Leadership and Performance: Does a System Dynamics Flight Simulator Support the Need for Leaders to Learn Subordinate Personalities?

by
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by
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ABSTRACT

Leaders and subordinates share a complex and complicated relationship, and leaders directly influence the mental state and subsequent physical performance of their subordinates. System Dynamics (SD) models complex relationships and variables via causal feedback loops. Participants interacted with the Leadership and Performance Model (LPM) Flight Simulator. after being briefed on their given subordinate. One group knew the simulated Subordinate's personality ahead of time, and one did not. Players' choices influenced their Subordinates' Army Combat Fitness Test (ACFT) scores, motivation, and energy. The average Overall Simulation Scores (OSS) suggested that knowing a subordinate's personality can expedite performance improvement. However, there was no statistical significance between the two groups. There was also no statistical significance between the speed of learning between the two groups, but there was an overall increase in scores from earlier simulations to later simulations, suggesting that participants profiled their Subordinate more accurately as time went on. It is also possible that an SD education of these dynamic relationships may inspire Army leaders to make more informed choices.

Keywords: System Dynamics, leadership, performance, Army, ACFT, motivation, interface, flight simulator

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Leadership and Performance: Does a System Dynamics Flight Simulator Support the Need for Leaders to Learn Subordinate Personalities?

This project focuses on the relationship between leaders and subordinates, and how that modeled relationship may behave in a simulated environment. The research will test human participants' interactions with a flight simulator interface of the Leadership and Performance Model (LPM). The Interactive Qualifying Project (IQP) titled *The Interaction of Physiological and Psychological Factors on Human Physical Performance in the U.S. Army - A System Dynamics Approach,* by Champagne et al. (2022), explains the creation of the LPM in depth. This model divides psychophysiological factors and physical performance into sectors, and mathematically calculates a Subordinate's predicted performance based on the goals their Leader sets for them, their physical and psychological state, and whether or not their Leader behaves towards them positively or negatively.

This project focuses more closely on the psychological and cognitive aspects of the existing model, and conducts a scientific experiment with an existing System Dynamics model. This project is essentially a continuation of that IQP. Creating a user-friendly interface for the LPM was a large part of the research, but actually collecting the data needed for analysis was essential to answering the following research questions:

> How does a Leader's knowledge of Subordinate personality affect Army leadership choices in Leader/Subordinate relationships? And, in turn, affect

Subordinate physical performance? Do real Army leaders make the choices necessary to adapt to their subordinate's personality styles?

These research questions were selected based upon the knowledge that the IQP revealed. The creation of the LPM was made possible under the assumption that there was some sort of link between someone's psychological state and their physical performance, and that leaders can affect the psychological state of their subordinates. Originally, the four personalities in the LPM existed solely for calibration purposes. The MQP expands on these personality styles, assuming that real people identify with at least one of the personalities. Of course, there are more than four personalities that a person could have. Once operating under this assumption, the MQP tested Army leaders in-person on how well they could improve their simulated Subordinate's performance based on whether or not they were aware which of the four personalities the Subordinate had been calibrated with. Not only was this independent variable tested for statistical significance, but there was additional analysis on the overall learning curve of each participant, which offered insight into how leaders may adapt to input over time.

It was hypothesized that if Army leaders are aware of their subordinate's personality and likely reaction to certain behavior, then they will be able to adapt to their subordinates and improve performance in a more efficient fashion than those that are not aware of their subordinate's personality. It was also hypothesized that participants will achieve a higher score in their later simulations than their first simulation, regardless of any knowledge of their Subordinate's personality. This will support the notion that participants are learning about their simulated Subordinate along the way and adapting to the feedback that they are provided with.

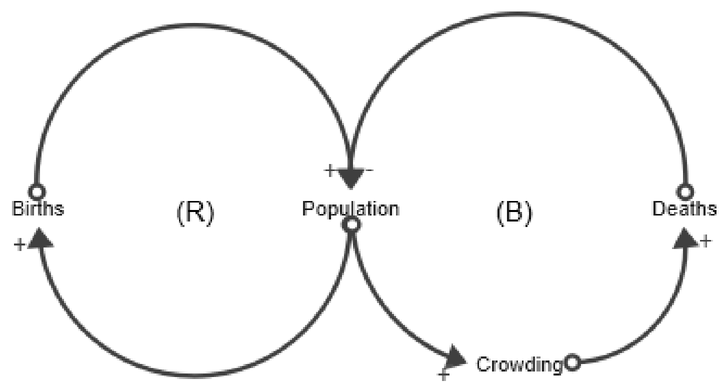
This hypothesis will be tested with the two different groups, one group aware of their subordinate's personality, and the other unaware. A statistical analysis of the data will be conducted in order to determine if there are any statistically significant differences between the five Overall Simulation Scores (OSS) of the two data sets.

This type of research has not been conducted through any distinguishable academic avenues. It is uncommon for psychological science to be utilized in System Dynamics at all, but to actually create a model, a user-friendly interface, and then statistically test that interface with in-person participants in the psychological science domain is virtually unheard of in System Dynamics literature. This project has importance because it has the capacity to provide a statistical analysis on whether or not knowing a subordinate's personality style is conducive to their leader making the correct decisions for improvement. If the knowledge, or lack thereof, of a subordinate's personality allows for a leader to improve their performance via feedback, then it suggests that perhaps steps should be taken in order for leaders to learn about their subordinate's personality style upon meeting them. If there is no significant difference in the simulation scores between those that know the personality, and those that do not, then it suggests that simply the knowledge of the relationships and how certain variables interact is enough to improve performance. This would suggest a necessity for an education on this Leadership and Performance Model, to ensure leaders are aware of these dynamic relationships.

1.1 System Dynamics Overview

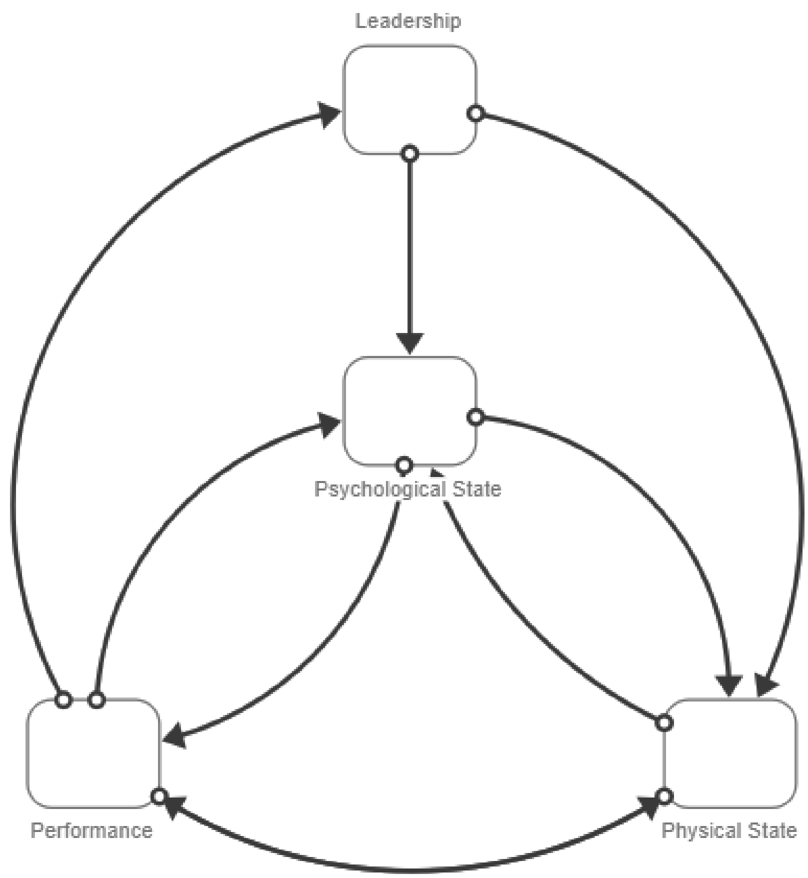
System Dynamics (SD) is a technique primarily used to model complex and dynamic systems. For the LPM, this is accomplished by utilizing the STELLA (Systems Thinking, Experimental Learning Laboratory with Animation) Architect software to externalize mental models between variables that share some sort of cause and effect relationship. These mental models are born from feedback loops that one may create from a causal loop diagram (CLD), that illustrates the positive or negative effects that certain variables may have upon each other. A causal loop diagram (CLD) is a simple way for SD modelers to conceptualize the variables they are choosing to include in their model, and to hypothesize how these variables may interact with each other. The modeler must first designate whether the relationship between the two variables is negative or positive, as shown in Figure 1.

Figure 1: ***Population Causal Loop Diagram***
The causal loops in a population. Notice that more population causes an increase in births, crowding, and deaths, while an increase in deaths decreases the population. The nature of the relationship is designated by a (+) or (-), and the arrows exhibit which variable has an effect on the other.



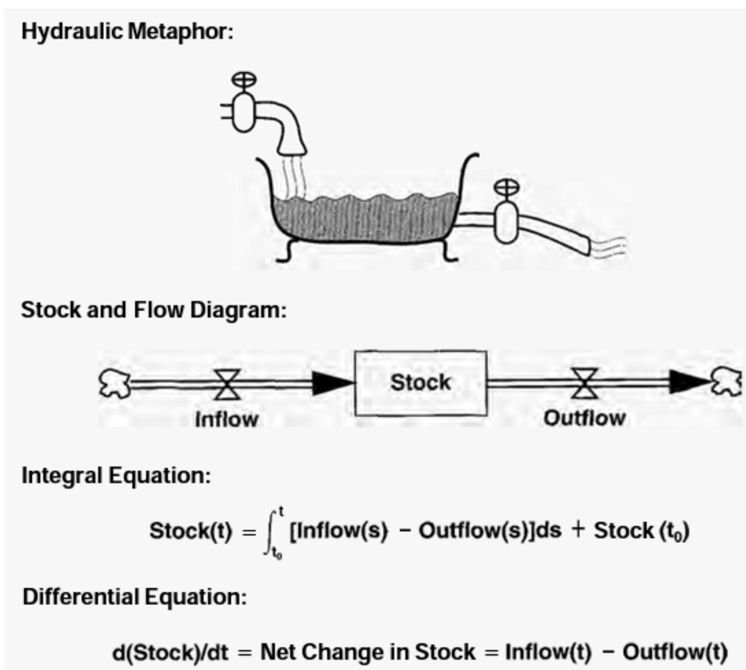
As expected, these causal loop diagrams can get very complicated after a session of brainstorming. In the population example, there are many more causes to an increase in deaths than simply more people in the population. It is up to the modeler how many variables they decide they want to include. When it comes to actually creating the model, it can get quite overwhelming. There can be hundreds of arrows and hundreds of variables. A way to simplify this process is to organize the variables into sectors in a sector diagram. The more complex a system is, the more sectors there should be. For the Leadership and Performance Model(LPM), there are four sectors: Leadership, Psychological State, Physical State, and Performance. The relationships between these sectors can be seen in Figure 2.

Figure 2: ***Champagne et al.'s (2022) LPM Sector Diagram (p. 31)***
The sectors are not classified as stocks or flows, and instead house the stock and flow systems that make up each sector. The amount of stocks or flows in each sector depends on the variables the modeler deems relevant.



An understanding of the basic stock and flow structure is necessary for genuinely understanding the importance of variables in all SD models, not just the LPM. After crafting a CLD and organizing relationships into overarching structures, one must decide whether each variable is a stock, or a flow. Sterman (2000) gives a basic overview of the inner workings of SD in his book. Stocks are defined as steady state variables. In a more mathematical sense, these are the integrals. Flows are defined as rates of change, or the derivatives. A helpful mental image of how stocks and flows work together would be to imagine a bathtub. The water in the tub at any point in time is the *stock*, the faucet is the *inflow,* and the drain is the *outflow.* If the inflow and outflow are equivalent to each other, then the system is said to be in equilibrium (p. 196). For a conceptualization of this type of system, see Figure 3. This figure also likens the conceptualization to the actual equations in effect, as well as how the stock-flow relationship appears in STELLA.

Figure 3: ***Sterman's (2000) Stock and Flow Structure (p. 194)***
Four methods of representing the relationship between a stock and its flows.



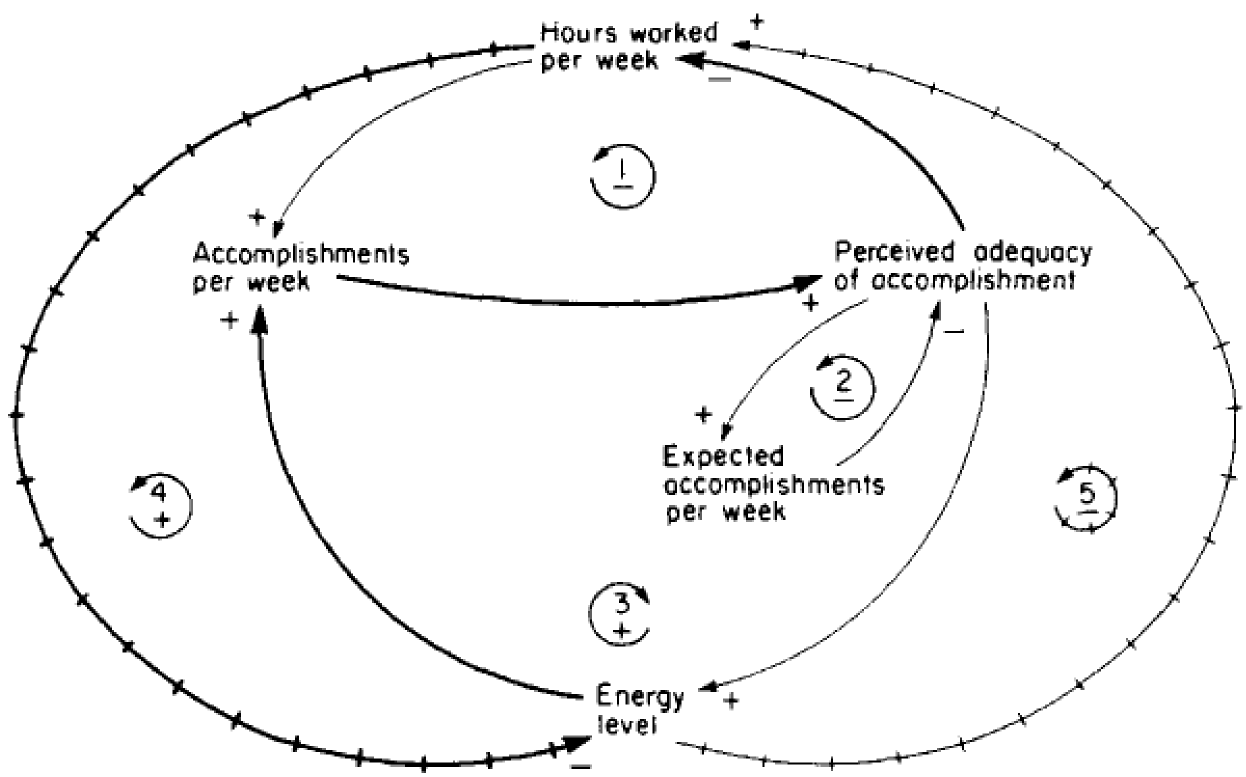
1.2 Prior SD Models

Before diving into the stocks and flows of each sector in the LPM, one must first understand why SD modeling is so important. System dynamics often models relationships in business, public health, or, namely, economics. It is not often that SD models attempt to create models based on psychological cause and effect systems. However, there are some examples of

System Dynamics modelers that focus on psychological phenomena. The first would be the Worker Burnout Model (WBM), followed by the Eating Disorder Model.

Homer's Worker Burnout Model investigates work productivity changes depending on the significance of a worker's burnout. Burnout is calculated by two factors: hours worked in a week, energy level, and a worker's perception of their performance. The causal loop diagram for the WBM can be found in Figure 4.

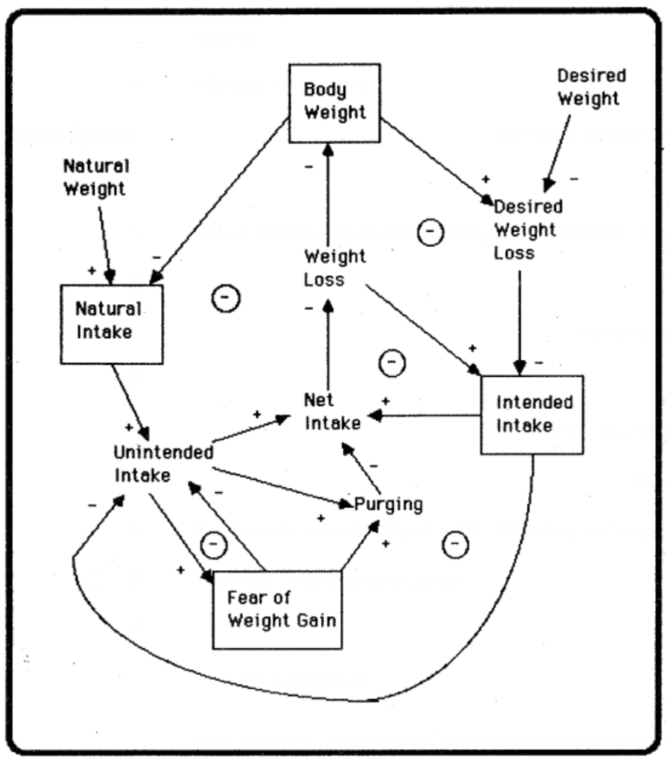
Figure 4: ***Homer's (1985) Worker Burnout Model (p. 54)***
Causal Loop Diagram of the Worker Burnout Model



It is easy to see in the CLD for Homer's model that the factors that determine worker burnout are how many hours one has worked, their accomplishments, their perceived adequacy contrasted with their expected accomplishments, and their energy level. The LPM takes some inspiration from Homer's work, considering both perceived adequacy (or perceived ability), and the individual's performance and energy level. These factor into the LPM quite heavily, and the motivation level of the subordinate is largely dependent on their perception of their own abilities. This will be discussed further when the discussion about each of the LPM's sectors is deepened.

Another model of Homer's that he developed with colleagues John and Cotreau is the Eating Disorder Model (EDM). This model is more complex than the WBM, and one of the sectors is pictured in Figure 5.

Figure 5: ***Homer et al.'s (1986) Eating Disorder Model (p. 210)***
CLD of Caloric Intake stock within the Behavior sector of the Eating Disorder Model. The Behavior sector is one of three sectors, the other two being Cognition and Physiology.



The EDM is even more similar to the Leadership and Performance Model, for its Cognition sector is comparable to Psychological State, the WBM's Behavior to the LPM's Performance, and Physiology to Physical State, respectively. The difference between the EDM and the LPM is the LPM's inclusion of the Leadership sector, which accounts for the subordinate's environmental factors, but with a very specific stock and flow structure. Figure 4 is only one main stock and flow structure, but notice that there are multiple other stocks that interact with the main stock. For example, Body Weight is a stock that directly feeds into Natural Intake. The relationship is negative, which is logical, since if someone with an eating disorder has a high body weight, then they will likely lower their natural intake. This type of relationship is important to understand, as it appears very often in the Leadership and Performance Model.

1.3 Importance of SD Models

Now that a basic understanding of the structures of the molecules and structure of stock and flows in a system has been reached, one asks the question: Why do we need to create these models? This is a complicated process, and creating these CLDs and sector diagrams and sectors and diagrams with a plethora of arrows pointing every which way may seem overly complicated and unnecessary. However, there is a method to the madness. These models are integral to elucidating any emergent phenomena of these complex systems, phenomena that may have not been evident to the naked eye. By modeling these dynamic relationships, one can find problems that may be causing other issues down the line. Models are also incredibly important to teaching people about various subject matters. One example of this is a System Dynamics model created specifically to enrich public knowledge of water management. (Stave, 2002, p. 304).

Essentially, these creations model a problem, not just the system itself. The modeler has simply created a massive mathematical equation to solve a problem that they might not even be aware of. By modeling these issues and taking a closer look at the cause and effect relationships within them, a modeler can suggest holistic policy changes to the system in order to address these highlighted issues. This is helpful in making the system more efficient. That is the goal of creating these models, and it is no different with the Leadership and Performance Model.

As the world grows and progresses, there is not often a catch-all answer to problems that may arise. There is nuance. It is not uncommon that policies implemented by governments or corporations do not fully resolve the original problem. Or, even worse, their policies may cause new, different issues to emerge. This is especially true in the military, for leaders often have to make choices that put soldiers' lives on the line. An Infantry platoon leader is responsible for emplacing their most casualty producing weapon systems in a location with a tactical advantage, often within 400 meters of their troops on the ground. A small miscalculation could result in a mass casualty of nearly half the platoon. They must make these decisions often within 200 meters of an enemy objective, often right after seeing the terrain for the first time. An Army leader in a combat arms branch is faced with these types of decisions every single day.

It takes true leadership skill to see these eclectic problems and come up with creative solutions that holistically address the surfeit of problems that will inevitably emerge while they are in command. This is where System Dynamics comes in. If SD modeling is so useful and effectively empowers leaders to make intelligent decisions based on a full understanding of the situation in front of them, then it should be used more often. Especially in situations where a decision could cost the life of a subordinate.

Although the LPM does not focus on any life-threatening situations, but instead on the physical performance of a soldier, and how their relationship with their leader affects their physical performance, it is still useful in corroborating the continued use of SD modeling in the military. If a soldier does poorly on a physical assessment due to a leader's poor decisions, the leader does not necessarily have to claim responsibility for the decrease of the soldier's performance. However, if that same leader made a decision in a similar fashion on the battlefield, then they could be responsible for the deaths of their subordinates. Needless to say, a military leader's decision making skill is incredibly important, and the LPM is one of the first steps towards training young soldiers and improving their decision making skills.

Systems thinking and modeling allows leaders a heightened awareness of the system within which they operate, and may address any inadequate mental models they may have had prior. This proves to be especially effective in developing leadership skills as defined by the Army, whether that be for interpersonal tact, as modeled, or for greater combat effectiveness and warfighting ability on the battlefield.

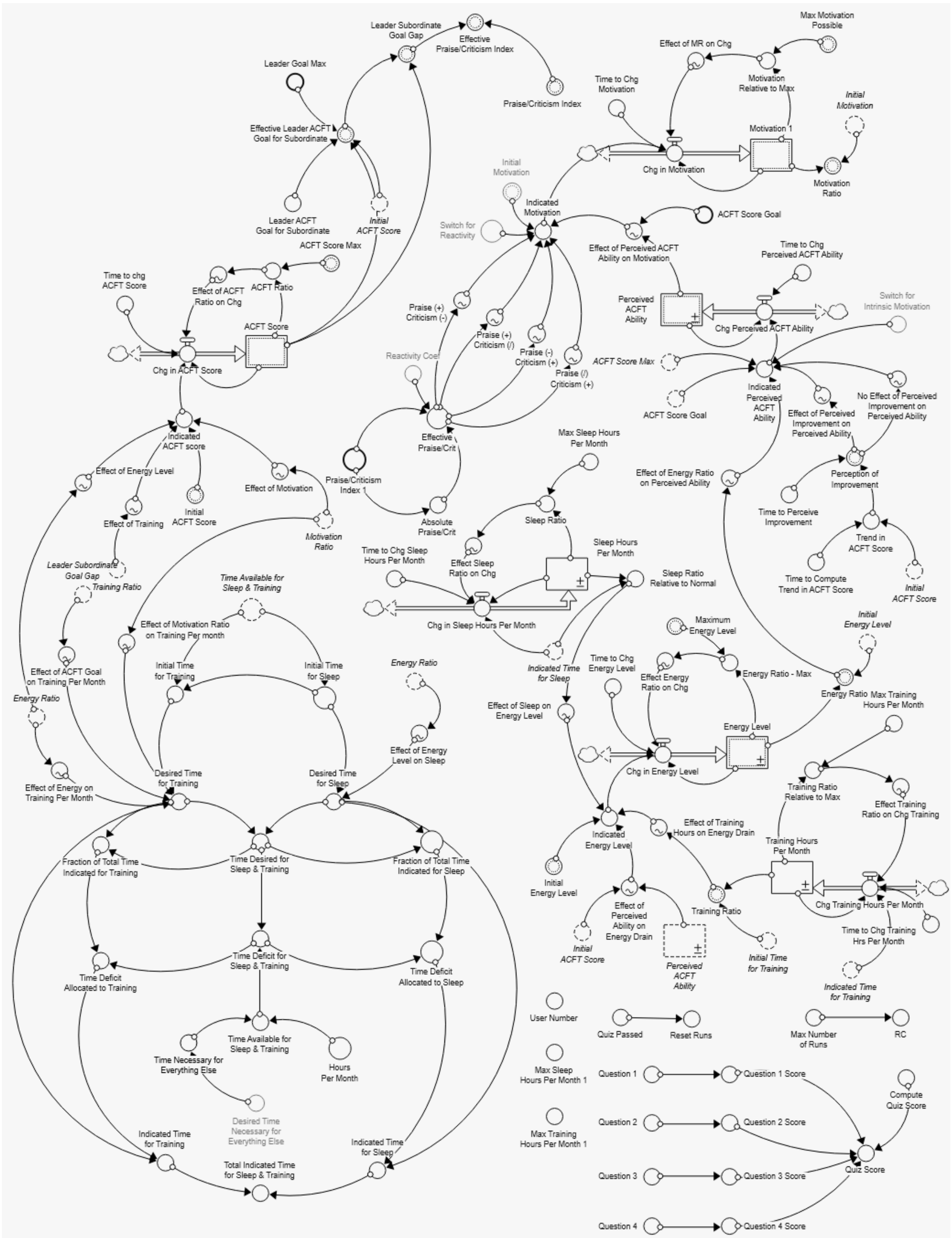
1.4 The Necessity of an Interface

One key difference between the previous IQP and this MQP is the addition of an interface onto the Leadership and Performance Model. Interfaces for SD models are the means by which users interact with and manipulate the model's structure and parameters. They provide a visually pleasing interface that allows users, or players, in this case, to easily input data and run simulations, which is also helpful when one wishes to view and analyze results.

Overall, interfaces for SD models play a critical role in making these models accessible to a wide range of users, from novice to advanced. For example, in the IQP, project members had to learn how to use the STELLA software in order to create the model. It has been a common theme that although the LPM is fairly straightforward, users unfamiliar with STELLA feel overwhelmed by the seemingly endless molecules and arrows. This can be demonstrated visually. An example of a full STELLA model is pictured in Figure 6 in a screengrab of the software. It is important to mention that the model pictured is not the model utilized in the IQP. The model below includes changes to the Physical sector, fleshing out a Subordinate's time available and time desired for training This model also includes a complete revision of the Leadership sector.

Since players are now interacting with the model, the Player makes up most of the Leadership sector. Typically, this model is divided visually into the four sectors, to make these relationships more manageable, but this image includes every single relationship from each of the four sectors in one place:

Figure 6: ***The Leadership and Performance Model in STELLA***



This visual representation is not meant to be understood to its full capacity. It is simply meant to illustrate how convoluted a STELLA model can be, and how one's audience may benefit from a user-friendly interface. It is quite challenging for someone to look at the model in its current state and make sense of it, much less learn from it. So, by providing a user-friendly way to interact with the model, an interface will help to ensure that the model is used effectively and that its insights can be applied to real-world problems (Dyson, & Chang, 2005, p. 671).

1.5 Overview of the LPM

Before diving into the process of creating the interface, the main sectors of the Leadership and Performance Model need to be further explained. The most involved portion of *IQP: The Interaction of Physiological and Psychological Factors on Human Physical Performance in the U.S. Army - A System Dynamics Approach* was creating the model itself. If there is any further interest in the extensive research that went into creating each of the stocks and flows of each sector, that work provides some valuable insight, and can be found in the WPI Database. The goal of this project is to expand on that model and conduct research on the already existing model, so the overviews of each of the four sectors will be brief[1].

1.5a Physical State Sector

In the IQP, the Physical Sector had to be simplified due to time and personnel limitations. Each of the molecular structures, stocks, and flows in the LPM necessitate a need for an equation that mathematically models that relationship. Some relationships are modeled by table functions, which is a graphical representation of the relationship. Because of the sheer amount of research

[1] See Appendix F for updated equations and relationships between variables.

and effort that goes into creating each molecule cluster, it was decided that this sector would represent the energy of the subordinate on a scale of one to ten. The main culprit for energy drain would be training hours, while sleep was responsible for energy replenishment. Hydration and nutrition, although major factors in a person's energy levels, were not included in this early iteration of the model. This is mostly due to the fact that it is nearly impossible to accurately represent the average person's consumption of calories on a table function, as eating habits vary greatly depending on size, appetite, mental state, and nutrition goals. This sector is mostly cut and dry, and represents a bi-flow of energy in and energy out.

However, the subordinate's perception of their physical abilities played a part in the energy drain. For example, if the subordinate perceives their effort to be greater than they can sustain, and they do not believe they can complete the exercise at a certain intensity, then they will be physically weaker than if they believed the opposite (Blanchfield et al., 2014, p. 1). This neurobiological relationship is closely related to the Dunning-Kruger effect, which is described in Sullivan et al.'s (2019) study on sport coaching as a phenomenon "whereby individuals' perceptions of their abilities differ significantly from objective assessments of ability" (p. 591). Simply put, athletes often underestimate their actual physical ability depending on their mental state. If this underestimation is large enough, it can affect the athlete's perception of their ability, which decreases their motivation, and in turn, decreases their performance.

An addition to the Physical sector in preparation for the interface were functions that took into account the Subordinate's both desired and available time for training and for sleep. This considered the fact that a Subordinate may need to use that time for everything else, whether it be employment, school, and leisure time. The desired time for training increased based on the goal that the motivation levels of the Subordinate, and the goals that the Leader has set for them. If a Subordinate is intrinsically motivated, then they will complete their training of their own volition. If they are more extrinsically motivated, then the Leader's goal for them is going to deeply affect their desire to train more (Bénabou & Tirole, 2003, p. 492). This addition to the LPM was necessary in calculating the simulation scores of the players when they were to interact with the model.

1.5b Psychological State Sector

The Psychological sector is one of the more convoluted sectors. This sector extrapolates on Blanchfield et al.'s (2014) research, taking deep inspiration from these authors' writings on interoception, the status of the dorsal insular cortex and the anterior cingulate cortex, and the limbic sensory cortex[2]. Essentially, a person's physical environment and the sensations they feel (like muscle fatigue or lactic acid build-up) translates into emotion on a neurobiological level (p. 13). When one feels emotions, one acts on them. Inaction is also considered an action in the Leadership and Performance Model. Perceived Ability is not only calculated by these factors of emotion and sensation. It is also calculated by the athlete's perception of their level of effort. Beedie et al. (2008) maintain that when athlete's perceive themselves as exhibiting less effort, they tend to push through any discomfort and exercise for longer amounts of time and at a higher intensity. This remains true across the board, regardless of what their actual physiological ability may be. This suggests that emotional state and perception of one's performance are key in determining the scope of one's overall physical performance (p. 59). Kosa et al.'s (2021) research provided evidence that regulating one's emotions during physical exertion is more of a

[2]Although not discussed at length here, each of these topics and how they connect to Subordinate motivation are deeply explored in the Interactive Qualifying Project work.

subconscious choice (p. 2). This suggests that the subordinate's in an LPM scenario cannot effectively affect their own Perceived Ability on a conscious level. These emotions and perceptions in tandem translate into the motivation calculation in the LPM, through the concept of Perceived Ability coupled with the individual Subordinate's personality style and how they are reacting to the Leader's input.

Although there are many more possibilities, the LPM and resulting interface have four possible personalities that have varying effects based on the reactivity coefficient of the Subordinate. Essentially, the reactivity coefficient is multiplied by the effective input of the Leader on the Subordinate, along with their actual personality style. It should be mentioned that these four personalities are by no means representative of the entire population. These four conditions are simply how a person is going to react to praise or criticism. Even in this small aspect of personality, there are still several possibilities not accounted for as of yet, such as Subordinates that react to both praise and criticism at varying times. The four personalities are dictated by the Subordinate's reception to praise and/or criticism, as outlined below.

Table 1: Subordinate Personality Switches in LPM

Personality Switch	Praise	Criticism
1	Positive Reaction	Negative Reaction
2	Positive Reaction	No Reaction
3	Negative Reaction	Positive Reaction
4	No Reaction	Positive Reaction

The effective praise or criticism from the Leader is determined by how much of a gap there is between the Leader's Goal for their Subordinate, multiplied by Subordinate reactivity. If there is a larger gap between the goal and the performance, then that means that the Subordinate is quite far off from the goal of the Leader, so they react more strongly to the Leader's input. The Reactivity Coefficient is on a scale from zero to one. The larger the number, the greater the percentage of effective feedback from the Leader to the Subordinate.

The Indicated Motivation value is determined by the initial motivation of the Subordinate, their personality style, and the effect of Perceived Ability on Motivation, which is represented by a table function. Therefore, the main output of this sector is Motivation, denoted by a numerical score on a scale from one to ten.

1.5c Leadership Sector

The Leadership sector received the largest overhaul in the transition from the STELLA model to the interactive interface. Since the players in the study made up the Leadership sector, there were things that did not need to be included in the model anymore. Originally, the Leadership sector consisted of the Leadership Style, the Goal for Subordinate, and the Praise/Criticism Index. The Initial Leadership Style Switch denoted if the Leader began the simulation praising or criticizing their Subordinate. The Switch for Adaptability controlled whether or not the Leader adapted to the Subordinate's reactions to their initial feedback. If the switch was turned off, the Leader maintained their initial course, ignoring the hints at the Subordinate's personality and what they would best react to.

These switches were not all necessary for the interface, since the Player themselves acted as the Leader. So, in preparation for the interface, the Leadership sector was cut down to only two factors: Leader's Goal for Subordinate and Praise/Criticism Index. This sector is what made up the cockpit of the flight simulator (interface), which enabled the Leader/Player to have a direct effect on Subordinate motivation, energy, and performance.

Army doctrine, supported by empirical research, has shown that developing relationships with subordinates is incredibly integral to transforming them into better leaders and performers in their field (NCO Journal, 2018, p. 3). This is what the Leadership and Performance Model is based on, and how this sector came to be (Champagne et al., 2022, p. 10).

1.5d Performance Sector

The fourth and final sector of the Leadership and Performance Model is by far the simplest. It only contains the Army Combat Fitness Test (ACFT) score, and the components that determine that output. These components include the initial ACFT score, Motivation, Energy, and Training. The ACFT is a physical fitness test required by the Army to maintain soldier readiness and warfighter ability. It comprises six events: Three Repetition Maximum Deadlift, Standing Power Throw, Hand-Release Push-up, Sprint-Drag-Carry, Plank , and Two Mile Run. Each event is scored on a scale from 0 to 100, with 60 points in each event being the minimum to pass the ACFT. Therefore, although it is possible to get 600 points in total, the minimum points required to pass is 360. The goal of course is to get as high of a score as possible, which is also the goal of this simulation. The ultimate goal of the Leader is to get their Subordinate to the highest possible ACFT score with high motivation and energy levels, in as timely a manner as possible in this scenario.

For the flight simulator interface, there was nothing removed from the Performance sector. However, there were quite a bit of additions. The most important calculation for the new interface of the LPM was the Overall Simulation Score (OSS). The score was calculated through a snapshot of the Subordinate's motivation levels, energy levels, and Army Combat Fitness Test (ACFT) score coupled with the time and effort it took to get to that score (efficiency measure) and the importance of each of the three factors (weight). The goal of creating this calculation was to ensure that all four sectors had a hand in the final overview of the data, whether that be performance, energy, or motivation. These equations and stock and flow structures make up most of the Performance sector, but do not have a part in the actual simulation itself. The Performance sector was essentially a collection point for all of the necessary additions for the LPM flight simulator.

In addition to the calculation of the OSS score, the Performance sector also housed the molecules necessary for collecting the participants' User Number, Quiz Answers, and final Quiz Score. These molecules were not fed into the main model, but it was necessary to create them in STELLA so that the software for the interface would collect historical data on each of these factors for research and analysis.

1.6 Priming the LPM for Interface Format

The Leadership and Performance Model, before it was ready to be fitted into an attractive interface and published to the iSee Systems database, had some inner workings that needed to be reconsidered. Since the Leadership was represented by a human person, that sector needed to be overhauled. There were also some additions that needed to be made.

1.6a Subtractions from the LPM

The specific stocks and flows that were removed from the Leadership sector included everything that had to do with the Leader's choices when faced with feedback from the Subordinate. For example, the Leader Adaptability switch was completely removed. Also, any converter or module initializing the leadership sector in any way was cast to the wayside. This is because the human being interacting with the interface would input this data themselves. The case was the same for any table functions that represented the Leader's change in behavior over time. The Leader would be reacting in real time to the simulation, so it was unnecessary to try to predict their behavior over time from research when all they would need to do would be to input the ACFT Goal for their Subordinate and indicate whether their behavior towards them would be positive or negative. No other subtractions from the original Leadership and Performance Model were necessary.

1.6b Additions to the LPM

There were many additions that had to be addressed in order to prep the LPM for full interface initiation. First, the Physical sector needed to be rounded out. Equations and molecules were added that took the Subordinate's time available and time desired to train into consideration. This made the Physical sector more robust, therefore ensuring that the feedback that the players would get was more accurate to real life. The Psychological sector did not need any additions, as it was heavily researched and fairly robust from the first release of the LPM.

The Performance sector did not have additions made to its core stock and flow structure, but the structures and equations necessary for calculating the Overall Simulation Score (OSS) were created within this sector. Stock and flow relationships denoting the distance traveled for three separate variables were added: ACFT Score, Motivation, and Energy. These molecules determined the length of each of the lines in each graph of results. In simple terms, a straight line was considered to be more efficient as opposed to a flexuous line, since there was less distance traveled from one point in time to another. These distance traveled functions fed into an efficiency measure for each variable, which spit out a numerical value. This numerical value was then multiplied by its own weight (how important it was to the overall score), and then multiplied with the other two variables. This value was then plugged into another stock and flow structure, which provided the actual value of Overall Simulation Score translated into the aggregate OSS on a scale from 0 to 500.

An extra addition to the Performance Sector was the creation of the Cockpit Pre-Quiz. This quiz had to be cleverly designed in order to allow for the run count to maintain its integrity while also not allowing players to advance into the cockpit without achieving a perfect score on the quiz. This assessment ensured that the Player had a deeper understanding of System Dynamics and the relationships in the LPM. The quiz was a control measure for any random button mashing that may not have provided accurate results for true learning within the flight simulator. The addition of a Username function was also necessary, so that players could be differentiated from when reviewing the data in the server. All players were to use the exact same simulator, but only half were to know their Subordinate's personality. By asking them to input their Username into the interface, the researchers would be able to differentiate between players who were briefed on personality and those that were not.

1.7 Initializing the Model

Although real people were to be interacting with the interface, there were still some variables that had to be initialized. All players were faced with the same initialized simulations. Initial Motivation and Initial Energy were both set at a five. This was to be described to the players as "not very motivated". The Initial Training Hours were set to be at 40 hours per month, or ten hours per week. The simulated Subordinate was to get eight hours of sleep a night (240 hours per month). The initial ACFT score was set to begin at 300 points, 60 points beneath the minimum requirement. Finally, the Subordinate Personality switch was set to personality 3, with a reactivity coefficient of 0.3. As a reminder, Personality 3 represents a Subordinate that is responsive to criticism, but reacts negatively to praise. All of these initial conditions were briefed to the participants via the Player Handout[3], save for the personality. Half of the handouts said "You have been assigned Personality 3. Your assigned Subordinate has a personality that is receptive to criticism but reacts negatively to praise", while the other half said "You have been assigned a Subordinate. Your assigned Subordinate has one of the four personalities above, but you do not know which one". The handouts also included specific examples of what praise or criticism may be interpreted as.

1.8 Building the Interface

When building the interface, there were specific goals in mind. First, it had to be aesthetically pleasing and follow a common theme. It also had to be informative and engaging, to ensure proper learning on behalf of the participants. It also had to include very concise and clear instructions, as most participants would be completing their simulations without any outside help. The researcher would be available to answer questions, but the goal was to ensure that the process was as seamless as possible. The overall theme of the flight simulator is an Army aircraft hangar, which is something most of the participants were familiar with, since they were all Army ROTC cadets. The welcoming screen can be seen in Figure 7:

[3] See Appendix C.

Figure 7: ***LPM Simulator Welcome Screen***

Players entered the hangar and were greeted with options to explore the objectives of the research project and learn about the model structure. There were many opportunities for participants to learn more about the Leadership and Performance Model, its inner workings, and any extra information on System Dynamics[4]. Figure 8 depicts the model structure page, where participants could be taken into each sector, where there are artistic renderings of the relationships within each sector. After players felt as if they had a good understanding of the LPM, they were prompted to take the Cockpit Pre-Quiz. They had to answer all four questions correctly before they could advance into the cockpit.

[4] For the link to the full simulator, see Appendix A.

Figure 8: ***Interface's LPM Sector Diagram***

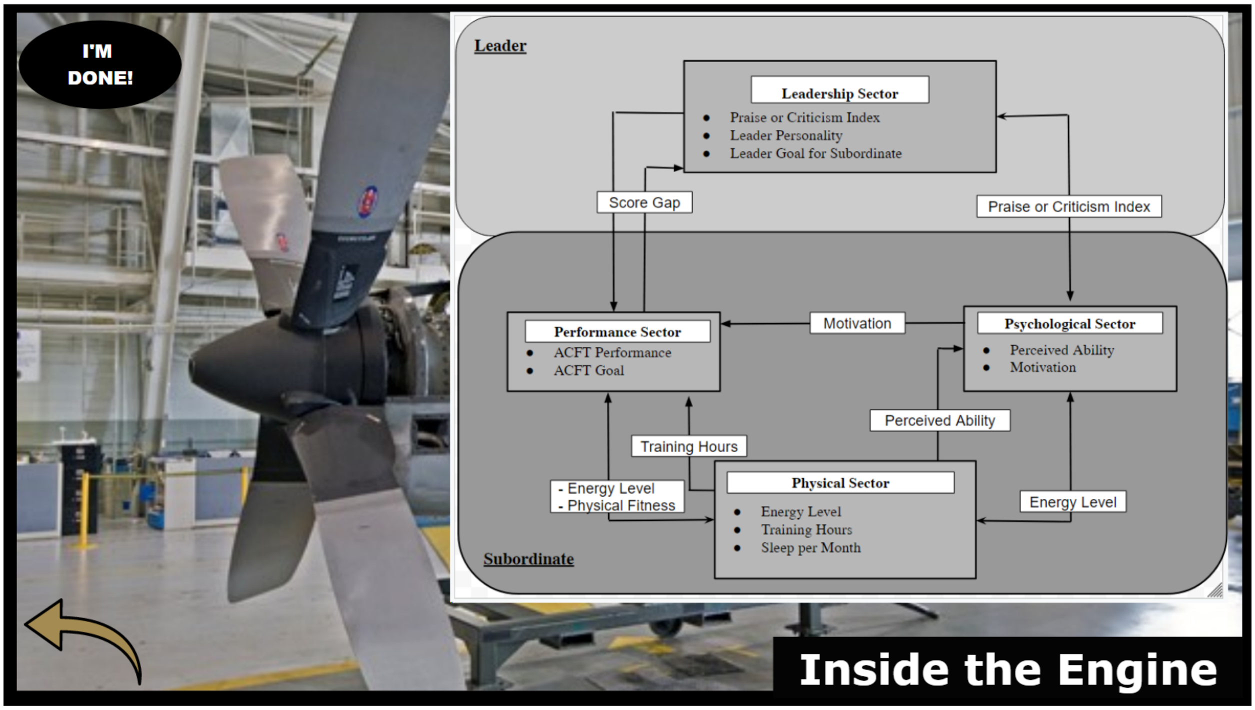
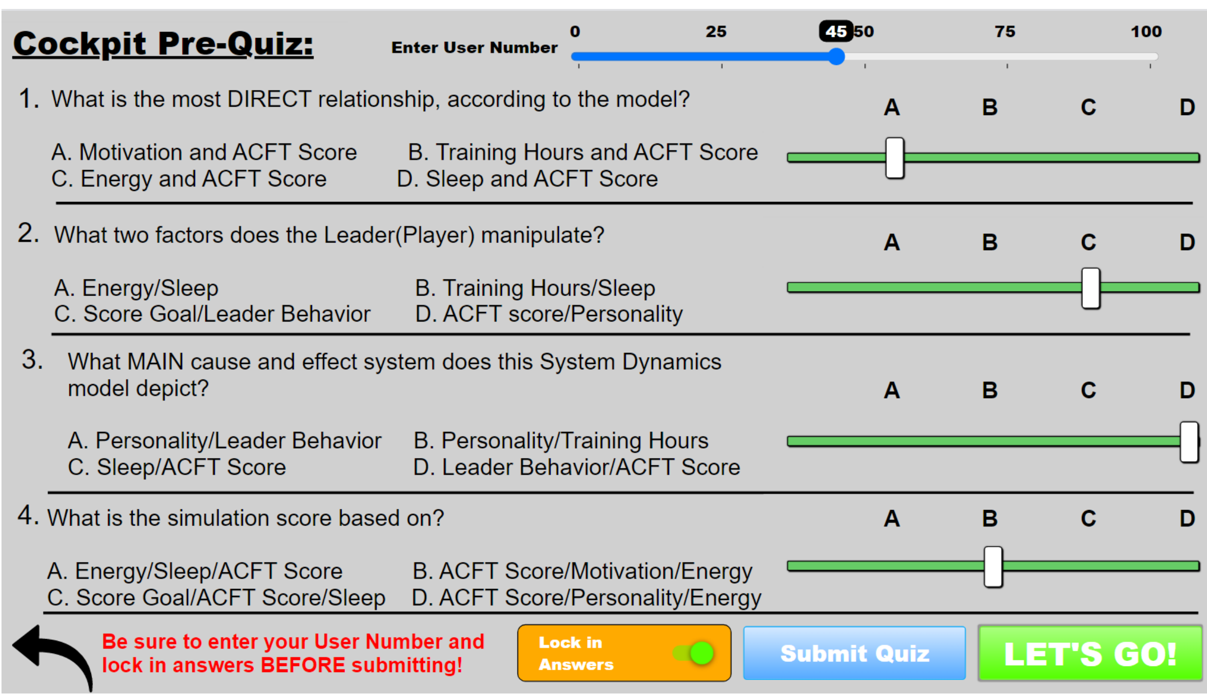


Figure 9: ***Cockpit Pre-Quiz***

The "Let's Go!" button did not turn green until players achieved a perfect score.



Finally, the cockpit was created. The player inputs were front and center, with a clear set of instructions. The decision for which data would be shown to the player was made based on what factored into the Overall Simulation Score. The cockpit is pictured in Figure 10:

Figure 10: ***LPM Flight Simulator Cockpit***

This simulator took images from real Army operations to provide an immersive experience for the cadets. The instructions used verbiage similar to the vernacular of Army soldiers like “mission brief”, “back to base”, and did not explain what an ACFT score is, since all cadets have taken the ACFT themselves and are very familiar with it. Although this may come off as myopic and foreign to those not in the military, it was designed specifically with soldiers in mind.

1.9 Introduction Conclusion

This study aims to investigate the relevance of leader knowledge of subordinate personality and the learning trends of players who interact with the LPM flight simulator. By allowing real Army leaders to interact with the interface after being educated on the relationships in the LPM, researchers can draw conclusions based on the data collected.

By manipulating independent variables, the data can provide real insight on what, if anything, can be done to expedite the increase of soldier performance and simultaneous betterment of their leaders. This study could potentially inspire Army doctrine to learn more about their real-life subordinates in the future. It may also help explore if knowing about the nature of these relationships is enough to adapt to a subordinate over time due to adaptability and learning potential. Essentially, the goal is to learn something about these relationships, and the interface provides the opportunity to do that utilizing the scientific method.

Chapter 2: Methodology

2.1 Participants

All participants were college students that attend a number of small institutions in New England. Since collection of data was completely anonymous, there was no data collected on the race or gender demographics of individual participants. Their ages ranged from 18 to 25 years old. Participants were all Army cadets that were either contracted, enrolled, or participating in some capacity in ROTC. No cadets were refused the opportunity to participate in the study, unless they had worked on the LPM for the Interactive Qualifying Project the year prior.

Of the 52 participants that interacted with the simulator, eight (15%) were excluded due to a lapse in input of User Numbers. This allowed for 44 usable data sets, where 22 participants were placed under Condition 1 (knowledge of Subordinate personality), and 22 were placed under Condition 2 (no knowledge of Subordinate personality). Without the researcher having the ability to link a set of run results to the condition (knowledge of personality or not), those results were not usable for statistical analysis. For the post-simulation questions, all 52 participants filled out the individual response sheet. However, of those 52, 3 (5.7%) participants are excluded. This is due to 1 (1.9%) participant requesting that their answers not be included, and 2 (3.8%) participants did not turn in their handouts after completing them. Therefore, there were 49 individual response sheets analyzed for trends.

2.2 Materials

In this study, there is one Independent Variable (IV) and three Dependent Variables (DV). The IV was represented by whether or not participants were briefed on their simulated Subordinate's personality or not. Every participant received the same simulated Subordinate, and were given exactly the same instructions. DV 1 is represented by the Overall Simulation Score (OSS) of each simulation. This numerical score is calculated by the Subordinate's ACFT Score, Motivation Levels, and Energy Levels, coupled with the efficiency of the rate of improvement from month 1 to month 48 in a single simulation. Each player completed a total of five simulations. DV 2 is represented by each participant's overall increase in score from Run 1 to Run 4. DV 3 is represented by each participant's overall increase in score from Run 1 to Run 5. These DVs were calculated by subtracting the first run score from the fourth and fifth scores, respectively. A positive integer represented improvement over time, and a negative integer represented a decrease in the OSS over time.

At the conclusion of the simulations, participants had the opportunity to complete the Post-Simulation Handout[5]. These questions were:

1. What leadership style do you think would best work for you to improve your own ACFT score? (positive or critical) Why?
2. Do you think the model was accurate to real life? Rate from 1-10, then explain.
3. How much confidence do you have in the accuracy of your scores? Rate from 1-10, then explain.
4. How satisfied were you with your results? Rate from 1-10, then explain.
5. Do you have any questions about this study or suggestions for future research?
6. Can the researchers use your answers to these questions in their write-up? Write yes or no.

This handout was completely individually and completely anonymous. After all participants had turned in their responses, the following Post-Simulation Group Discussion Questions[6] were asked to the group to initiate discussion:

1. Was it helpful to know your Subordinate's personality ahead of time?
2. Did anything surprise you about the model's structure?
3. What, if anything, was challenging about getting a high score?
4. How challenging was it to get a perfect score on a scale of 1 to 10? Why?

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[5] See Appendix D.
[6] See Appendix E.

5. What strategies do you think pair best with what personality types?

These questions were administered to assess participant learning, overall trust in the simulation, and participant reactions to the simulation and their performance.

2.3 Procedures

Upon the day of collecting data, 52 participants were visited in their ROTC classrooms during the time that Physical Training (PT) would normally occur. Participants were given the choice to participate, and if they did not wish to participate, they completed the workout that was planned for the ahead of time with no consequence to them. The participants who chose to take part were taken to a classroom and instructed to sit in every other chair if possible to mitigate any peeking at each other's papers. The Informed Consent Form and Player Handout were passed out, and participants were instructed not to put their name on any forms. Participants were informed that remaining in the classroom constituted their agreement to participate in the study, and they were welcome to leave at any time, for any reason.

Half of the Player Handouts had one Subordinate personality message telling the player the exact personality style, and half of the handouts only stated that the player had been assigned a subordinate. Every other circumstance was exactly the same for every participant. These handouts were shuffled together and picked at random by the participants, so that there would be no possibility of researcher bias. If they wished, participants could input their Military Science (MS) level, which denotes what year of ROTC they are in. This data did not identify anyone, but was helpful in noting possible trends across cadets with more leadership experience in ROTC.

Once everyone has been walked through the Informed Consent form, they were briefed with an Introduction and Information Script and walked through the simulator up until the

Cockpit Pre-Quiz. This took approximately 15 minutes. Participants were then left to their own devices to look back through the information and complete the quiz on their own time. Some participants needed assistance with finding the answers to the quiz questions, so the researcher provided leading information as to where the information could be found in the background information provided. The goal of the quiz was not to evaluate the cadets on their intelligence, but to ensure that they had a full understanding of the model.

Once all participants had passed the quiz and entered the cockpit simulator, they were reminded what each of the sliders did, and were instructed to only write down their final simulation score for the first five simulations. Each run paused every six months for a 48 month period. At the end of the 48 months, the simulation reflected the participant's final OSS for that run. It took about 45 minutes for all participants to complete the quiz and their subsequent five total simulation runs. Since the quiz completion was at the pace of the individual, some participants began and finished simulating earlier than others.

When all participants had finished their simulations, they turned in their handouts face down and filled out the Post-Simulation Handout individually. Once everyone had finished those and turned those in face down, it was time for the Post-Simulation Group Discussion Questions. The researcher wrote down notes from the discussion, the participants' responses, and denoted how many people agreed to each response by a show of hands. Once everyone took part in the discussion, the researcher opened up the discussion for any other questions or comments, debriefed, and then dismissed the participants.

2.3a Data Collection and Analysis

Data collection was accomplished through the use of the Player Handout, the iSee Systems software where the LPM was published for public use, and the discussion questions, both group and individual alike. The focus group questions in the Post-Simulation Discussion, however, did not investigate the proposed research questions or hypotheses. Therefore, they were not included as part of the results. These questions were used to facilitate learning throughout the group and share opinions amongst the group.

The iSee Systems server collected data on how much time each participant spent on each page, how many tries it took them to get a perfect score on the quiz, and any specific variables that the researcher had identified ahead of time, which included, in no particular order:

- ACFT Score
- Energy Level
- Leader Goal for Subordinate
- Motivation Level
- Quiz Score
- Training Hours
- User Number
- Praise/Criticism Index
- Sleep Hours
- Overall Simulation Score

The amount of data collected was enormous, so the most important variables had to be prioritized, for with 52 participants each running 5 simulations, there were an expected 260 individual simulation runs to analyze. The researcher decided to prioritize the Overall Simulation Score (OSS), Quiz Score, and the User Number of each participant. This is because the OSS was an amalgamation energy, motivation, and ACFT score, coupled with an efficiency measure. It was determined that the OSS provided a clear snapshot of each simulation. Quiz Score was prioritized to ensure that all participants completed the questions at 100% accuracy. Finally the

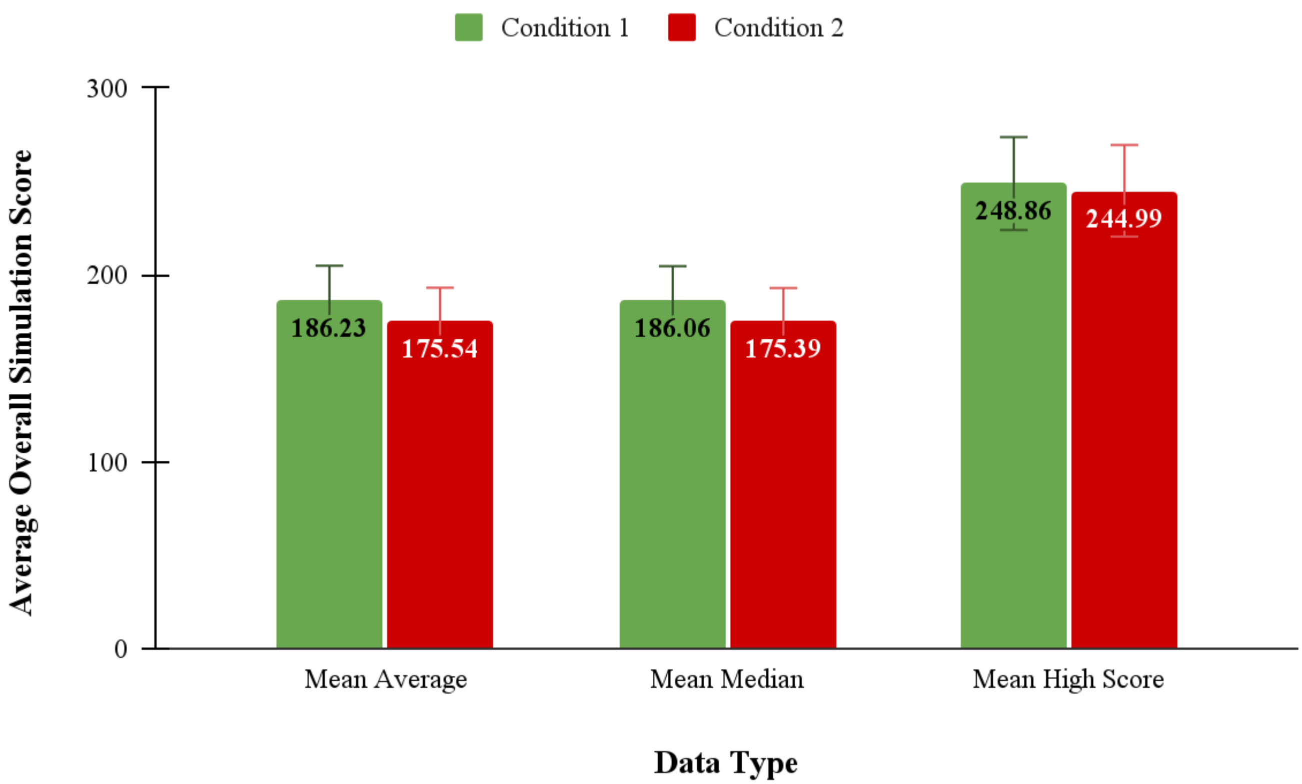
User Number identified which sets of data identified with Condition 1, and which set identified with Condition 2.

Chapter 3: Results

Researchers collected results investigating the significance of a Leader's awareness of their Subordinate's personality style and reactivity. It was hypothesized that prior knowledge of personality would enable players to achieve a higher Overall Simulation Score in the flight simulator. It was also hypothesized that players would achieve a higher OSS in later simulations than their first simulation, which represents learning and adaptability. A one-tailed t-test for unequal variance was conducted on each data set, which accounted for any possible statistical significance by calculating the overall average OSS of the five simulations, the average median OSS, and the average all-time high score of each group. Any statistical significance in the overall change in score for each group was identified by utilizing a one-tailed t-test for unequal variance. Then, the average change of score was taken for all participants, once accounting for each condition, and once to assess any overall change in score in order to assess learning over time. Statistical significance is defined for this study as $p < 0.05$.

The average OSS scores for each average that underwent a t-test are reflected in Figure 11:

Figure 11: ***Raw Data Under Each Condition***



The first hypothesis speculated that the group informed of their Subordinate's personality would perform better. Also, each set of data had quite a bit of variability in scores, which necessitated a test with variance that was not equal. Thus, a one-tailed t-test with unequal variance was conducted. There was no statistical significance between the average scores of Condition 1 and Condition 2 (t(42) = .46, p = .323), the average median scores (t(42) = .4, p = .344), nor the average high scores (t(42) = .14, p = .444).

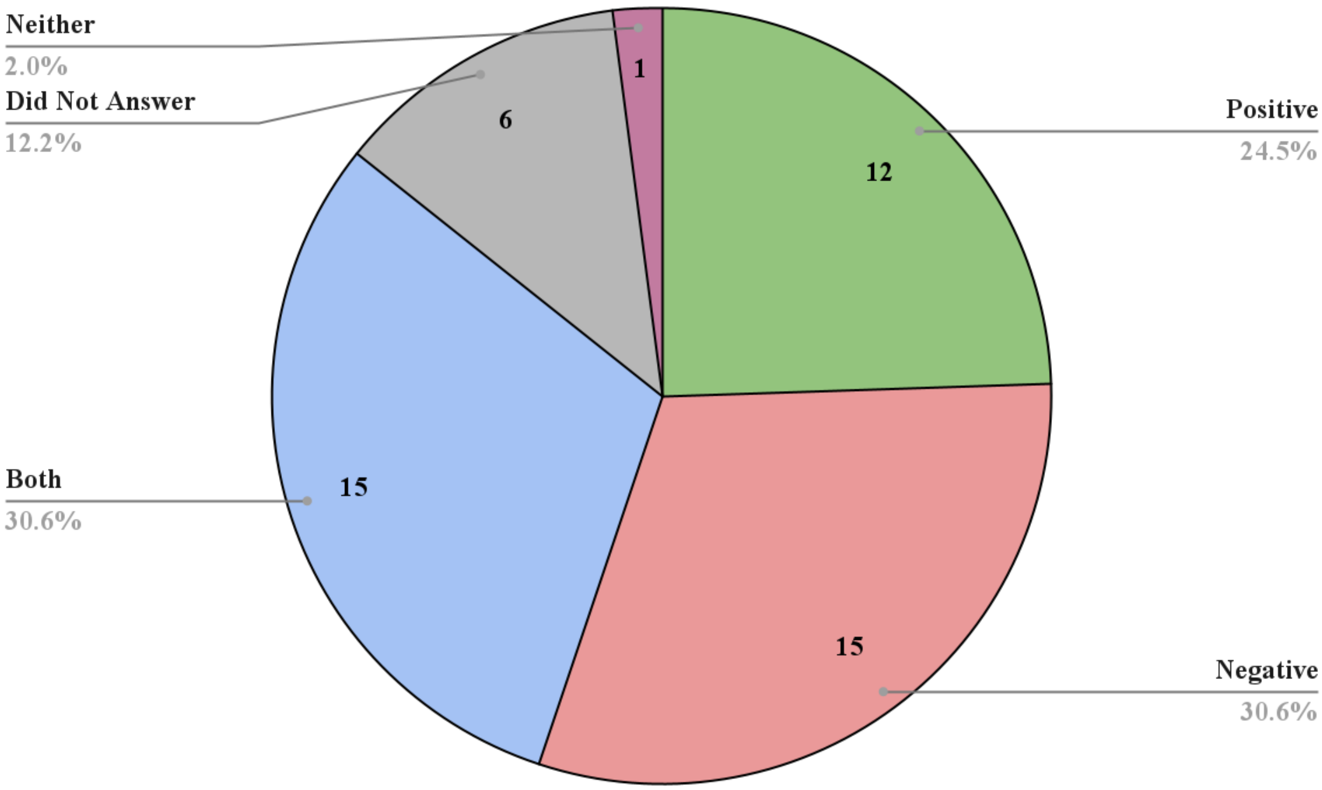
The second hypothesis speculated that participants would increase their scores after every simulation, which was supported by the data. However, there was no statistical significance between learning differences between the two conditions. These results are reflected in Figure 12:

Figure 12: ***Changes in OSS from Run to Run***

The increase in score was lowest on the second run, but strangely highest on the third run. Increase in score was still present in Run 4 and Run 5, but is not as high as the change from Run 1 to Run 3. For Run 1 to Run 2, there was no statistical significance (t(42) = - .09, *p* = .466), which was also the case from Run 1 to Runs 3, 4, and 5, respectively (t(42) = .21, *p* = .416, t(42) = -1.26, *p* = .107, and t(42) = -1.18, *p* = .122).

Next, participants completed the Post-Simulation Handout. Of the 49 participant handouts included, there were a wide array of responses. To represent the answers to each question, the following pie charts depict the number of participants that answered each question in a certain way. The graphs depicting the answers and explanations to each of the questions below. The first question concerns a participant's personal feelings on what leadership style they believe would work best for them as a soldier, and is reflected in the figure below:

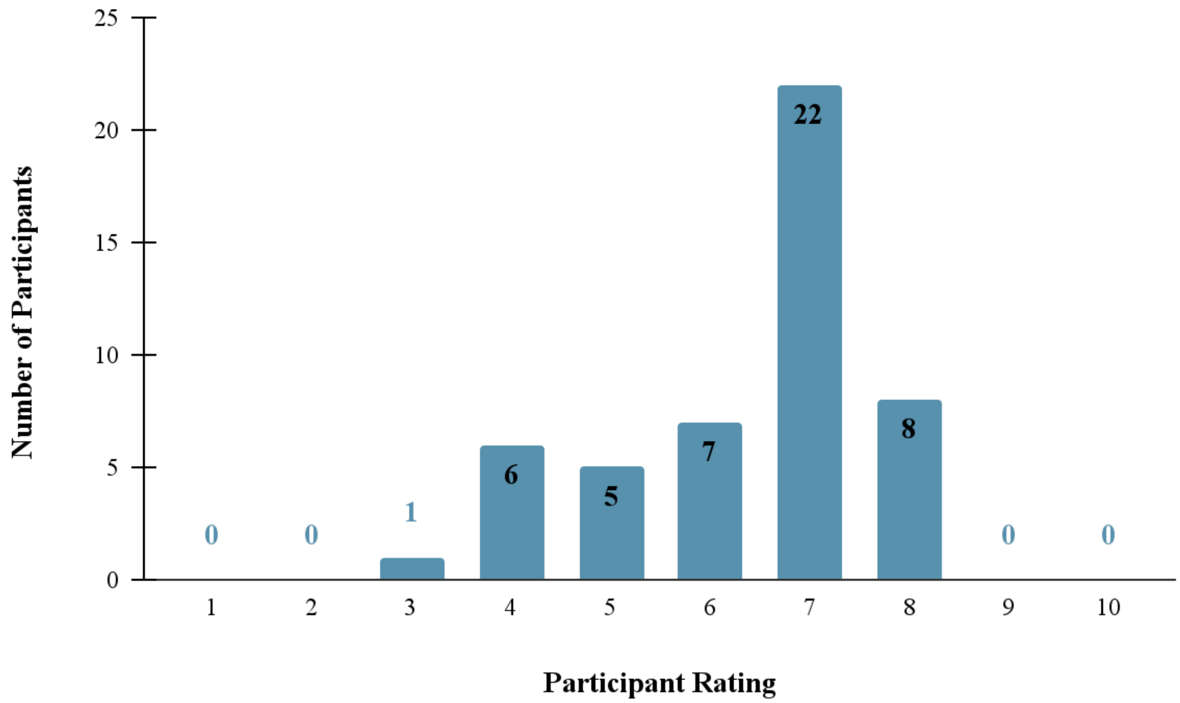
Figure 13: ***Question 1 Answers***
What leadership style do you think would best work for you to improve your own ACFT score and why? (positive or critical)



This question was helpful in assessing participant's personal opinions on how they believe Army leaders should behave towards their subordinates. It can be seen that 15 participants believe that a dynamic leadership style of mixing both positive and negative feedback is best. Another 15 participants believe that a negative style is best, and 12 believe that a positive style is best. This data reflects that there are a wide array of personalities, and individuals will respond differently to each leadership style based on their personality.

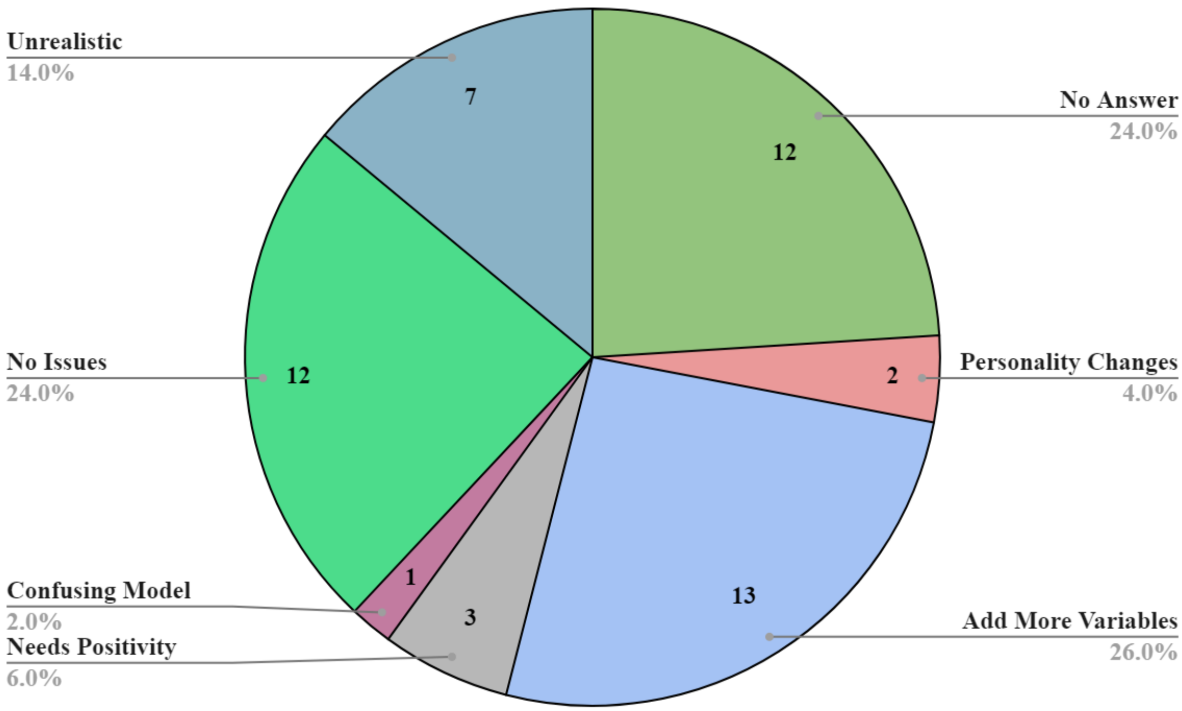
The second question evaluated each participant's opinion on the LPM's real-life accuracy. Participants were asked to rate accuracy on a scale from 1 to 10. The numerical ratings are reflected below:

Figure 14: ***Question 2 Answers***
Do you think the model was accurate to real life? Rate from 1-10, then explain.



Most participants rated model accuracy a 7 out of 10. The overall average score for accuracy was 6.38 out of 10. Figure 15 represents each participant's explanations for their rating.

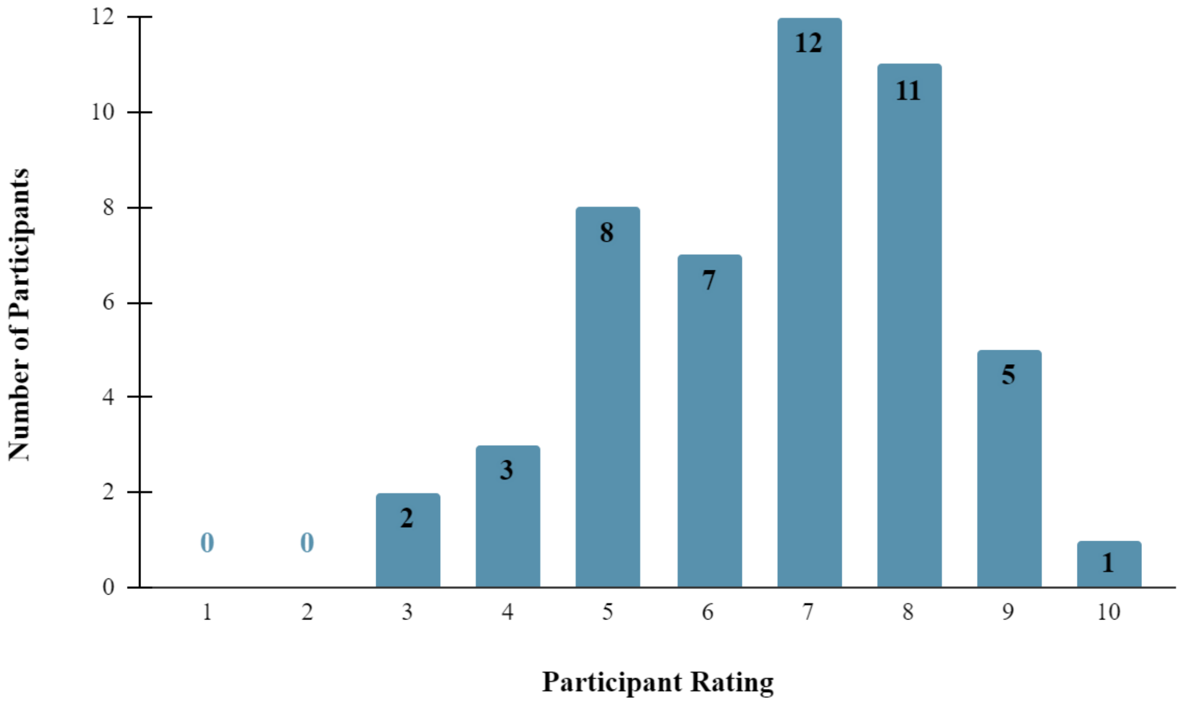
Figure 15: ***Question 2 Explanations***



As can be seen here, the majority of participants that answered the question stated that the LPM needed even more variables to be perfectly accurate to real life experiences.

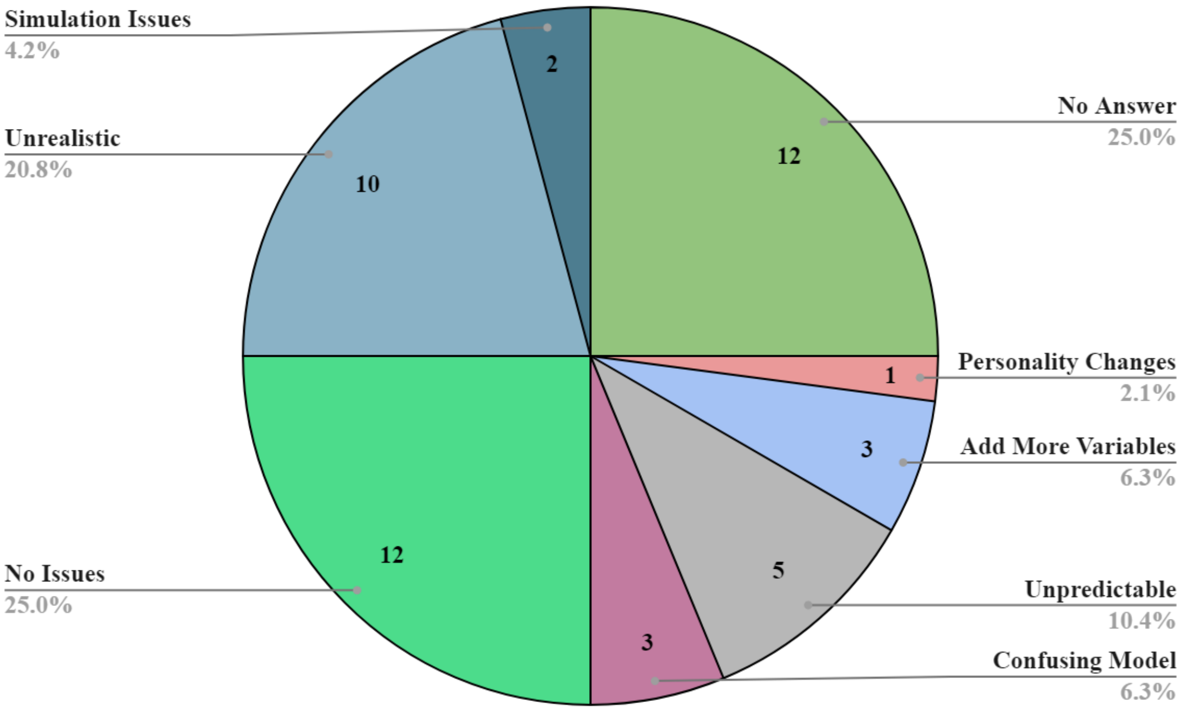
Question 3 concerned the participants' confidence in the accuracy of their scores on a scale from 1 to 10. Participant responses are reflected below:

Figure 16: ***Question 3 Answers***
How much confidence do you have in the accuracy of your scores? Rate from 1-10, then explain.



Most participants rated their confidence in their score at a 7 out of 10. The average response for this question was 6.67 out of 10. Figure 17 represents the participants' explanations for their rating for this question:

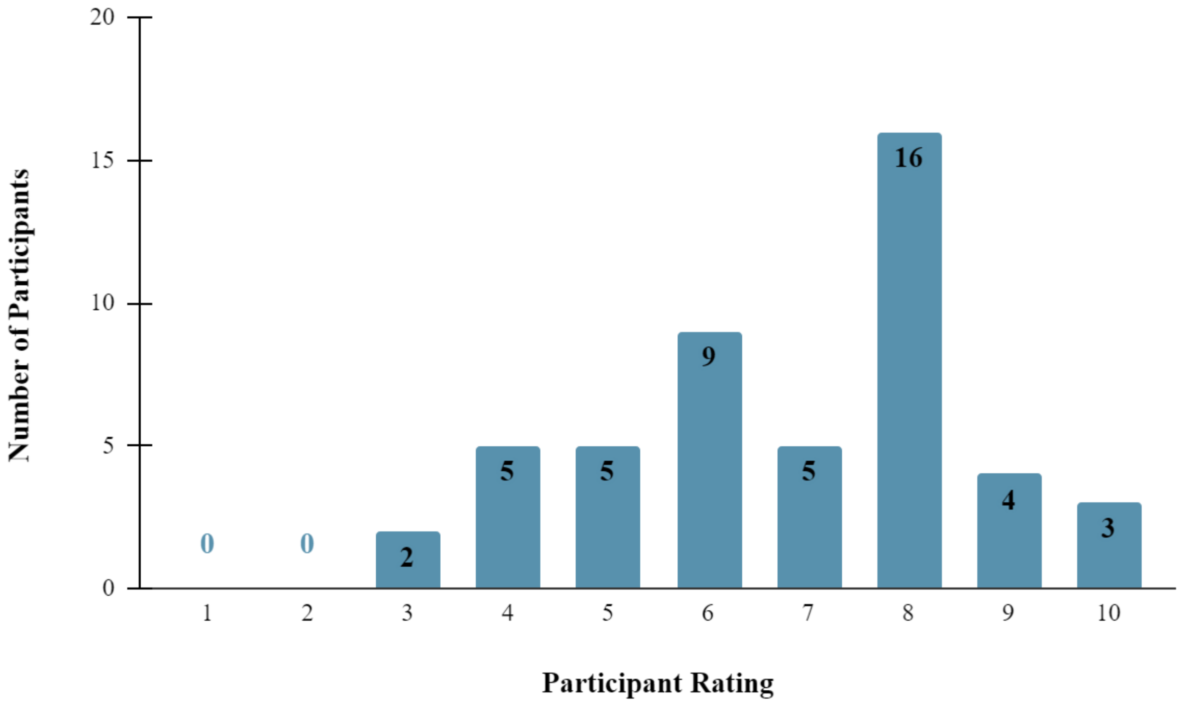
Figure 17: ***Question 3 Explanations***



Most participants who answered stated that they had confidence in their scores because they had confidence in the simulation, and that they had no issues. The second most common response is that they rated simulation confidence based on perceived inaccuracy of the simulation.

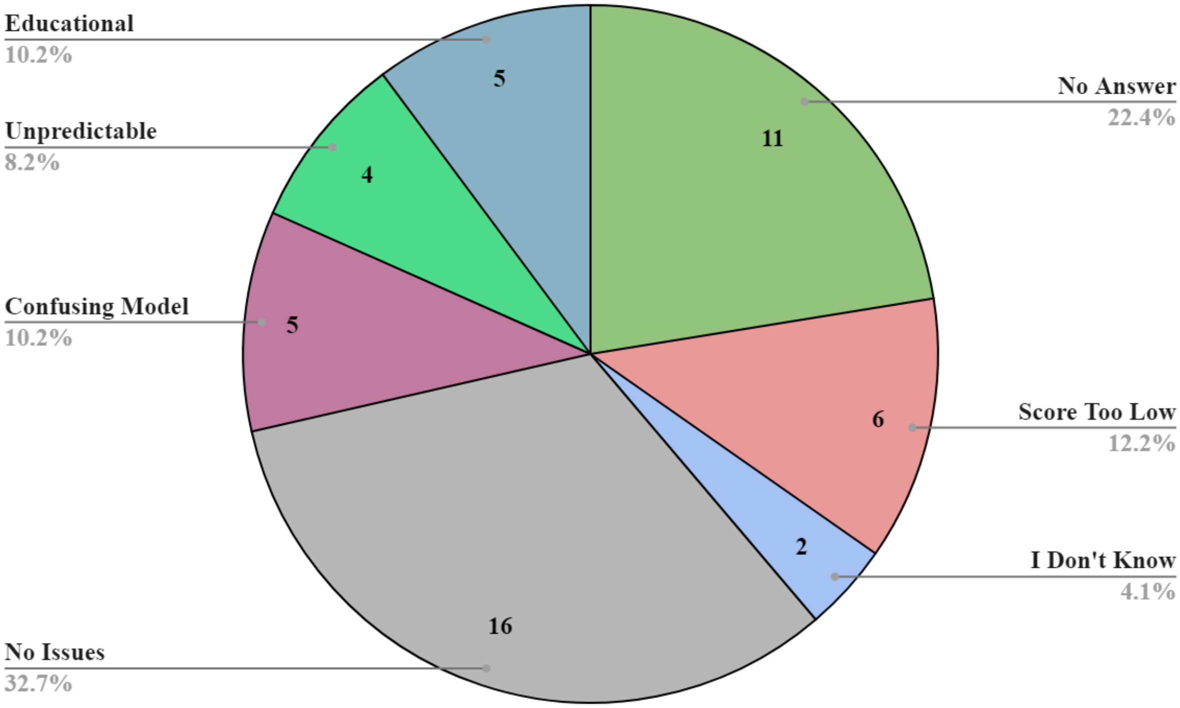
Question 4 concerned how satisfied the participants were with their final Overall Simulation scores. Their responses are reflected in Figure 18.

Figure 18: ***Question 4 Answers***
How satisfied are you with your results? Rate from 1-10, then explain.



Most participants had high satisfaction with their results, coming in at an 8 out 10. The average score for satisfaction was 6.82 out of 10. Figure 19 reflects participant explanations for their rating.

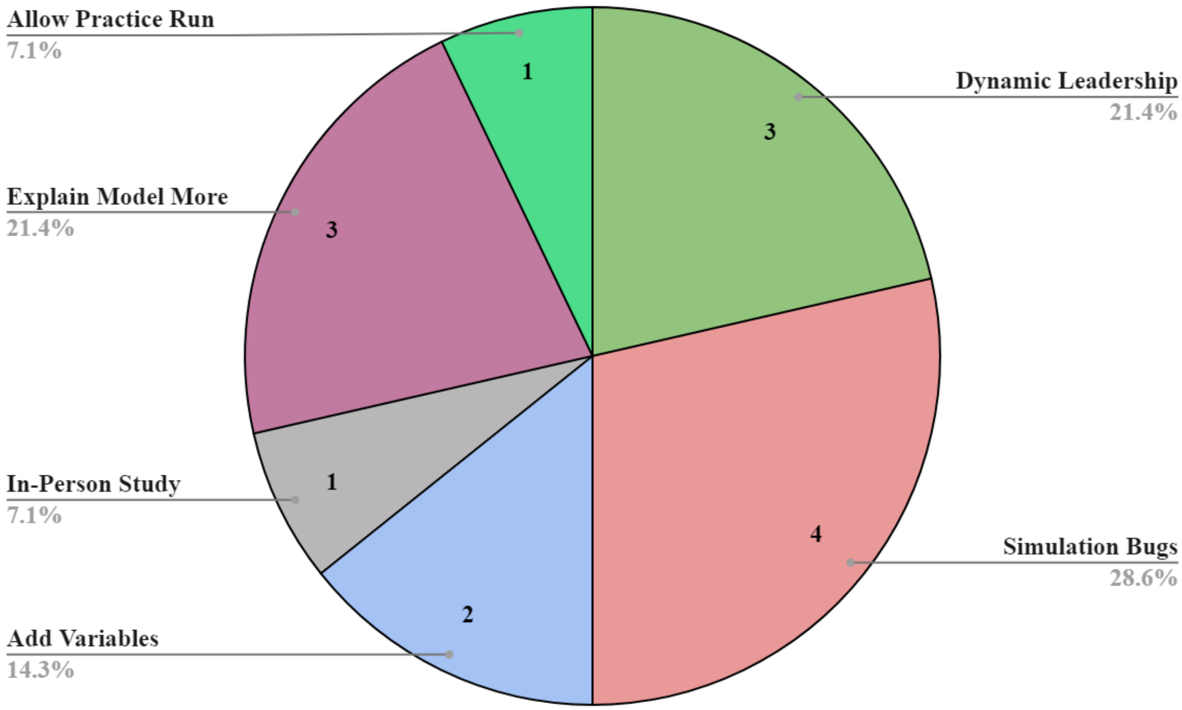
Figure 19: ***Question 4 Explanations***



Most participants reported that they were very satisfied with their results and that they had no issues. Of the participants that had complaints, the most common issue was that they were initially hoping for a high score, and thought that they could have done better.

The last question on the Post-Simulation Handout asked if there were any questions about the study or suggestions for future research. Of the 49 handouts, 14 (28.6%) had extra comments or questions that they added in this section. Figure 20 reflects the answers of those that filled in that section.

Figure 20: ***Question 5 Answers***



The most common recommendation for improvement regarded the user-friendliness of the interface. Some participants had to complete their simulations on a mobile device, and the simulator had only been properly formatted for desktop. Also, there were some issues with the internet and refresh speed. The second most common recommendation was to take into account dynamic leadership, and in future research consider a Subordinate that responds to both praise and criticism at varying levels.

When administering the group discussion, participants showed their agreement to a peer's statement by a show of hands. It should be of note that it was difficult to get volunteers to offer feedback. Most of the feedback from the participants came from the Post-Simulation Group Discussion Question handout, which is relevant to their learning process but not to the hypotheses of this investigation.

CHAPTER 4: Discussion

4.1 Overview of Findings

This study did not find any statistical significance between the two groups regarding if knowledge of subordinate personality is integral to expediting leadership decisions. Therefore, the first hypothesis was not supported. However, the trend in the change in results supports the second hypothesis, which concerns the accumulation of knowledge of the Leadership and Performance Model (LPM). Participants, regardless of what simulation out of the five was investigated, always did better than their first simulation. The third iteration proved to be where the greatest increase in score manifested, and the average score went back down for most participants. However, scores improved again after the fourth iteration. For the rate of learning, there was no statistical significance between the two groups. Most participants displayed confidence in their simulation scores and within the model itself. Most participants were also satisfied with their final results.

Findings regarding knowledge of personality are not consistent with previous works. Studies have shown that developing a rapport with subordinates and learning their personalities are the most important aspects of transformational leadership (NCO Journal, 2018, p. 3). Findings regarding learning are consistent with past work regarding the use of System Dynamics (SD) to teach groups of people about various subject matters (Stave, 2002, p. 304). Participants displayed signs of learning from the LPM and from running simulations for themselves.

4.2 Limitations

Due to the nature of simulations, it is nearly impossible to truly mimic the intricacies of real life, even with years of research and hundreds of differential equations. Because of the nature of STELLA, every variable needs its own module, and every stock and flow structure needs to be created from scratch, each with an initial value and a value of time it takes to change the indicated variable. As evident in Appendix E, the Leadership and Performance Model is already quite large. It took an entire year to build, and another year to add additional variables that were needed and then create an interface for the LPM. There are currently 165 variables in the LPM, an additional 50 variables added from the time of the IQP this time last year, but as many participants pointed out, it is still missing important variables.

One example of missing variables can be found in the Physical State sector. It does not take into account how many calories the Subordinate is eating, or how intense their exercise is (how many calories they burn). The main output of this sector is Energy, which plays a key factor in Motivation, Psychological State, and Performance. There was simply not enough time nor manpower to elevate the Physical sector to take these extra variables into account. In addition, the Psychological sector could have many additions made to include a vast expansion of personality styles. The LPM currently only reflects four personality styles. There are endless possibilities and variables that could affect the inner workings of the LPM. Unfortunately, the current state of the LPM does not precisely mirror the relationship between a leader and their subordinate, but is instead merely an approximation based on decades of research. Future research should continue expanding the LPM and utilizing peer-reviewed research to calibrate additional sectors and variables.

In the available participant pool at this private institution, there are not many cadets in comparison to other ROTC programs, which limits the participants. The lack of statistical significance may be partially attributed to the small sample size. Future research should focus on a larger sample size after adding additional relevant variables to the LPM.

4.3 Conclusions

Although there was no statistically significant difference between the two conditions, learning about these relationships was still facilitated. Every participant had to pass the Cockpit Pre-Quiz before they were allowed into the cockpit and begin their first simulation. Upon beginning simulations, participants statistically improved their scores, regardless of condition. Therefore, it can be argued that all participants had at least an elementary knowledge of the LPM and the ability to adapt to their assigned Subordinate. Thus, it is possible that simply possessing the knowledge of these dynamic systems can inspire leaders to be more adaptive in their choices for their subordinates. Several participants mentioned that they learned something new about the relationships between leaders and their subordinates.

Investigating future groups with an independent variable regarding knowledge of System Dynamics and the LPM could prove to be of importance. This can help differentiate between learning being attributed to knowledge of the model being applied or simply a case of adaptation to simulator feedback. Alternatively, participants could be instructed to reach a certain score, and the data analysis could focus on how many attempts it took to achieve the prescribed score. This might provide insight into how necessary the education of SD is in teaching leaders about these relationships, or how knowledge of personality affects the speed at which players learn and adapt to their subordinate. This can assist further in differentiating between the root of participant learning. Participants may achieve the goal more expeditiously if they are in the group that teaches them about System Dynamics.

Before introducing the LPM to new participant pools, it is recommended that each sector be added to in order to achieve a new level of accuracy and robust calculations. Some participants commented on inconsistencies in the simulation with reality (lack of variables), and it is certainly worth investigating and pursuing further. There are always new and interesting ways to expand upon prior research, and the Leadership and Performance Model is no exception.

Overall, although no statistical significance was achieved, there are many things to be learned from this research. All participants learned how to interact with their Subordinate based on simulation feedback and improve their scores over time. This enforces the precedent that System Dynamics is an effective teaching tool for complex systems. The intersection of Psychological Science, System Dynamics, and Army doctrine has proven to be rich with information and exciting new questions. Further research has the potential to inspire real change not only in aspiring leaders in civilian fields, but also the way that monoliths like the Department of Defense may be able to adopt some day.

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APPENDICES

Appendix A: Flight Simulator Link

https://ecdyndev.iseesystems.com/public/mike-radzicki/champagne

Appendix B: Acronym Index

ACFT	Army Combat Fitness Test
CLD	Causal Loop Diagram
DV	Dependent Variable
EDM	Eating Disorder Model
IQP	Interactive Qualifying Project
IV	Independent Variable
LPM	Leadership and Performance Model
MQP	Major Qualifying Project
MS	Military Science
OSS	Overall Simulation Score
PT	Physical Training
ROTC	Reserve Officer Training Corps
SD	System Dynamics
STELLA	Systems Thinking, Experimental Learning Laboratory with Animation
WBM	Worker Burnout Model

Appendix C: Player Handouts

Username: _______________ MS Level: _______________

Please read the model instructions carefully, and raise your hand if you have any questions. Your username on this paper MUST be exactly the same as what you input into the simulation as your username.

Personality	**Praise**	**Criticism**
1	Positive Reaction	Negative Reaction
2	Positive Reaction	No Reaction
3	Negative Reaction	Positive Reaction
4	No Reaction	Positive Reaction

*You have been assigned Personality 3. Your assigned Subordinate has a personality that is receptive to criticism but reacts negatively to praise. **OR** You have been assigned a Subordinate. Your assigned Subordinate has one of the four personalities above, but you do not know which one.* Your Subordinate starts off their four-year term at your unit not very motivated or energetic, but they train about 10 hours a week. They are very sensitive to your feedback. They get about 240 hours of sleep per month, or 8 hours of sleep a night. Their initial ACFT score upon arrival is a 300. In order to pass, they must get a 360. You have five tries to get the highest simulation score possible. **WRITE DOWN EACH FINAL SCORE.**

Real World Praise Examples:

- *Keep it up!*
- *You got this!*
- *Light work!*
- *Too easy!*
- *Almost done!*
- *Power through, push it!*

Real World Criticism Examples:

- *You can do better than that!*
- *Come on, you've got to be kidding me!*
- *Don't mess this up!*
- *I thought you were a soldier, come on!*
- *Why are you so slow today?*
- *You're dragging, come on!*

Please write down your FINAL simulation score for each run of the model.

	Overall Simulation Score
Run 1	
Run 2	
Run 3	
Run 4	
Run 5	

Appendix D: Post-Simulation Handout

Discussion Questions:

1. What leadership style do you think would best work for you to improve your own ACFT score? (positive or critical) Why?

2. Do you think the model was accurate to real life? Rate from 1-10, then explain.

1	2	3	4	5	6	7	8	9	10
Not Accurate at All									Exactly Accurate

3. How much confidence do you have in the accuracy of your scores? Rate from 1-10, then explain.

1	2	3	4	5	6	7	8	9	10
Not Confident at All									Perfectly Confident

4. How satisfied were you with your results? Rate from 1-10, then explain.

1	2	3	4	5	6	7	8	9	10
Not Satisfied at All									Perfectly Satisfied

5. Do you have any questions about this study or suggestions for future research?

6. Can the researchers use your answers to these questions in their write-up? Write yes or no.

Appendix E: Post-Simulation Group Discussion Questions

<u>Group Questions:</u> (Ask these questions to the group)

6. Was it helpful to know your Subordinate's personality ahead of time?
7. Did anything surprise you about the model's structure?
8. What, if anything, was challenging about getting a high score?
9. How challenging was it to get a perfect score on a scale of 1 to 10? Why?
10. What strategies do you think pair best with what personality types?

Appendix F: LPM Variables and Equations

Leadership and Performance Model	Total
Variables	165
Modules	4
Stocks	10
Flows	10
Converters	145
Constants	42
Equations	113
Graphicals	23

Run Specs	
Start Time	0
Stop Time	48

DT	0.01
Fractional DT	False
Save Interval	1
Sim Duration	1.5
Time Units	Months
Pause Interval	6
Integration Method	Euler
Keep all variable results	True
Run By	Run
Calculate loop dominance information	True
Exhaustive Search Threshold	1000

	Variable	**Equation**	**Used By**
	Max_Number_of_Runs	6	RC
	Quiz_Passed	0	Reset_Runs
	RC	(Max_Number_of_Runs - RUNCOUNT)	
	Reset_Runs	IF Quiz_Passed =1 THEN RUNCOUNT-RUNCOUNT ELSE RUNCOUNT	
	Leadership.Effective_Leader_ACFT_Goal_for_Subordinate	IF TIME < 6 THEN Performance.Initial_ACFT_Score ELSE IF Leader_ACFT_Goal_for_Subordinate < Performance.ACFT_Score THEN	Leadership.Leader_Subordinate_Goal_Gap, Psychological_State.Effect_of_Perceived_ACFT_Ability_on_Motivation,

		Performance.ACFT_Score ELSE IF Leader_ACFT_Goal_for_Subordinate > Performance.ACFT_Score_Max THEN Performance.ACFT_Score_Max ELSE Leader_ACFT_Goal_for_Subordinate	Psychological_State.Indicated_Perceived_ACFT_Ability
○	Leadership."Effective_Praise/Criticism_Index"	IF Leader_Subordinate_Goal_Gap <= 0 THEN 0 ELSE "Praise/Criticism_Index"	Psychological_State."Absolute_Praise/Crit", Psychological_State."Effective_Praise/Crit"
○	Leadership.Leader_ACFT_Goal_for_Subordinate	400	Leadership.Effective_Leader_ACFT_Goal_for_Subordinate
○	Leadership.Leader_Subordinate_Goal_Gap	(Effective_Leader_ACFT_Goal_for_Subordinate - Performance.ACFT_Score) /Effective_Leader_ACFT_Goal_for_Subordinate	Leadership."Effective_Praise/Criticism_Index", Physical_State.Effect_of_ACFT_Goal_on_Training_Per_Month
○	Leadership."Praise/Criticism_Index"	0	Leadership."Effective_Praise/Criticism_Index"
○	Leadership.User_Number	0	
○	Performance.ACFT_Ratio	ACFT_Score / ACFT_Score_Max	Performance.Effect_of_ACFT_Ratio_on_Chg
▭	Performance.ACFT_Score(t)	ACFT_Score(t - dt) + (Chg_in_ACFT_Score) * dt	Performance.Chg_in_ACFT_Score, Performance.ACFT_Ratio, Performance.Discrete_ACFT_Score, Performance.Efficient_Distance_ACFT_Score, Performance.Ratio_ACFT_Score, Leadership.Leader_Subordinate_Goal_Gap, Leadership.Effective_Leader_ACFT_Goal_for_Subordinate
○	Performance.ACFT_Score_Max	600	Performance.ACFT_Ratio, Psychological_State.Indicated_Perceived_ACFT_Ability,

			Leadership.Effective_Leader_ACFT_Goal_for_Subordinate
	Performance.Change_in_OSS	(OSS - Overall_Simulation_Score) / Time_to_Chg_OSS	Performance.Overall_Simulation_Score
	Performance.Chg_Distance_Traveled_ACFT_Score	IF TIME < 1 THEN 0 ELSE ABS (Discrete_ACFT_Score - Lagged_Discrete_ACFT_Score) // DT	Performance.Distance_Traveled_ACFT_Score
	Performance.Chg_Distance_Traveled_Energy_Level	IF TIME < 1 THEN 0 ELSE ABS (Discrete_Energy_Level - Lagged_Discrete_Energy_Level) // DT	Performance.Distance_Traveled_Energy_Level
	Performance.Chg_Distance_Traveled_Motivation	IF TIME < 1 THEN 0 ELSE ABS (Discrete_Motivation - Lagged_Discrete_Motivation) // DT	Performance.Distance_Traveled_Motivation
	Performance.Chg_in_ACFT_Score	((Indicated_ACFT_score - ACFT_Score) / Time_to_chg_ACFT_Score) * Effect_of_ACFT_Ratio_on_Chg	Performance.ACFT_Score
	Performance.Compute_Quiz_Score	0	Performance.Quiz_Score
	Performance.Discrete_ACFT_Score	IF TIME = INT(TIME) THEN ACFT_Score ELSE 0	Performance.Lagged_Discrete_ACFT_Score, Performance.Chg_Distance_Traveled_ACFT_Score
	Performance.Discrete_Energy_Level	IF TIME = INT(TIME) THEN Physical_State.Energy_Level ELSE 0	Performance.Lagged_Discrete_Energy_Level, Performance.Chg_Distance_Traveled_Energy_Level
	Performance.Discrete_Motivation	IF TIME = INT(TIME) THEN Psychological_State.Motivation ELSE 0	Performance.Lagged_Discrete_Motivation, Performance.Chg_Distance_Traveled_Motivation
	Performance.Distance_Traveled_ACFT_Score(t)	Distance_Traveled_ACFT_Score(t - dt) + (Chg_Distance_Traveled_ACFT_Score) * dt	Performance.Efficiency_ACFT_Score

	Performance.Distance_Traveled_Energy_Level(t)	Distance_Traveled_Energy_Level(t - dt) + (Chg_Distance_Traveled_Energy_Level) * dt	Performance.Efficiency_Energy_Level
	Performance.Distance_Traveled_Motivation(t)	Distance_Traveled_Motivation(t - dt) + (Chg_Distance_Traveled_Motivation) * dt	Performance.Efficiency_Motivation
	Performance.Effect_of_ACFT_Ratio_on_Chg	GRAPH(ACFT_Ratio) Points: (0.000, 2.000), (0.100, 1.982), (0.200, 1.954), (0.300, 1.913), (0.400, 1.852), (0.500, 1.762), (0.600, 1.626), (0.700, 1.424), (0.800, 1.122), (0.900, 0.6717), (1.000, 0.000)	Performance.Chg_in_ACFT_Score
	Performance.Effect_of_Energy_Level	GRAPH(Physical_State.Energy_Ratio) Points: (0.500, 0.5067), (0.600, 0.518), (0.700, 0.5474), (0.800, 0.6192), (0.900, 0.7689), (1.000, 1.000), (1.100, 1.231), (1.200, 1.381), (1.300, 1.453), (1.400, 1.482), (1.500, 1.493)	Performance.Indicated_ACFT_score
	Performance.Effect_of_Motivation	GRAPH(Psychological_State.Motivation_Ratio) Points: (0.500, 0.5067), (0.600, 0.518), (0.700, 0.5474), (0.800, 0.6192), (0.900, 0.7689), (1.000, 1.000), (1.100, 1.231), (1.200, 1.381), (1.300, 1.453), (1.400, 1.482), (1.500, 1.493)	Performance.Indicated_ACFT_score
	Performance.Effect_of_Training	GRAPH(Physical_State.Training_Ratio) Points: (0.500, 0.5067), (0.600, 0.518), (0.700, 0.5474), (0.800, 0.6192), (0.900, 0.7689), (1.000, 1.000), (1.100, 1.231), (1.200, 1.381), (1.300, 1.453), (1.400, 1.482), (1.500, 1.493)	Performance.Indicated_ACFT_score
	Performance.Efficiency_ACFT_Score	Efficient_Distance_ACFT_Score // Distance_Traveled_ACFT_Score	Performance.OSS
	Performance.Efficiency_Energy_Level	Efficient_Distance_Energy_Level // Distance_Traveled_Energy_Level	Performance.OSS

○	Performance.Efficiency_Motivation	Efficient_Distance_Motivation // Distance_Traveled_Motivation	Performance.OSS
○	Performance.Efficient_Distance_ACFT_Score	IF (ACFT_Score - Initial_ACFT_Score) < 0 THEN 0 ELSE (ACFT_Score - Initial_ACFT_Score)	Performance.Efficiency_ACFT_Score
○	Performance.Efficient_Distance_Energy_Level	IF (Physical_State.Energy_Level - Physical_State.Initial_Energy_Level) < 0 THEN 0 ELSE (Physical_State.Energy_Level - Physical_State.Initial_Energy_Level)	Performance.Efficiency_Energy_Level
○	Performance.Efficient_Distance_Motivation	IF (Psychological_State.Motivation - Psychological_State.Initial_Motivation) < 0 THEN 0 ELSE (Psychological_State.Motivation - Psychological_State.Initial_Motivation)	Performance.Efficiency_Motivation
○	Performance.Indicated_ACFT_score	Initial_ACFT_Score * Effect_of_Motivation * Effect_of_Training *Effect_of_Energy_Level	Performance.Chg_in_ACFT_Score
○	Performance.Initial_ACFT_Score	300	Performance.Indicated_ACFT_score , Performance.Efficient_Distance_ACFT_Score, Psychological_State.Trend_in_ACFT_Score, Physical_State.Effect_of_Perceived_Ability_on_Energy_Drain, Leadership.Effective_Leader_ACFT_Goal_for_Subordinate
○	Performance.Lagged_Discrete_ACFT_Score	DELAY(Discrete_ACFT_Score , 1 , 0)	Performance.Chg_Distance_Traveled_ACFT_Score
○	Performance.Lagged_Discrete_Energy_Level	DELAY(Discrete_Energy_Level , 1 , 0)	Performance.Chg_Distance_Traveled_Energy_Level
○	Performance.Lagged_Discrete_Motivation	DELAY(Discrete_Motivation , 1 , 0)	Performance.Chg_Distance_Traveled_Motivation

	Performance.Leader_Goal_for_ACFT_Score	400	Performance.Ratio_ACFT_Score
	Performance.OSS	Reference_Score * ((Ratio_ACFT_Score ^ Weight_to_ACFT_Score) * (Ratio_Energy_Level ^ Weight_to_Energy_Level) * (Ratio_Motivation ^ Weight_to_Motivation) + (Efficiency_ACFT_Score ^ Weight_to_Efficiency_ACFT_SCore) * (Efficiency_Energy_Level ^ Weight_to_Efficiency_Energy_Level) * (Efficiency_Motivation ^ Weight_to_Efficiency_Motivation))	Performance.Change_in_OSS
	Performance.OSS_Translated	(100*Overall_Simulation_Score)/250	
	Performance.Overall_Simulation_Score(t)	Overall_Simulation_Score(t - dt) + (Change_in_OSS) * dt	Performance.Change_in_OSS, Performance.OSS_Translated
	Performance.Question_1	0	Performance.Question_1_Score
	Performance.Question_1_Score	IF Question_1 = 1 THEN (1) ELSE (0)	Performance.Quiz_Score
	Performance.Question_2	0	Performance.Question_2_Score
	Performance.Question_2_Score	IF Question_2 = 3 THEN (1) ELSE (0)	Performance.Quiz_Score
	Performance.Question_3	0	Performance.Question_3_Score
	Performance.Question_3_Score	IF Question_3 = 4 THEN (1) ELSE (0)	Performance.Quiz_Score
	Performance.Question_4	0	Performance.Question_4_Score

○	Performance.Question_4_Score	IF Question_4 = 2 THEN (1) ELSE (0)	Performance.Quiz_Score
○	Performance.Quiz_Score	IF Compute_Quiz_Score = 0 THEN 0 ELSE Question_1_Score * Question_2_Score * Question_3_Score * Question_4_Score	
○	Performance.Ratio_ACFT_Score	ACFT_Score / Leader_Goal_for_ACFT_Score	Performance.OSS
○	Performance.Ratio_Energy_Level	Physical_State.Energy_Level / Physical_State.Initial_Energy_Level	Performance.OSS
○	Performance.Ratio_Motivation	Psychological_State.Motivation / Psychological_State.Initial_Motivation	Performance.OSS
○	Performance.Reference_Score	100	Performance.OSS
○	Performance.Time_to_chg_ACFT_Score	6	Performance.Chg_in_ACFT_Score
○	Performance.Time_to_Chg_OSS	6	Performance.Change_in_OSS
○	Performance.Weight_to_ACFT_Score	2	Performance.OSS
○	Performance.Weight_to_Efficiency_ACFT_SCore	.6	Performance.OSS
○	Performance.Weight_to_Efficiency_Energy_Level	.5	Performance.OSS
○	Performance.Weight_to_Efficiency_Motivation	.5	Performance.OSS
○	Performance.Weight_to_Energy_Level	1	Performance.OSS
○	Performance.Weight_to_Motivation	2	Performance.OSS

	Physical_State.Chg_in_Energy_Level	((Indicated_Energy_Level - Energy_Level) / Time_to_Chg_Energy_Level) * Effect_Energy_Ratio_on_Chg	Physical_State.Energy_Level
	Physical_State.Chg_in_Sleep_Hours_Per_Month	((Indicated_Time_for_Sleep-Sleep_Hours_Per_Month)/Time_to_Chg_Sleep_Hours_Per_Month) * Effect_Sleep_Ratio_on_Chg	Physical_State.Sleep_Hours_Per_Month
	Physical_State.Chg_Training_Hours_Per_Month	((Indicated_Time_for_Training-Training_Hours_Per_Month)/Time_to_Chg_Training_Hrs_Per_Month) * Effect_Training_Ratio_on_Chg_Training	Physical_State.Training_Hours_Per_Month
○	Physical_State.Desired_Time_for_Sleep	Initial_Time_for_Sleep * Effect_of_Energy_Level_on_Sleep	Physical_State.Time_Desired_for_Sleep_&_Training, Physical_State.Fraction_of_Total_Time_Indicated_for_Sleep, Physical_State.Indicated_Time_for_Sleep
○	Physical_State.Desired_Time_for_Training	Initial_Time_for_Training * Effect_of_ACFT_Goal_on_Training_Per_Month * Effect_of_Energy_on_Training_Per_Month * Effect_of_Motivation_Ratio_on_Training_Per_month	Physical_State.Time_Desired_for_Sleep_&_Training, Physical_State.Fraction_of_Total_Time_Indicated_for_Training, Physical_State.Indicated_Time_for_Training
○	Physical_State.Desired_Time_Necessary_for_Everything_Else	475	Physical_State.Time_Necessary_for_Everything_Else
○	Physical_State.Effect_Energy_Ratio_on_Chg	GRAPH("Energy_Ratio_-_Max") Points: (0.000, 1.000), (0.100, 0.9908), (0.200, 0.9771), (0.300, 0.9567), (0.400, 0.9262), (0.500, 0.8808), (0.600, 0.813), (0.700, 0.7118), (0.800, 0.5609), (0.900, 0.3358), (1.000, 0.000)	Physical_State.Chg_in_Energy_Level

○	Physical_State.Effect_of_ACFT_Goal_on_Training_Per_Month	GRAPH(Leadership.Leader_Subordinate_Goal_Gap) Points: (0.000, 1.000), (0.100, 1.336), (0.200, 1.662), (0.300, 1.816), (0.400, 1.921), (0.500, 1.978), (0.600, 2.000), (0.700, 2.000), (0.800, 2.000), (0.900, 2.000), (1.000, 2.000)	Physical_State.Desired_Time_for_Training
○	Physical_State.Effect_of_Energy_Level_on_Sleep	GRAPH(Energy_Ratio) Points: (0.000, 2.000), (0.100, 1.991), (0.200, 1.977), (0.300, 1.957), (0.400, 1.926), (0.500, 1.881), (0.600, 1.813), (0.700, 1.712), (0.800, 1.561), (0.900, 1.336), (1.000, 1.000)	Physical_State.Desired_Time_for_Sleep
○	Physical_State.Effect_of_Energy_on_Training_Per_Month	GRAPH(Energy_Ratio) Points: (0.000, 0.7533), (0.200, 0.7590), (0.400, 0.7737), (0.600, 0.8096), (0.800, 0.8845), (1.000, 1.0000), (1.200, 1.1160), (1.400, 1.1900), (1.600, 1.2260), (1.800, 1.2410), (2.000, 1.2470)	Physical_State.Desired_Time_for_Training
○	Physical_State.Effect_of_Motivation_Ratio_on_Training_Per_month	GRAPH(Psychological_State.Motivation_Ratio) Points: (0.000, 0.500), (0.200, 0.5126), (0.400, 0.5434), (0.600, 0.6165), (0.800, 0.7676), (1.000, 1.000), (1.200, 1.232), (1.400, 1.383), (1.600, 1.457), (1.800, 1.487), (2.000, 1.500)	Physical_State.Desired_Time_for_Training
○	Physical_State.Effect_of_Perceived_Ability_on_Energy_Drain	GRAPH(Psychological_State.Perceived_ACFT_Ability / Performance.Initial_ACFT_Score) Points: (0.000, 0.9013), (0.200, 0.9036), (0.400, 0.9095), (0.600, 0.9238), (0.800, 0.9538), (1.000, 1.0000), (1.200, 1.0460), (1.400, 1.0760), (1.600, 1.0910), (1.800, 1.0960), (2.000, 1.0990)	Physical_State.Indicated_Energy_Level
○	Physical_State.Effect_of_Sleep_on_Energy_Level	GRAPH(Sleep_Ratio_Relative_to_Normal) Points: (0.000, 0.000), (0.100, 0.0407), (0.200, 0.08908), (0.300, 0.1466), (0.400, 0.215), (0.500, 0.2963), (0.600, 0.393), (0.700, 0.5079), (0.800, 0.6445), (0.900, 0.8069), (1.000, 1.000)	Physical_State.Indicated_Energy_Level

○	Physical_State.Effect_of_Training_Hours_on_Energy_Drain	GRAPH(Training_Ratio) Points: (1.000, 1.0000), (1.100, 0.9233), (1.200, 0.8650), (1.300, 0.8206), (1.400, 0.7868), (1.500, 0.7610), (1.600, 0.7414), (1.700, 0.7265), (1.800, 0.7152), (1.900, 0.7066), (2.000, 0.7000)	Physical_State.Indicated_Energy_Level
○	Physical_State.Effect_Sleep_Ratio_on_Chg	GRAPH(Sleep_Ratio) Points: (0.000, 1.000), (0.100, 0.9908), (0.200, 0.9771), (0.300, 0.9567), (0.400, 0.9262), (0.500, 0.8808), (0.600, 0.813), (0.700, 0.7118), (0.800, 0.5609), (0.900, 0.3358), (1.000, 0.000)	Physical_State.Chg_in_Sleep_Hours_Per_Month
○	Physical_State.Effect_Training_Ratio_on_Chg_Training	GRAPH(Training_Ratio_Relative_to_Max) Points: (0.000, 1.000), (0.100, 0.9908), (0.200, 0.9771), (0.300, 0.9567), (0.400, 0.9262), (0.500, 0.8808), (0.600, 0.813), (0.700, 0.7118), (0.800, 0.5609), (0.900, 0.3358), (1.000, 0.000)	Physical_State.Chg_Training_Hours_Per_Month
▭	Physical_State.Energy_Level(t)	Energy_Level(t - dt) + (Chg_in_Energy_Level) * dt	Physical_State."Energy_Ratio_-_Max", Physical_State.Chg_in_Energy_Level, Physical_State.Energy_Ratio, Performance.Discrete_Energy_Level, Performance.Efficient_Distance_Energy_Level, Performance.Ratio_Energy_Level
○	Physical_State.Energy_Ratio	Energy_Level / Initial_Energy_Level	Physical_State.Effect_of_Energy_Level_on_Sleep, Physical_State.Effect_of_Energy_on_Training_Per_Month, Psychological_State.Effect_of_Energy_Ratio_on_Perceived_Ability, Performance.Effect_of_Energy_Level
○	Physical_State."Energy_Ratio_-_Max"	Energy_Level / Maximum_Energy_Level	Physical_State.Effect_Energy_Ratio_on_Chg

○	Physical_State.Fraction_of_Total_Time_Indicated_for_Sleep	Desired_Time_for_Sleep // Time_Desired_for_Sleep_&_Training	Physical_State.Time_Deficit_Allocated_to_Sleep
○	Physical_State.Fraction_of_Total_Time_Indicated_for_Training	Desired_Time_for_Training // Time_Desired_for_Sleep_&_Training	Physical_State.Time_Deficit_Allocated_to_Training
○	Physical_State.Hours_Per_Month	720	Physical_State.Time_Available_for_Sleep_&_Training
○	Physical_State.Indicated_Energy_Level	Initial_Energy_Level * Effect_of_Sleep_on_Energy_Level * Effect_of_Perceived_Ability_on_Energy_Drain * Effect_of_Training_Hours_on_Energy_Drain	Physical_State.Chg_in_Energy_Level
○	Physical_State.Indicated_Time_for_Sleep	Desired_Time_for_Sleep + Time_Deficit_Allocated_to_Sleep	Physical_State.Total_Indicated_Time_for_Sleep_&_Training, Physical_State.Chg_in_Sleep_Hours_Per_Month, Physical_State.Sleep_Ratio_Relative_to_Normal
○	Physical_State.Indicated_Time_for_Training	Desired_Time_for_Training + Time_Deficit_Allocated_to_Training	Physical_State.Total_Indicated_Time_for_Sleep_&_Training, Physical_State.Chg_Training_Hours_Per_Month
○	Physical_State.Initial_Energy_Level	5	Physical_State.Indicated_Energy_Level, Physical_State.Energy_Ratio, Performance.Efficient_Distance_Energy_Level, Performance.Ratio_Energy_Level
○	Physical_State.Initial_Time_for_Sleep	IF Time_Available_for_Sleep_&_Training > 0 AND Time_Available_for_Sleep_&_Training < 240 THEN INIT(Time_Available_for_Sleep_&_Training) ELSE 240	Physical_State.Initial_Time_for_Training, Physical_State.Desired_Time_for_Sleep

	Physical_State.Initial_Time_for_Training	IF Time_Available_for_Sleep_&_Training = 0 THEN 0 ELSE INIT(Time_Available_for_Sleep_&_Training - Initial_Time_for_Sleep)	Physical_State.Desired_Time_for_Training, Physical_State.Training_Ratio
	Physical_State.Max_Sleep_Hours_Per_Month	280	Physical_State.Sleep_Ratio
	Physical_State.Max_Sleep_Hours_Per_Month_1	300	
	Physical_State.Max_Training_Hours_Per_Month	84	Physical_State.Training_Ratio_Relative_to_Max
	Physical_State.Max_Training_Hours_Per_Month_1	120	
	Physical_State.Maximum_Energy_Level	10	Physical_State."Energy_Ratio_-_Max"
	Physical_State.Sleep_Hours_Per_Month(t)	Sleep_Hours_Per_Month(t - dt) + (Chg_in_Sleep_Hours_Per_Month) * dt	Physical_State.Chg_in_Sleep_Hours_Per_Month, Physical_State.Sleep_Ratio, Physical_State.Sleep_Ratio_Relative_to_Normal
	Physical_State.Sleep_Ratio	Sleep_Hours_Per_Month / Max_Sleep_Hours_Per_Month	Physical_State.Effect_Sleep_Ratio_on_Chg
	Physical_State.Sleep_Ratio_Relative_to_Normal	Sleep_Hours_Per_Month // Indicated_Time_for_Sleep	Physical_State.Effect_of_Sleep_on_Energy_Level
	Physical_State.Time_Available_for_Sleep_&_Training	IF Time_Necessary_for_Everything_Else > Hours_Per_Month THEN 0 ELSE Hours_Per_Month - Time_Necessary_for_Everything_Else	Physical_State.Time_Deficit_for_Sleep_&_Training, Physical_State.Initial_Time_for_Training, Physical_State.Initial_Time_for_Sleep
	Physical_State.Time_Deficit_Allocated_to_Sleep	IF Time_Deficit_for_Sleep_&_Training >= 0 THEN 0 ELSE	Physical_State.Indicated_Time_for_Sleep

		Fraction_of_Total_Time_Indicated_for_Sleep * Time_Deficit_for_Sleep_&_Training	
○	Physical_State.Time_Deficit_Allocated_to_Training	IF Time_Deficit_for_Sleep_&_Training >= 0 THEN 0 ELSE Fraction_of_Total_Time_Indicated_for_Training * Time_Deficit_for_Sleep_&_Training	Physical_State.Indicated_Time_for_Training
○	Physical_State.Time_Deficit_for_Sleep_&_Training	Time_Available_for_Sleep_&_Training - Time_Desired_for_Sleep_&_Training	Physical_State.Time_Deficit_Allocated_to_Training, Physical_State.Time_Deficit_Allocated_to_Sleep
○	Physical_State.Time_Desired_for_Sleep_&_Training	Desired_Time_for_Training + Desired_Time_for_Sleep	Physical_State.Time_Deficit_for_Sleep_&_Training, Physical_State.Fraction_of_Total_Time_Indicated_for_Sleep, Physical_State.Fraction_of_Total_Time_Indicated_for_Training
○	Physical_State.Time_Necessary_for_Everything_Else	IF Desired_Time_Necessary_for_Everything_Else > 475 THEN 475 ELSE Desired_Time_Necessary_for_Everything_Else	Physical_State.Time_Available_for_Sleep_&_Training
○	Physical_State.Time_to_Chg_Energy_Level	3	Physical_State.Chg_in_Energy_Level
○	Physical_State.Time_to_Chg_Sleep_Hours_Per_Month	3	Physical_State.Chg_in_Sleep_Hours_Per_Month
○	Physical_State.Time_to_Chg_Training_Hrs_Per_Month	3	Physical_State.Chg_Training_Hours_Per_Month
○	Physical_State.Total_Indicated_Time_for_Sleep_&_Training	Indicated_Time_for_Training + Indicated_Time_for_Sleep	

	Physical_State.Training_Hours_Per_Month(t)	Training_Hours_Per_Month(t - dt) + (Chg_Training_Hours_Per_Month) * dt	Physical_State.Chg_Training_Hours_Per_Month, Physical_State.Training_Ratio_Relative_to_Max, Physical_State.Training_Ratio
	Physical_State.Training_Ratio	Training_Hours_Per_Month // Initial_Time_for_Training	Physical_State.Effect_of_Training_Hours_on_Energy_Drain, Performance.Effect_of_Training
	Physical_State.Training_Ratio_Relative_to_Max	Training_Hours_Per_Month / Max_Training_Hours_Per_Month	Physical_State.Effect_Training_Ratio_on_Chg_Training
	Psychological_State."Absolute_Praise/Crit"	ABS(Leadership."Effective_Praise/Criticism_Index")	Psychological_State."Effective_Praise/Crit"
	Psychological_State.Chg_in_Motivation	((Indicated_Motivation - Motivation) / Time_to_Chg_Motivation) * Effect_of_MR_on_Chg	Psychological_State.Motivation
	Psychological_State.Chg Perceived_ACFT_Ability	(Indicated_Perceived_ACFT_Ability - Perceived_ACFT_Ability) / Time_to_Chg_Perceived_ACFT_Ability	Psychological_State.Perceived_ACFT_Ability
	Psychological_State.Effect_of_Energy_Ratio_on_Perceived_Ability	GRAPH(Physical_State.Energy_Ratio) Points: (0.000, 0.01339), (0.200, 0.04669), (0.400, 0.144426666667), (0.600, 0.34663), (0.800, 0.645189285714), (1.000, 1.000), (1.200, 1.35465), (1.400, 1.6532), (1.600, 1.85546666667), (1.800, 1.9534), (2.000, 1.987)	Psychological_State.Indicated_Perceived_ACFT_Ability
	Psychological_State.Effect_of_MR_on_Chg	GRAPH(Motivation_Relative_to_Max) Points: (0.000, 1.000), (0.100, 0.9908), (0.200, 0.9771), (0.300, 0.9567), (0.400, 0.9262), (0.500, 0.8808), (0.600, 0.813), (0.700, 0.7118), (0.800, 0.5609), (0.900, 0.3358), (1.000, 0.000)	Psychological_State.Chg_in_Motivation

○	Psychological_State.Effect_of_Perceived_ACFT_Ability_on_Motivation	GRAPH(Perceived_ACFT_Ability / Leadership.Effective_Leader_ACFT_Goal_for_Subordinate) Points: (0.000, 0.005002), (0.166666666667, 0.0190833333333), (0.333333333333, 0.0678855555556), (0.500, 0.213966666667), (0.666666666667, 0.434), (0.833333333333, 0.704), (1.000, 1.000), (1.16666666667, 1.270), (1.33333333333, 1.421), (1.500, 1.495)	Psychological_State.Indicated_Motivation
○	Psychological_State.Effect_of_Perceived_Improvement_on_Perceived_Ability	GRAPH(Perception_of_Improvement) Points: (-0.2000, 0.5067), (-0.1600, 0.518), (-0.1200, 0.5474), (-0.0800, 0.6192), (-0.0400, 0.7689), (0.0000, 1.000), (0.0400, 1.231), (0.0800, 1.381), (0.1200, 1.453), (0.1600, 1.482), (0.2000, 1.493)	Psychological_State.Indicated_Perceived_ACFT_Ability
○	Psychological_State."Effective_Praise/Crit"	IF Leadership."Effective_Praise/Criticism_Index" < 0 THEN ("Absolute_Praise/Crit" ^ Reactivity_Coef) * -1 ELSE Leadership."Effective_Praise/Criticism_Index" ^ Reactivity_Coef	Psychological_State."Praise_(/)_Criticism_(+)", Psychological_State."Praise_(+)_Criticism_(/)", Psychological_State."Praise_(+)_Criticism_(-)", Psychological_State."Praise_(-)_Criticism_(+)"
○	Psychological_State.Indicated_Motivation	IF Switch_for_Reactivity = 1 THEN ABS(Initial_Motivation *Effect_of_Perceived_ACFT_Ability_on_Motivation* "Praise_(+)_Criticism_(-)") ELSE IF Switch_for_Reactivity=2 THEN ABS(Initial_Motivation*Effect_of_Perceived_ACFT_Ability_on_Motivation*"Praise_(+)_Criticism_(/)") ELSE IF Switch_for_Reactivity = 3 THEN ABS(Initial_Motivation*Effect_of_Perceived_ACFT_Ability_on_Motivation*"Praise_(-)_Criticism_(+)") ELSE ABS(Initial_Motivation*Effect_of_Perceived_ACFT_Ability_on_Motivation*"Praise_(/)_Criticism_(+)")	Psychological_State.Chg_in_Motivation

	Psychological_State.Indicated_Perceived_ACFT_Ability	IF Switch_for_Intrinsic_Motivation = 1 THEN MIN(Performance.ACFT_Score_Max , Leadership.Effective_Leader_ACFT_Goal_for_Subordinate * Effect_of_Energy_Ratio_on_Perceived_Ability * Effect_of_Perceived_Improvement_on_Perceived_Ability) ELSE MIN(Performance.ACFT_Score_Max , Leadership.Effective_Leader_ACFT_Goal_for_Subordinate * Effect_of_Energy_Ratio_on_Perceived_Ability * No_Effect_of_Perceived_Improvement_on_Perceived_Ability)	Psychological_State.Chg_Perceived_ACFT_Ability
	Psychological_State.Initial_Motivation	5	Psychological_State.Indicated_Motivation, Psychological_State.Motivation_Ratio, Performance.Efficient_Distance_Motivation, Performance.Ratio_Motivation
	Psychological_State.Max_Motivation_Possible	10	Psychological_State.Motivation_Relative_to_Max
	Psychological_State.Motivation(t)	Motivation(t - dt) + (Chg_in_Motivation) * dt	Psychological_State.Chg_in_Motivation, Psychological_State.Motivation_Relative_to_Max, Psychological_State.Motivation_Ratio, Performance.Ratio_Motivation, Performance.Discrete_Motivation, Performance.Efficient_Distance_Motivation
	Psychological_State.Motivation_Ratio	Motivation / Initial_Motivation	Performance.Effect_of_Motivation, Physical_State.Effect_of_Motivation_Ratio_on_Training_Per_month

○	Psychological_State.Motivation_Relative_to_Max	Motivation / Max_Motivation_Possible	Psychological_State.Effect_of_MR_on_Chg
○	Psychological_State.No_Effect_of_Perceived_Improvement_on_Perceived_Ability	GRAPH(Perception_of_Improvement) Points: (-0.2000, 1.000), (-0.0666666666667, 1.000), (0.0666666666667, 1.000), (0.2000, 1.000)	Psychological_State.Indicated_Perceived_ACFT_Ability
▭	Psychological_State.Perceived_ACFT_Ability(t)	Perceived_ACFT_Ability(t - dt) + (Chg_Perceived_ACFT_Ability) * dt	Psychological_State.Chg_Perceived_ACFT_Ability, Psychological_State.Effect_of_Perceived_ACFT_Ability_on_Motivation, Physical_State.Effect_of_Perceived_Ability_on_Energy_Drain
○	Psychological_State.Perception_of_Improvement	SMTH1(Trend_in_ACFT_Score , Time_to_Perceive_Improvement , Trend_in_ACFT_Score)	Psychological_State.Effect_of_Perceived_Improvement_on_Perceived_Ability, Psychological_State.No_Effect_of_Perceived_Improvement_on_Perceived_Ability
○	Psychological_State."Praise_(+)_Criticism_(-)"	GRAPH("Effective_Praise/Crit") Points: (-0.500, 0.000), (-0.400, 0.026), (-0.300, 0.061), (-0.200, 0.149), (-0.100, 0.430), (0.000, 1.000), (0.100, 1.73105857863), (0.200, 1.88079707798), (0.300, 1.95257412682), (0.400, 1.98201379004), (0.500, 1.99330714908)	Psychological_State.Indicated_Motivation
○	Psychological_State."Praise_(+)_Criticism_(/)"	GRAPH("Effective_Praise/Crit") Points: (-0.500, 1.000), (-0.400, 1.000), (-0.300, 1.000), (-0.200, 1.000), (-0.100, 1.000), (0.000, 1.000), (0.100, 1.73105857863), (0.200, 1.88079707798), (0.300, 1.95257412682), (0.400, 1.98201379004), (0.500, 1.99330714908)	Psychological_State.Indicated_Motivation
○	Psychological_State."Praise_(-)_Criticism_(+)"	GRAPH("Effective_Praise/Crit") Points: (-0.500, 1.99330714908), (-0.400, 1.97771598115), (-0.300, 1.9031669053),	Psychological_State.Indicated_Motivation

		(-0.200, 1.71667814114), (-0.100, 1.44322585432), (0.000, 1.000), (0.100, 0.535), (0.200, 0.272), (0.300, 0.167), (0.400, 0.061), (0.500, 0.000)	
○	Psychological_State."Praise_(/)_Criticism_(+)"	GRAPH("Effective_Praise/Crit") Points: (-0.500, 1.99330714908), (-0.400, 1.97771598115), (-0.300, 1.9031669053), (-0.200, 1.71667814114), (-0.100, 1.44322585432), (0.000, 1.000), (0.100, 1.000), (0.200, 1.000), (0.300, 1.000), (0.400, 1.000), (0.500, 1.000)	Psychological_State.Indicated_Motivation
○	Psychological_State.Reactivity_Coef	.3	Psychological_State."Effective_Praise/Crit"
○	Psychological_State.Switch_for_Intrinsic_Motivation	1	Psychological_State.Indicated_Perceived_ACFT_Ability
○	Psychological_State.Switch_for_Reactivity	3	Psychological_State.Indicated_Motivation
○	Psychological_State.Time_to_Chg_Motivation	3	Psychological_State.Chg_in_Motivation
○	Psychological_State.Time_to_Chg_Perceived_ACFT_Ability	3	Psychological_State.Chg_Perceived_ACFT_Ability
○	Psychological_State.Time_to_Compute_Trend_in_ACFT_Score	3	Psychological_State.Trend_in_ACFT_Score
○	Psychological_State.Time_to_Perceive_Improvement	3	Psychological_State.Perception_of_Improvement
○	Psychological_State.Trend_in_ACFT_Score	TREND(Performance.Initial_ACFT_Score , Time_to_Compute_Trend_in_ACFT_Score , 0)	Psychological_State.Perception_of_Improvement