document Findings

Figure 6-60Run 8 Generation 10 Solution to Administering Albuterol

Run 8 Generation 15 Solution to Administering Albuterol	
01 - Read Medical Triage Report	16 - Complete Albuterol Worksheet
02 - Collect Stethoscope	17 - Post Medication Assess Lung Sound Stridor
03 - Collect Blood Pressure Cuff	18 - Post Medication Gauge Temperature High
04 - Collect Thermometer	19 - Pre Medication Gauge Blood Pressure Normal High
05 - Administer Albuterol Yes	20 - Pre Medication Gauge Respiratory Rate Normal
06 - Determine Ready to Enter Patient Room	21 - Collect Albuterol
07 - Administer Albuterol Yes	22 - Post Medication Gauge Heart Rate Normal
08 - Pre Medication Gauge Temperature High	23 - Introduce Self
09 - Administer Albuterol Yes	24 - Determine Medication Worked Yes
10 - Knock Door	25 - Determine Medication Worked Yes
11 - Determine Safe to Administer Medication Yes	26 - Complete Albuterol Worksheet
12 - Pre Medication Gauge Respiratory Rate Fast	27 - Gauge IV Bag Low
13 - Introduce Self	28 - Post Medication Gauge Respiratory Rate Fast
14 - Pre Medication Gauge Temperature Normal	29 - Determine Safe to Administer Medication Yes
15 - Collect Albuterol	30 - Document Findings

Figure 6-61Run 8 Generation 15 Solution to Administering Albuterol

Run 8 Generation 20 Solution to Administering Albuterol	
01 - Read Medical Triage Report	16 - Pre Medication Gauge Blood Pressure Normal High
02 - Post Medication Gauge Respiratory Rate Normal	17 - Introduce Self
03 - Determine Medication Worked Yes	18 - Knock Door
04 - Collect Stethoscope	19 - Pre Medication Gauge Temperature High
05 - Collect Thermometer	20 - Gauge IV Bag Half
06 - Knock Door	21 - Post Medication Assess Lung Sound Crackles
07 - Administer Albuterol Yes	22 - Pre Medication Gauge Heart Rate Slow
08 - Collect Blood Pressure Cuff	23 - Document Findings
09 - Post Medication Gauge Blood Pressure Normal High	24 - Collect Blood Pressure Cuff
10 - Pre Medication Assess Lung Sound Crackles	25 - Determine Medication Worked Yes
11 - Complete Albuterol Worksheet	26 - Administer Albuterol Yes
12 - Pre Medication Gauge Respiratory Rate Fast	27 - Determine Conditions Right to Administer Yes
13 - Post Medication Gauge Temperature High	28 - Complete Flonase Worksheet
14 - Determine Safe to Administer Medication Yes	29 - Determine Medication Worked Yes
15 - Knock Door	30 - Document Findings

Figure 6-62Run 8 Generation 20 Solution to Administering Albuterol

Run 8 Generation 25 Solution to Administering Albuterol	
01 - Read Medical Triage Report	16 - Pre Medication Gauge Blood Pressure Normal High
02 - Post Medication Gauge Respiratory Rate Normal	17 - Introduce Self
03 - Determine Medication Worked Yes	18 - Knock Door
04 - Collect Stethoscope	19 - Pre Medication Gauge Temperature High
05 - Collect Thermometer	20 - Gauge IV Bag Half
06 - Knock Door	21 - Post Medication Assess Lung Sound Crackles
07 - Administer Albuterol Yes	22 - Pre Medication Gauge Heart Rate Slow
08 - Collect Blood Pressure Cuff	23 - Document Findings
09 - Post Medication Gauge Blood Pressure Normal High	24 - Collect Blood Pressure Cuff
10 - Pre Medication Assess Lung Sound Crackles	25 - Determine Medication Worked Yes
11 - Complete Albuterol Worksheet	26 - Administer Albuterol Yes
12 - Pre Medication Gauge Respiratory Rate Fast	27 - Determine Conditions Right to Administer Yes
13 - Post Medication Gauge Temperature High	28 - Complete Flonase Worksheet
14 - Determine Safe to Administer Medication Yes	29 - Determine Medication Worked Yes
15 - Knock Door	30 - Document Findings

Figure 6-63Run 8 Generation 25 Solution to Administering Albuterol

Run 8 Generation 30 Solution to Administering Albuterol	
01 - Read Medical Triage Report	16 - Pre Medication Gauge Blood Pressure Normal High
02 - Post Medication Gauge Respiratory Rate Normal	17 - Introduce Self
03 - Determine Medication Worked Yes	18 - Knock Door
04 - Collect Stethoscope	19 - Pre Medication Gauge Temperature High
05 - Collect Thermometer	20 - Gauge IV Bag Half
06 - Knock Door	21 - Post Medication Assess Lung Sound Crackles
07 - Administer Albuterol Yes	22 - Pre Medication Gauge Heart Rate Slow
08 - Collect Blood Pressure Cuff	23 - Document Findings
09 - Post Medication Gauge Blood Pressure Normal High	24 - Collect Blood Pressure Cuff
10 - Pre Medication Assess Lung Sound Crackles	25 - Determine Medication Worked Yes
11 - Wash Hands	26 - Administer Albuterol Yes
12 - Pre Medication Gauge Respiratory Rate Fast	27 - Determine Conditions Right to Administer Yes
13 - Post Medication Gauge Temperature High	28 - Complete Flonase Worksheet
14 - Determine Safe to Administer Medication Yes	29 - Determine Medication Worked Yes
15 - Knock Door	30 - Document Findings

Figure 6-64Run 8 Generation 30 Solution to Administering Albuterol

Section 6.5.9: Best Solutions - Run # 09

Run 9 Generation 0 Solution to Administering Albuterol	
01 - Collect Specimen Cup	16 - Complete Benadryl
02 - Read Medical Triage Report	17 - Knock Door
03 - Collect Xolair	18 - Complete Benadryl
04 - Collect Stethoscope	19 - Collect Claritin
05 - Collect Brush	20 - Collect Mouthwash
06 - Post Medication Gauge Temperature Normal	21 - Read Consultation
07 - Read Discharge Planing or Patient Education	22 - Collect Pajamas
08 - Pre Medication Gauge Temperature High	23 - Read Consultation
09 - Collect Wireless on Wheels	24 - Knock Door
10 - Collect Toothbrush	25 - Read History and Physical
11 - Collect Ice	26 - Determine Ready to Enter Patient Room
12 - Complete Flonase Worksheet	27 - Post Medication Gauge Temperature Normal
13 - Complete Caffiene Worksheet	28 - Read Nursing Data
14 - Collect Albuterol	29 - Knock Door
15 - Complete Ibuprofen Worksheet	30 - Document Findings

Figure 6-65Run 9 Generation 0 Solution to Administering Albuterol

Run 9 Generation 5 Solution to Administering Albuterol	
01 - Read Medical Triage Report	16 - Post Medication Assess Lung Sound Rhonci
02 - Collect Pajamas	17 - Post Medication Assess Lung Sound Stridor
03 - Collect Blood Pressure Cuff	18 - Post Medication Gauge Temperature High
04 - Collect Thermometer	19 - Pre Medication Gauge Blood Pressure Normal High
05 - Administer Albuterol Yes	20 - Pre Medication Gauge Respiratory Rate Normal
06 - Determine Ready to Enter Patient Room	21 - Collect Albuterol
07 - Collect Thermometer	22 - Post Medication Gauge Blood Pressure Normal Normal
08 - Collect Blood Pressure Cuff	23 - Introduce Self
09 - Administer Albuterol Yes	24 - Determine Medication Worked Yes
10 - Knock Door	25 - Complete Benadryl
11 - Determine Safe to Administer Medication Yes	26 - Complete Albuterol Worksheet
12 - Determine Ready to Enter Patient Room	27 - Gauge IV Bag Low
13 - Pre Medication Gauge Heart Rate Fast	28 - Post Medication Gauge Respiratory Rate Fast
14 - Pre Medication Gauge Temperature Normal	29 - Determine Safe to Administer Medication Yes
15 - Complete Albuterol Worksheet	30 - Document Findings

Figure 6-66Run 9 Generation 5 Solution to Administering Albuterol

Run 9 Generation 10 Solution to Administering Albuterol	
01 - Read Medical Triage Report	16 - Post Medication Gauge Temperature High
02 - Collect Stethoscope	17 - Post Medication Assess Lung Sound Stridor
03 - Collect Blood Pressure Cuff	18 - Read Labs
04 - Collect Thermometer	19 - Pre Medication Gauge Blood Pressure Normal High
05 - Administer Albuterol Yes	20 - Pre Medication Gauge Respiratory Rate Normal
06 - Determine Ready to Enter Patient Room	21 - Collect Albuterol
07 - Collect Ice	22 - Post Medication Gauge Heart Rate Normal
08 - Pre Medication Gauge Temperature High	23 - Collect Blue Otoscope
09 - Administer Albuterol Yes	24 - Determine Medication Worked Yes
10 - Knock Door	25 - Read Nursing Data
11 - Determine Safe to Administer Medication Yes	26 - Complete Albuterol Worksheet
12 - Collect Wireless on Wheels	27 - Gauge IV Bag Low
13 - Introduce Self	28 - Post Medication Gauge Respiratory Rate Fast
14 - Pre Medication Gauge Temperature Normal	29 - Determine Safe to Administer Medication Yes
15 - Complete Albuterol Worksheet	30 - Document Findings

Figure 6-67Run 9 Generation 10 Solution to Administering Albuterol

Run 9 Generation 15 Solution to Administering Albuterol	
01 - Read Medical Triage Report	16 - Post Medication Gauge Temperature High
02 - Collect Stethoscope	17 - Post Medication Assess Lung Sound Stridor
03 - Collect Blood Pressure Cuff	18 - Read Labs
04 - Collect Thermometer	19 - Pre Medication Gauge Blood Pressure Normal High
05 - Collect Blood Pressure Cuff	20 - Pre Medication Gauge Respiratory Rate Normal
06 - Determine Ready to Enter Patient Room	21 - Collect Albuterol
07 - Collect Ice	22 - Post Medication Gauge Heart Rate Normal
08 - Pre Medication Gauge Temperature High	23 - Collect Blue Otoscope
09 - Administer Albuterol Yes	24 - Determine Medication Worked Yes
10 - Knock Door	25 - Read Nursing Data
11 - Determine Safe to Administer Medication Yes	26 - Complete Albuterol Worksheet
12 - Collect Wireless on Wheels	27 - Gauge IV Bag Low
13 - Introduce Self	28 - Post Medication Gauge Respiratory Rate Fast
14 - Pre Medication Gauge Temperature Normal	29 - Determine Safe to Administer Medication Yes
15 - Complete Albuterol Worksheet	30 - Document Findings

Figure 6-68Run 9 Generation 15 Solution to Administering Albuterol

Run 9 Generation 20 Solution to Administering Albuterol	
01 - Read Medical Triage Report	16 - Post Medication Gauge Temperature High
02 - Collect Stethoscope	17 - Post Medication Assess Lung Sound Stridor
03 - Collect Blood Pressure Cuff	18 - Read Labs
04 - Collect Thermometer	19 - Pre Medication Gauge Blood Pressure Normal High
05 - Administer Albuterol Yes	20 - Pre Medication Gauge Respiratory Rate Normal
06 - Determine Ready to Enter Patient Room	21 - Collect Albuterol
07 - Collect Ice	22 - Post Medication Gauge Heart Rate Normal
08 - Pre Medication Gauge Temperature High	23 - Collect Blue Otoscope
09 - Administer Albuterol Yes	24 - Determine Medication Worked Yes
10 - Knock Door	25 - Read Nursing Data
11 - Determine Safe to Administer Medication Yes	26 - Complete Albuterol Worksheet
12 - Collect Wireless on Wheels	27 - Gauge IV Bag Low
13 - Introduce Self	28 - Post Medication Gauge Respiratory Rate Fast
14 - Pre Medication Gauge Temperature Normal	29 - Determine Safe to Administer Medication Yes
15 - Complete Albuterol Worksheet	30 - Document Findings

Figure 6-69Run 9 Generation 20 Solution to Administering Albuterol

Run 9 Generation 25 Solution to Administering Albuterol	
01 - Read Medical Triage Report	16 - Post Medication Gauge Temperature High
02 - Collect Stethoscope	17 - Post Medication Assess Lung Sound Stridor
03 - Collect Blood Pressure Cuff	18 - Read Labs
04 - Collect Thermometer	19 - Pre Medication Gauge Blood Pressure Normal High
05 - Administer Albuterol Yes	20 - Pre Medication Gauge Respiratory Rate Normal
06 - Determine Ready to Enter Patient Room	21 - Collect Albuterol
07 - Collect Ice	22 - Post Medication Gauge Heart Rate Normal
08 - Pre Medication Gauge Temperature High	23 - Collect Blue Otoscope
09 - Administer Albuterol Yes	24 - Determine Medication Worked Yes
10 - Knock Door	25 - Read Nursing Data
11 - Determine Safe to Administer Medication Yes	26 - Complete Albuterol Worksheet
12 - Collect Wireless on Wheels	27 - Gauge IV Bag Low
13 - Introduce Self	28 - Post Medication Gauge Respiratory Rate Fast
14 - Pre Medication Gauge Temperature Normal	29 - Determine Safe to Administer Medication Yes
15 - Complete Albuterol Worksheet	30 - Document Findings

Figure 6-70Run 9 Generation 25 Solution to Administering Albuterol

Run 9 Generation 30 Solution to Administering Albuterol	
01 - Read Medical Triage Report	16 - Post Medication Gauge Temperature High
02 - Collect Stethoscope	17 - Post Medication Assess Lung Sound Stridor
03 - Collect Blood Pressure Cuff	18 - Read Labs
04 - Collect Thermometer	19 - Pre Medication Gauge Blood Pressure Normal High
05 - Collect Blood Pressure Cuff	20 - Pre Medication Gauge Respiratory Rate Normal
06 - Determine Ready to Enter Patient Room	21 - Collect Albuterol
07 - Collect Ice	22 - Post Medication Gauge Heart Rate Normal
08 - Pre Medication Gauge Temperature High	23 - Collect Blue Otoscope
09 - Administer Albuterol Yes	24 - Determine Medication Worked Yes
10 - Knock Door	25 - Read Nursing Data
11 - Determine Safe to Administer Medication Yes	26 - Complete Albuterol Worksheet
12 - Collect Wireless on Wheels	27 - Gauge IV Bag Low
13 - Introduce Self	28 - Post Medication Gauge Respiratory Rate Fast
14 - Pre Medication Gauge Temperature Normal	29 - Determine Safe to Administer Medication Yes
15 - Complete Albuterol Worksheet	30 - Document Findings

Figure 6-71Run 9 Generation 30 Solution to Administering Albuterol

Section 6.5.10: Best Solutions - Run # 10

Run 10 Generation 0 Solution to Administering Albuterol	
01 - Collect Isolation Gown	16 - Collect Flonase
02 - Collect Sterile Gloves	17 - Wash Hands
03 - Collect Caffiene	18 - Complete Ibuprofen Worksheet
04 - Collect Thermometer	19 - Read Medical Triage Report
05 - Read Medical Triage Report	20 - Collect Stethoscope
06 - Complete Caffiene Worksheet	21 - Introduce Self
07 - Collect Blood Pressure Cuff	22 - Document Findings
08 - Collect Blood Pressure Cuff	23 - Complete Ibuprofen Worksheet
09 - Complete Acetaminophen Worksheet	24 - Collect Slippers
10 - Read Nursing Data	25 - Collect Benadryl
11 - Collect Toothbrush	26 - Post Medication Gauge Blood Pressure Normal Normal
12 - Determine Ready to Enter Patient Room	27 - Collect Tissues
13 - Collect Thermometer	28 - Collect Toothpaste
14 - Collect Flonase	29 - Collect Acetaminophen
15 - Collect Styrofoam Cup	30 - Document Findings

Figure 6-72Run 10 Generation 0 Solution to Administering Albuterol

Run 10 Generation 5 Solution to Administering Albuterol	
01 - Read Medical Triage Report	16 - Complete Albuterol Worksheet
02 - Collect Stethoscope	17 - Post Medication Assess Lung Sound Stridor
03 - Collect Advair	18 - Post Medication Gauge Temperature High
04 - Collect Thermometer	19 - Pre Medication Gauge Blood Pressure Normal High
05 - Collect Tissues	20 - Pre Medication Gauge Respiratory Rate Normal
06 - Determine Ready to Enter Patient Room	21 - Collect Albuterol
07 - Read Discharge Planing or Patient Education	22 - Collect Lotion
08 - Collect Acetaminophen	23 - Read Medical Triage Report
09 - Administer Albuterol Yes	24 - Determine Medication Worked Yes
10 - Knock Door	25 - Read Labs
11 - Administer Albuterol Yes	26 - Complete Albuterol Worksheet
12 - Determine Ready to Enter Patient Room	27 - Read Labs
13 - Introduce Self	28 - Post Medication Gauge Respiratory Rate Fast
14 - Pre Medication Assess Lung Sound Rhonci	29 - Collect Gloves
15 - Determine Ready to Enter Patient Room	30 - Document Findings

Figure 6-73Run 10 Generation 5 Solution to Administering Albuterol

Run 10 Generation 10 Solution to Administering Albuterol	
01 - Read Medical Triage Report	16 - Complete Albuterol Worksheet
02 - Collect Stethoscope	17 - Post Medication Assess Lung Sound Stridor
03 - Collect Blood Pressure Cuff	18 - Post Medication Gauge Temperature High
04 - Collect Thermometer	19 - Pre Medication Gauge Blood Pressure Normal High
05 - Administer Albuterol Yes	20 - Pre Medication Gauge Respiratory Rate Normal
06 - Determine Ready to Enter Patient Room	21 - Collect Albuterol
07 - Read Discharge Planing or Patient Education	22 - Administer Albuterol Yes
08 - Collect Blood Pressure Cuff	23 - Introduce Self
09 - Administer Albuterol Yes	24 - Determine Medication Worked Yes
10 - Knock Door	25 - Read Labs
11 - Administer Albuterol Yes	26 - Complete Albuterol Worksheet
12 - Read Consultation	27 - Gauge IV Bag Low
13 - Pre Medication Gauge Heart Rate Fast	28 - Post Medication Gauge Respiratory Rate Fast
14 - Pre Medication Gauge Temperature Normal	29 - Determine Safe to Administer Medication Yes
15 - Collect Albuterol	30 - Document Findings

Figure 6-74Run 10 Generation 10 Solution to Administering Albuterol

Run 10 Generation 15 Solution to Administering Albuterol	
01 - Read Medical Triage Report	16 - Complete Albuterol Worksheet
02 - Collect Stethoscope	17 - Post Medication Assess Lung Sound Stridor
03 - Collect Blood Pressure Cuff	18 - Post Medication Gauge Temperature High
04 - Collect Thermometer	19 - Pre Medication Gauge Blood Pressure Normal High
05 - Administer Albuterol Yes	20 - Pre Medication Gauge Respiratory Rate Normal
06 - Determine Ready to Enter Patient Room	21 - Collect Albuterol
07 - Read Discharge Planing or Patient Education	22 - Administer Albuterol Yes
08 - Collect Blood Pressure Cuff	23 - Introduce Self
09 - Administer Albuterol Yes	24 - Determine Medication Worked Yes
10 - Knock Door	25 - Read Labs
11 - Administer Albuterol Yes	26 - Complete Albuterol Worksheet
12 - Read Consultation	27 - Gauge IV Bag Low
13 - Pre Medication Gauge Heart Rate Fast	28 - Post Medication Gauge Respiratory Rate Fast
14 - Pre Medication Gauge Temperature Normal	29 - Determine Safe to Administer Medication Yes
15 - Collect Albuterol	30 - Document Findings

Figure 6-75Run 10 Generation 15 Solution to Administering Albuterol

Run 10 Generation 20 Solution to Administering Albuterol	
01 - Read Medical Triage Report	16 - Complete Albuterol Worksheet
02 - Collect Stethoscope	17 - Post Medication Assess Lung Sound Stridor
03 - Collect Blood Pressure Cuff	18 - Post Medication Gauge Temperature High
04 - Collect Thermometer	19 - Pre Medication Gauge Blood Pressure Normal High
05 - Administer Albuterol Yes	20 - Pre Medication Gauge Respiratory Rate Normal
06 - Determine Ready to Enter Patient Room	21 - Pre Medication Gauge Heart Rate Normal
07 - Complete Acetaminophen Worksheet	22 - Administer Albuterol Yes
08 - Collect Mask	23 - Introduce Self
09 - Collect Benadryl	24 - Determine Medication Worked Yes
10 - Knock Door	25 - Collect Lotion
11 - Administer Albuterol Yes	26 - Complete Albuterol Worksheet
12 - Wash Hands	27 - Gauge IV Bag Low
13 - Pre Medication Gauge Heart Rate Fast	28 - Post Medication Gauge Respiratory Rate Fast
14 - Pre Medication Gauge Temperature Normal	29 - Determine Safe to Administer Medication Yes
15 - Collect Albuterol	30 - Document Findings

Figure 6-76Run 10 Generation 20 Solution to Administering Albuterol

Run 10 Generation 25 Solution to Administering Albuterol	
01 - Read Medical Triage Report	16 - Complete Albuterol Worksheet
02 - Collect Stethoscope	17 - Post Medication Assess Lung Sound Stridor
03 - Collect Blood Pressure Cuff	18 - Post Medication Gauge Temperature High
04 - Collect Thermometer	19 - Pre Medication Gauge Blood Pressure Normal High
05 - Administer Albuterol Yes	20 - Pre Medication Gauge Respiratory Rate Normal
06 - Determine Ready to Enter Patient Room	21 - Pre Medication Gauge Heart Rate Normal
07 - Complete Acetaminophen Worksheet	22 - Administer Albuterol Yes
08 - Collect Mask	23 - Introduce Self
09 - Collect Benadryl	24 - Determine Medication Worked Yes
10 - Knock Door	25 - Collect Lotion
11 - Administer Albuterol Yes	26 - Complete Albuterol Worksheet
12 - Wash Hands	27 - Gauge IV Bag Low
13 - Pre Medication Gauge Heart Rate Fast	28 - Post Medication Gauge Respiratory Rate Fast
14 - Pre Medication Gauge Temperature Normal	29 - Determine Safe to Administer Medication Yes
15 - Collect Albuterol	30 - Document Findings

Figure 6-77Run 10 Generation 25 Solution to Administering Albuterol

Run 10 Generation 30 Solution to Administering Albuterol	
01 - Read Medical Triage Report	16 - Complete Albuterol Worksheet
02 - Collect Stethoscope	17 - Post Medication Assess Lung Sound Stridor
03 - Collect Blood Pressure Cuff	18 - Post Medication Gauge Temperature High
04 - Collect Thermometer	19 - Pre Medication Gauge Blood Pressure Normal High
05 - Administer Albuterol Yes	20 - Pre Medication Gauge Respiratory Rate Normal
06 - Determine Ready to Enter Patient Room	21 - Pre Medication Gauge Heart Rate Normal
07 - Complete Acetaminophen Worksheet	22 - Administer Albuterol Yes
08 - Collect Mask	23 - Introduce Self
09 - Collect Benadryl	24 - Determine Medication Worked Yes
10 - Knock Door	25 - Collect Lotion
11 - Administer Albuterol Yes	26 - Complete Albuterol Worksheet
12 - Wash Hands	27 - Gauge IV Bag Low
13 - Pre Medication Gauge Heart Rate Fast	28 - Post Medication Gauge Respiratory Rate Fast
14 - Pre Medication Gauge Temperature Normal	29 - Determine Safe to Administer Medication Yes
15 - Collect Albuterol	30 - Document Findings

Figure 6-78Run 10 Generation 30 Solution to Administering Albuterol

Chapter 7: CONCLUSIONS

In summary, this thesis presented Cultural Algorithms (CA) as an avenue for learning critical decision making skills (plans) in the Pediatric Nursing world. There was a journey that started with a statement of a real-world problem to solve. It continued with the set up for CA within the scope of solving that problem. It ended with an analysis of the learning that took place at various generations for the best run of experiments.

The computed optimal solution was compared to a human optimal solution for the same stated problem. The end result was not only an optimal progression of tasks, but also a glimpse into just how Pediatric Nurses learn themselves.

Section 7.1: Future Work

The optimal solutions generated here shared many elements of the human generated one. In fact, the best solution only satisfied 80% of these elements based on the programmed domain knowledge. To this end, future work would concentrate on a possible way to refine that rules set. Moreover, that work could also be extended to allow for two-way interaction between Nurse and Patient.

Section 7.1.1: Make Domain Knowledge Non-Static

To simplify the evolutionary process of Cultural Algorithms, the Domain Knowledge rules contained in the Belief Space was purposefully kept static. Initially, rules were developed based on “common” knowledge in physical systems. For example, the stethoscope must have been collected before taking a lung assessment. Additional rules were developed based on “medical treatment” knowledge taken from the Pediatric Nursing domain expert. For example, Albuterol should only be administered if the patient temperature is “Normal” and the pre-

medication lung assessment is "Wheezing." In the process generation, over 50 rules were introduced. Not all 50 rules can be considered necessary however. By adding Domain Knowledge to the evolutionary process, unnecessary rules could be weeded out. Fewer rules translate into less processing time, especially for 10 runs at 1000 generations each. Moreover, rules that were deemed necessary could be weighted differently and could result in solutions that are more in alignment with human optimal ones.

Section 7.1.2: Inject Patient Interactions to the Task List Mix

For these experiments, all tasks were based on an agent's assessment of various conditions. For example, tasks were geared towards a co-operative patient who allowed for easy access to vital signs and other patient interaction. It would be interesting to interject non-cooperative patient responses. For example, additional tasks could be added and evaluated for patients that are in pain or non-responsive. Moreover, additional dialogue-related tasks could be added and evaluated for parents that are interfering with the Nurses' delivery of quality medical care.

Section 7.1.3: Allow For Decision to Not Delivery Albuterol

For the results chapter, analysis was focused on a chain of tasks that were geared towards cases where albuterol was actually delivered. A more complete approach would be to allow for the opposite decision to NOT deliver an Albuterol Treatment.

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ABSTRACT

UBIQUITOUS LEARNING LABORATORY FOR PEDIATRIC NURSING: A CULTURAL ALGORITHM APPROACH

by

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December 2012

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Degree: Master of Science

Quality Medical Care is at the focus of all health care service providers. Each facility maintains a standard level of care that promises not only a precise diagnosis, but also the correct course of treatment. In part, this is due to the educational training and professional experience of Nurses. For high-risk patients such as children, the level of expertise of a Pediatric Nurse is even more critical in order to guarantee patient safety.

Pediatric Nurses do not necessarily have the same level of expertise in critical thinking and overall patient care, however. This can be attributed to variables in teaching institutions, training environments, and even demographic backgrounds. Moreover, the lack of a teaching paradigm that captures the attention of today's technology-savvy student could also be a contributing factor.

In this thesis, a learning framework is proposed that serves as an extension to accepted nursing curriculum. This framework is a 2d serious Educational Puzzle game based on the classic board game Clue. Clue involves solving a murder mystery utilizing character interaction and discovery / observation of objects within a given room. I-CARE is similar except this game involves determining a Medical Diagnoses utilizing patient interaction (i.e. character dialogue) and accessing various rooms (i.e. Class Room, Equipment, Patient, Medical Supplies, etc.) in order to deliver medical care.

The I-CARE application encapsulates a virtual world that makes use of all perceptual modes (i.e. visual, auditory, and haptic), just like a real Children's Hospital. The framework is developed for a mobile platform using XNA 4.0 technology. It offers a portable world where nurses can develop critical thinking skills and practice delivering quality medical care. With game play, they accumulate a progression of tasks required to deliver an Albuterol treatment to a pediatrics patient. These may not be the most efficient progression of tasks, however.

Cultural Algorithms is an agent-based evolutionary method used to computationally determine the most efficient progression of tasks to deliver an Albuterol treatment. It begins by capturing all of the tasks available in the I-CARE virtual world. Next, it describes the rules of how those tasks can come together in terms of pre- and post-conditions of task usage. Finally, these rules are weighted in a manner that allows for task inclusion along with its relative position within the task progression.

Cultural Algorithms is shown to be more than an experimental framework. It is also shown to be a learning mechanism as well. Through the execution of 10 runs at 1000 generations each, an analysis of the best learning example is performed. This analysis breaks

down the progression of fitness scores over each generation to identify segments of learning. The idea is to not only determine an optimal solution to the stated problem, but to also identify how pediatric nurses learn themselves.

AUTOBIOGRAPHICAL STATEMENT

David graduated with a B.S. in Computer Science from the University of Michigan, Ann Arbor in 1997. He has worked professionally in the IT field for over 20 years. His specialties include Database Architecture and Design as well as Application Development.

David had a calling to expand his educational experience and was excited to pursue a Master's Degree at Wayne State University. After taking both courses in Artificial Intelligence and Game Design taught by Dr. Robert Reynolds, David was further inspired to apply those new skills in a real-world scenario. He did this by working on a Master's Thesis Project versus the alternate bunch-of-classes approach.

In his spare time, David enjoys going to the movies, concerts at the DSO, attending events at the Detroit River Walk, as well as exploring fine-dining experiences throughout the Metro Detroit area.