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Investigation in Engineering Leadership Using System Engineering and Virtual Reality

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INVESTIGATION IN ENGINEERING LEADERSHIP USING SYSTEMS ENGINEERING AND VIRTUAL REALITY

by

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ABSTRACT

System Engineering can help derive requirements and specifications to build virtual environments which are good to test behaviors and attitudes. Virtual simulations can have a strong impact because role-playing facilitates active learning, permits the acceptance of new concepts, and generates increased interest, enthusiasm, and motivation. Research over the last 50 years has shown that **r**easoning with and about context is an essential aspect of human cognition, permeating language, memory, and reasoning capabilities. This integral process is developed over a lifetime through experiential learning. In this research, we utilize systems engineering to capture guidelines from psychologist and concepts of technological leadership. These guidelines are converted in requirements and technical specifications (using SySML) of virtual simulation environments (built in OpenSim). Then, this virtual simulation environments are used to test subjects and see the potential changes in leadership skills. The research is a promising step in the test of attitudes and leadership in STEM environments.

I would like to dedicate my fallen nephew, Albert Joseph Davis. May he rest in peace.

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This work in this dissertation would not be possible with the guidance of my advisor, Dr. Luis Rabelo, and his valuable leadership, mentorship, and advice during my graduate studies. I have sincerely enjoyed working on his research projects. I would also like to thank Dr. Ahmad Elshennawy, Dr. Pamela McCauley, and Dr. Falecia Williams for their valuable input, mentorship, and participation in my committee. I would like to thank my parents, Rosemary and Charles Davis, Sr., for their love and commitment of making me what I am today. I would like to thank the McKnight Fellowship for their unconditional support and encouragement throughout my graduate studies. I would like to acknowledge my fallen nephew, Albert Joseph Davis. May he rest in peace.

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CHAPTER 1: INTRODUCTION

1.1 Background of the Study

Systems Engineering has generally focused on the technological conditions of system design, such as hardware, software and automation, while predominantly neglecting the fact that these systems will fundamentally be utilized in the assistance of humans to fulfill challenges that work requires. Business leaders that are have realized the foresight of staging virtual simulations in team-based education by conducting it in a cost and time effective manner and prepare future leaders for the unforeseen complexities of operating in a universal environment. Although replacement for face-to-face engagement, virtual simulations can mirror real-life challenges and contingencies by allowing students to grasp from and connect with peers in an experiential environment. Engineers today require a skill set which was not as nearly important to retain even ten (10) years ago. Therefore, engineers now have a desire to demonstrate comprehensive competency to be employable and flourish in their careers. Immersing simulation activities is a favorited way to increase and give students environments to display proficiency while immersing them in inquiry-based decontextualized situations when acquiring the knowledge and principles of (STEM) fields in science, technology, engineering, and mathematics. It has been proven by using role-playing simulations in engineering students help develop higher order thinking skills, the ability to communicate clearly, and visualize multiple perspectives in ways they would not have been able to replicate in other environments. Despite engineering simulations are often technical, the study is where students focus on role-playing simulations assuming a character or perspective for experiential learning and development of technological leadership; thus the symbolic realities set of the simulations is the objective to test subjects and see the potential changes in leadership skills. Facing the challenge of human-system integration related to system engineering, how does system engineering make the optimum use of systems and people in a large-scale distributed and dynamic ventures? In this research, the researcher uses systems engineering to capture guidelines from psychologists and concepts of technological leadership to test and change behavior of subjects. To change behavior, one of the steps is testing attitudes and changing mental models with support of psychology and systems engineering. The response is to enhance the practice of System Engineering with techniques of Cognitive Modeling. Cognitive Modeling appeals to diverse disciplines, to include but not limiting to the following fields, Human-Computer Interaction, Cognitive Psychology, Human Factors Engineering, Decision Science, and Computer Science. Cognitive Modeling is rooted in Task Analysis and connects the key tasks or functions that are performed in a work domain and then breaks each task systematically into a series of lower-level tasks. Furnished with quite a task breakdown analysis, there is a possibility to make engineering decisions of allocating functions amongst people and systems. The most concern and of importance is to distinguish between Behavioral Task Analysis and Cognitive Task Analysis since Cognitive Engineering. Behavioral Task Analysis is concerned with behavioral actions that is directly recognized, as an example, moving dial or flipping switch, and most often utilized to calculate quantities like completion of time or total throughput in a specified time. Unlike Behavioral Task Analysis, Cognitive Task Analysis proceeds beyond observable behavior to quantify and model the mental activities (cognition) that motivate observable behaviors, and it can be used to gauge quantities such as throughput in addition to quality. Cognitive Task Analysis can be utilized to assess possible human errors in information processing and serve thereby as a rationale for designing decision support systems. Goal of Cognitive Modeling is to create systems and guidance to support cognitive functions in situation assessment, decision-making, resource allocation, course-of-action selection and other information processing tasks. Below are some design questions addressed by Cognitive Engineering:

- What information shall be given to system operators?
- How should the format be displayed so that it is conforms to operator goals and decision-making objectives?
- How effective can tasks be distributed across team members and system automation?
- How supportive of systems with humans so that human-system performance is better than systems or humans manage in isolation?

The main purpose of the research is to design an investigation to understand, analyze, manage, and develop ways to build technological leadership in engineering students through Cognitive Modeling methods and Systems Engineering. Cognitive Modeling methods are placed into five categories, based purpose and on the focus of each method. The five (5) categories depicted with several subcategories in Figure 1, are as follows: Modeling Behavioral Processes, Modeling Cognitive Processes, Behavioral Processes and Describing Cognitive, Modeling Human-Machine Systems and Modeling Erroneous Actions. Individual method was designated to a single category/subcategory, and although some methods may be arranged in several category selections were chosen believed to be the best fit. This will support the design of training systems, human interfaces, and communication systems, teams, and management systems. It will also engage principles and methods that convey training, processes, technology, and the design of procedures. The investigation will address methodologies and techniques allowing me to define the baseline performance on technological leadership, determine the best practices, set specific goals, measure the impacts, and lastly assess the initiatives. By utilizing this investigation, the virtual environment will have the ability to design and create a simulated platform on a distinctive planning process and a classification of technological leadership styles.

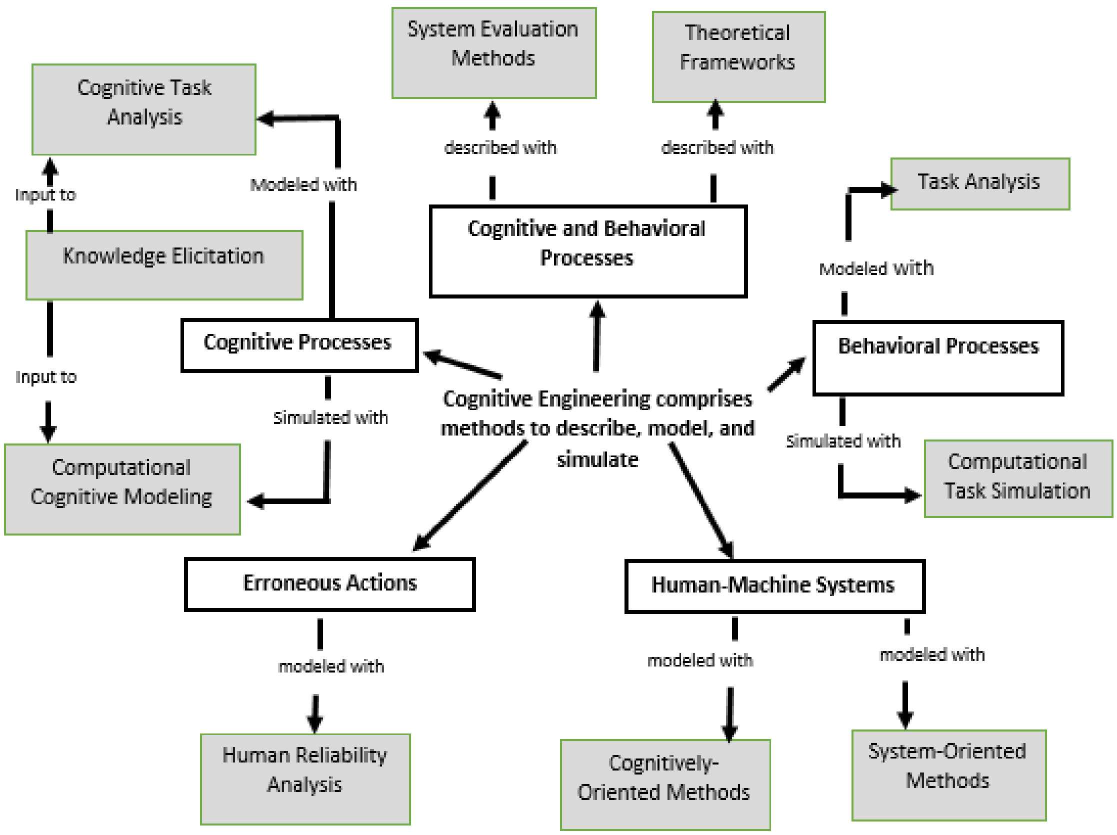


Figure 1: Classification of Cognitive Engineering Methods.

<u>Cognitive Processes:</u> Methods in this class are concerned fundamentality with the cognitive and knowledge activities used to execute tasks in a work domain. Subcategories in this network encompass Knowledge Elicitation (KE), Cognitive Task Analysis (CTA), and Computational Cognitive Modeling (CCM). Cognitive Task Analysis attempts to represent the intelligence and cognitive activities operators to take advantage of performing complex tasks in the work domain (Schraagen, Chipman, & Shalin, 2000). This is beneficial in developing guidance programs and execution measures, establishing a benchmark to identify people for selective jobs, and providing perception into the types of support systems that people require, as well as the algorithm such reinforce systems may utilize. CTA's products are typically descriptive models, while the family of methods attributed to as Computational Cognitive Modeling produces more descriptive models of human performance with complex cognitive tasks. The models that can run a computer may provide insight into how great a proposed system will support operators by anticipating operator performance and workload under various situations, along with estimated time required to learn and perform a cognitive task. Input provided from KE methods to both CTA and CCM, are used to arbitrate the knowledge required to perform work tasks. Think aloud or process tracing approach is a routine knowledge elicitation technique where the operator thinks aloud and simultaneously performing some task or solving a problem. The procedure achieves a protocol (i.e., operator's deliberations recording, possibly including observations and behavior of the operator) that can be analyzed and translated to divulge information about the operator's hypothesis sequences and objective structures.

Behavioral Processes: Methods in this category are primarily concerned with simulating and modeling sequences of behaviors, including rule-based decisions that influence when selective sequences are activated and interaction of the sequences. While these methods are not appropriate for analyzing highly cognitive tasks, identification of these tasks are cognitively demanding and therefore requires further analysis. Task Analysis (TA) and Computational Task Simulation (CTS) are subcategories in this area. Task Analysis includes techniques for producing meticulous descriptions of the way a task is performed or should be performed. A typical TA yields a briefly ordered sequence of actions necessary to complete a task and the duration estimates of each action. CTS techniques are the companion of CCM but model the noticeable actions necessary to perform tasks as oppose to the underlying cognitive activities that drive task performance. Dynamically, the simulations can run tasks in real or fast time as a means of estimating complete cycle times, accuracy, work, and error likelihoods (Kirwan & Ainsworth, 1992).

Cognitive and Behavioral Processes: These methods characterize people work tasks performance, so they are customarily less formal than the models previously mentioned. The methods examine operator's use of currently available tools and their performance tasks in the work domain, usually when a prototype or system already exist and can be assessed and refined. System Evaluation Methods evaluate interaction of how operators are with existing or proposed systems. Their goal is to assess how simplistic a system is to grasp and operate, and how efficient the system supports the tasks that are performed by the operators. The use of the methods is typically in a bilateral fashion to test and improve a proposed system design, emerging it from a prototype to its eventual design. A method commonly used in this group is the applicability study, where operators are observed during performance of tasks using a proposed system in a controlled environment. By observing many operators performing the equal tasks under controlled environments, it is conceivable to identify aspects of the human system interface where improvement is required.

Erroneous Actions with Human Reliability Analysis: Utilizing these methods evaluated circumstances where oversights have happened or could have happen. The intention is to have an impact on whether human errors will have crucial ramifications and quantify the possibilities of various category of mistakes. A common method in this family is The Fault Tree Analysis which describes various deficiencies that would need to develop to provoke an undesired event (i.e., a disaster). Constructed as a series of logic gates a fault tree descends through ancillary events to primary events, which may be hardware/software failures, human errors, or environment events. It is conceivable to determine the likely sources of errors with a fault tree and construct obstacles to prevent them (Henley & Kumamoto, 1981).

Human-Machine Systems: These techniques have an extensive focus on how the integrated system, consisting of people and technology, performs entirely to achieve the inclusive goals of the system. Focusing on cognitive demands, this category includes Cognitively Oriented Methods (COM) that are inflicted on the population operating in work disciplines, and System-Oriented Methods (SOM), which focus on facts flowing among systems and humans.

Human-Systems Integration is of predominantly important to Systems Engineering and the recommended methods of Cognitive Engineering should play an essential function in the practice of Systems Engineering. Attributes of positive behavior validate a system engineering leader to effectively communicate and generate sound decisions, while also acknowledging concerns of all stakeholders. Figure 2 shows fascinating behavioral attributes for a system leader incorporating characteristics (Fairley 2009).

- **Leadership** – encourages teamwork, influences others, creates a vision, mentors and motivates others.
- **Communication** – listens effectively, encourages open communication, strong oral and written communication skills, elicits information from others and translates information effectively.
- **Technical acumen** – is competent, experience in diverse areas.
- **Attitudes and attributes** – demonstrate trustworthiness, works well under stress, flexible, inquisitive and have great interpersonal skills.
- **Problem solving and system thinking** – integrates diverse information,

thinks holistically, enjoys problem solving, and asks lots of questions.

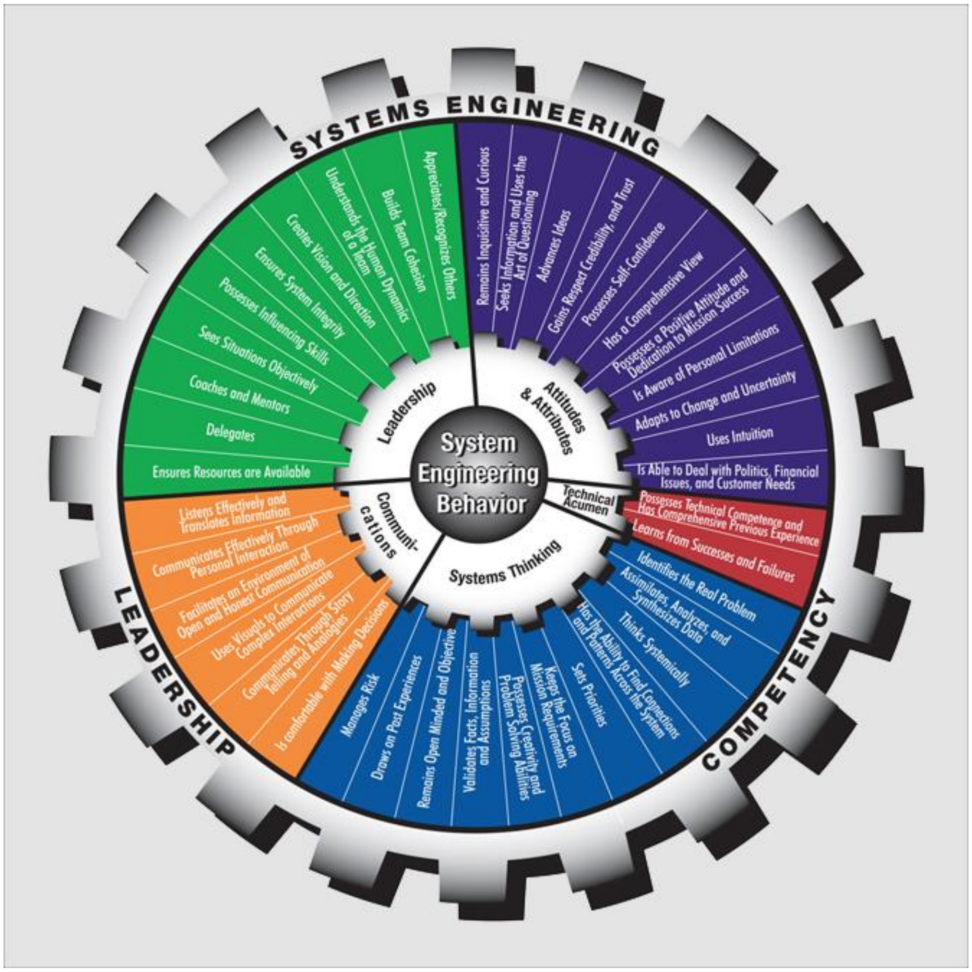


Figure 2: NASA Systems Engineering Behavior Competency Model.

Source: Academy of program/project and engineering leadership (appel.nasa.gov)

Figure 3 shows the utilization of systems engineering to design a virtual environment to build leadership skills. Systems engineering based on cognitive input and situational leadership models will develop the requirements and technical specifications to create virtual worlds to teach our students the leadership skills. For the research I have separated systems engineering into technical leadership and its collaborator, systems management. Technical leadership concentrates on a system's technical composition and technical principle for the duration of its lifecycle. Technical leadership, the craftsmanship of systems engineering, balances a comprehensive technical domain knowledge, problem solving, engineering instinct, leadership, creativity, and communication to establish new missions and systems. The focus of Systems management is to focus on governing the complexity correlated with having many technical disciplines, multiple institutions, and hundreds or thousands of humans engaged in an exceptionally technical activity. The science of systems engineering is Systems management. Its focus is on indisputably and methodically executing the development and operation of multiplex systems. Effective systems management requires the application of a standardized, discipline engineering perspective that is calculable, recurrent, repeatable, and undeniable.

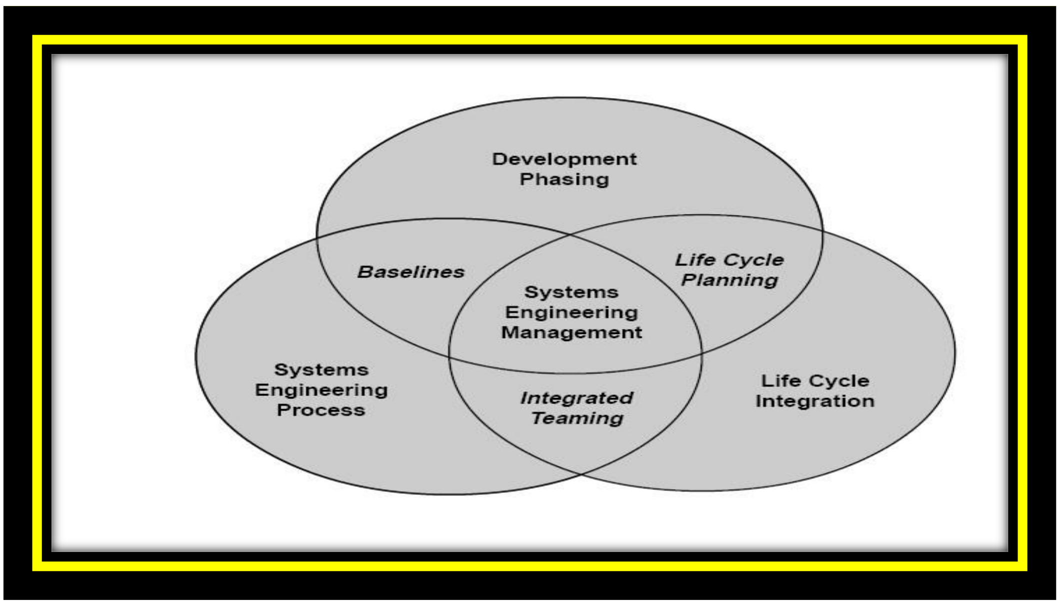


Figure 3: Research Investigation,

Source :The scope of systems engineering activities (Defense Acquisition, 2001)

At the time of the current study, the pedagogy of leadership for engineering students were traditional and moderately lacking in creativity and innovation. Leadership strategies were communicated through the traditional university structure by students selecting minors in leadership, obtaining a certificate through a specific program within the major, attending workshops, all with basically the same components, coursework, team related projects and industry experience (Crumpton-Young et al., 2010). Crumpton-Young et al. (2010) also noted a gap in the preparation of engineers with respect to leadership proficiency. Crumpton-Young et al. (2010) confirmed that to ensure to fully prepare future engineers to be great leaders, the current traditional engineering leadership development must include a holistic engineering leadership program.

To enhance engineering leadership, there is the capability for artificial intelligence and virtual reality to enhance engineering leadership. This method can be implemented to prepare both teams and individuals by using either agents or avatars. Avatars are controlled by humans to be virtual representations. In contrast, a specialist is an acting substance that incorporates artificial brilliance making restraint by a human unnecessary (von der Pütten, Krämer, Gratch, & Kang, 2010). The difference between avatars and agents are that an agent is controlled by computer algorithms, but an avatar is controlled by humans (Fox et al., 2015). Fox et al. concluded in his study that avatars are more persuasive in that avatars are typically perceived to produce more robust responses than agents when mutual and/or ambitious tasks are required. Fox et al. also recommended that future researchers recognize that the unimportant discernment of humankind in a computerized representation can be sufficiently capable to open social reactions with virtual situations. When there is human interaction in the virtual world, avatars have demonstrated to have a higher response rate than bots and intelligent agents (Hasler, Tuchman, & Friedman, 2013). This can be important for leadership education in team-based environments which are pervasive in engineering.

Many empirical studies recommend simulation-based education as an effective method that can enhance a students' education (Showanasai, Lu, & Hallinger, 2013). Furthermore, education that includes virtual simulation can introduce the students to real world challenges in the virtual environment, allowing them to manage those challenges in both individual and team settings. Virtual universes have been effectively utilized as devices for instructive, recreation and preparing utilize (Sequeira & Morgado, 2013a). Virtual simulation has the capability to provide students with shared, concurrent experiences and offers opportunities to have engaged discussions. Virtual simulation motivates students to take more risks and explore while learning new ideas and techniques (Siewiorek, Saarinen, Lainema, & Lehtinen, 2012). In contrast to traditional teaching methods, virtual simulations furnish a learner-centered approach to training and this technique allows the trainees to control the training through engagement with the virtual simulation utilizing a dynamic, live and interactive path (Williams-Bell, Kapralos, Hogue, Murphy, & Weckman, 2015). 2016).

1.2 Problem Definition

Because engineers normally work in teams to achieve most of their required tasks, leadership education in engineering must consider the use of team techniques. To satisfy industry demands with achieving leadership capabilities, engineers must have the cognitive aptitudes fundamental to accomplish industry challenges. They should be effective communicators in dealing with customer relations, making decisions, and working as members of a team (Crumpton-Young et al., 2010). This is a complex problem because unpredictability of business and influence of innovation on numerous assignments and capacities has brought about expanded requests on cognitive abilities of laborers. More procedural or unsurprising errands are presently dealt with by savvy machines, whereas people have gotten to be dependable for troublesome cognitive errands. The increment in cognitive requests set on laborers has made a requirement for preparing that targets cognitive abilities.

1.2.1 Translation of Psychology to Game/Virtual Scenario

Numerous approaches to agent-based virtual scenarios exist, including virtual characters playing parts in a story. Although they all share a restorative likeness, in substance these approaches regularly have diverse objectives in intellect. A few investigations point to display a show to the gathering of people whereas others center on utilize support. A few investigations point to protect the storyline and to bargain with special cases, whereas others permit the client to some degree impact the advance of the story. A few works on modeling a modern brief situation, whereas others attempt to improve the real-world of a long travel. These diverse objectives impact plan choices on run of potential results of the scenarios. Be that as it may, a few works right now have permitted the situation to advance in ways the investigation architect does not anticipate. When scenarios gotten to be longer and bigger scale, or when the characters gotten to be more independent, the human originator loses control of the course of story advancement unless he/she can limit the activities and their results. The stories with confined conceivable outcomes frequently take off human players pondering what the result would contrast in case they can act something else. These hypotheticals are key to a player's encounter almost the story, particularly in open-ended scenarios (i.e. part playing diversions) where engaged players act and take obligation of the results. As the result of the accentuation on the independence of both clients and virtual operators, players, non-player characters and the environment collaborate to make a story instead of taking after one that an investigation originator has predefined. So, to overcome this challenge of this approach, the necessity that character and the environment must react sensibly to a wide extend of activities. When building the multi-agent investigation where computer program specialists speak to characters within the story, the specialists ought to reason approximately the world and make plans powerfully instead of following predefined scripts. Arranging specialists can show way better flexibility that script-following operators since the previous do not ought to know in development everything within the environment in arrange to show sensible behaviors; instep, they can recover data from the environment create eagerly and feelings, and utilize objects within the environment for their plans. The capacity to utilize the environment will require the character operators to begin with get it the meaning and usefulness of the environment objects and relate them to their plans. In this way, the planner/designer of the character specialist must connect with the environment show to function in virtual scenarios. Selecting the fitting learning assignment (situation) and the fitting sum of back (manipulative bearings) are capable ways to direct the learner and make compelling preparing circumstances. The ability to add automated guidance to virtual learning situations, such as virtual recreations, it is vital to reveal the standards basic preparing errand choice and control. This is how situated Cognitive Modeling method will be employed to attain plan standards and an engineering for consequently coordinated scenario-based preparing. The strategy has been already connected to the defense and space for the plan of investigations including computer-supported task performance. The roots lie within the field of cognitive designing, a science of user-centered plan which extreme to reveal the standards behind human activity and execution that are important for the plan investigations foundation both individuals and machines in arrange to increase the execution of the solidified investigation. The arranged

Cognitive Modeling method (Figure 4) comprises of a handle of iterative advancement cycles. Each cycle is coordinated at refining the system's determinations in more detail. The system's beginning detail take after from cautious investigation of the errand space, human variables information (e.g., significant speculations, rules, and bolster concepts) and innovative openings. This set of specs, comprising of claims, necessities and utilize of cases, shapes the establishment for a model. This set is to be refined by assessing the model. This whole handle is arranged, meaning that it takes place inside the setting of the space.

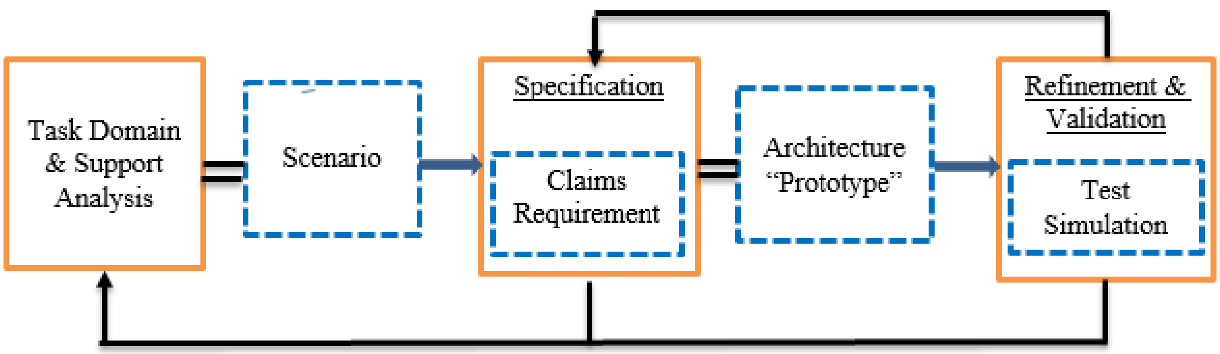


Figure 4: The situated Cognitive Modeling Method

System-based training has demonstrated to be an overwhelming preparing strategy. It is steady with the standards recognized in prevalent pedagogical theories. During system-based training, trainees plan, execute, and assess training scenarios, i.e., real-world, relevant, and purposeful storylines inside a simulated environment. The devotion of the simulated environment may change, extending from the real assignment environment to exceedingly characteristic representations. Compared to on-the-job training, the benefits of a simulated environment can be arranged, controlled, reused, and made strides upon, driving to the diminishment of dangers, costs, and assets. Preparing scenarios for the most part address learning goals. To guarantee verification and didactical esteem, scenarios are created and arranged in development of the preparing session by teachers. Most frequently the situation contains non-player characters with whom the learner ought to be connected, such as colleagues, officers, or rivals. These parts may be played by genuine people, by staff individuals and performing artists (particularly in case of adversaries), or by virtual performing artists such as cleverly operators. There are three (3) recurring and prominent principles relevant to design of scenario-based training. The 1st principle is exchange (keeping an eye on the subject matter). Viable preparing is gathered to pioneer to show of the prepared aptitudes amid future work execution. To advance exchange, preparing assignments should be true; (i.e., speak to the assignment that the learner will perform in his/her future calling). The preparing errands ought to come in wide differing qualities; by generalizing arrangements over different assignments, trainees learn to unique absent from them. This deliberation leads to acknowledgment of the basic standards to be connected within the actual assignment environment. The 2nd principle is adapting to the trainee's cognitive characteristics. To encourage learning, one must adjust the preparing to the trainee's competencies. Viable instruction takes limited working memory capacity into consideration. As the trainee's competencies develop amid training, the sum of data that can be handled by the trainee's working memory slowly increments, permitting for the errands stack to extend. This will be done by blurring bolster (investigation) by altering the sum of input, prompts, synchronous occasions, or time limitations. Another way to extend the errand stack is by expanding task complexity by selecting assignments that require a little more than the trainee's current competencies. Another perspective to be beyond any doubt is that learner's make use of distinctive learning procedures. This implies that the teachers should be able to select from diverse educating styles such as by implies of cases, through learning by doing, by applying information to cases, by assessing and reflecting on outcomes. The 3rd principle is increasing the trainee's will to memorize. The higher a trainee's inspiration, the more endeavors he/she will put into preparing and into exchanging the trained competencies to the real assignment environment. Inspiration is related to the level of self-efficacy. The trainee's honest convictions around his/her assignment execution capabilities. Motivation can be inherent (locks in a movement for its claim purpose) or outward (locks in action as an implication to a conclusion). Inherent being the more favorable one since it is emphatically related to learner accomplishments in differentiate to outward motivation which is contrarily related to learner accomplishments. Inherent inspiration is advanced by advertising the learner significant and important encounters.

1.2.2 Justifications for Leadership Development Deficiency

The conventional strategy of leadership development has not been very encouraging and successful with promising outcomes. In 2014, according to Gurdjian, Halbeisen, and Lane, historically, many organizations have not benefited monetarily on leadership development, and that around, $14 billion every year were spent on leadership development programs. Gurdjian et al. indicated that despite the huge investment, with tuition for such programs sometimes reaching $150,000 per person, 500 managers surveyed ranked leadership development as one of their most important human resource needs. Gurdjian et al. identified four reasons for leadership development failure: (a) no coordinate between specific leadership aptitudes and traits to the setting at hand, (b) leadership development was not inserted in genuine work, (c) there was a fear of questioning the leaders' mind-sets; and

(d) there was no way of monitoring the impact of improvements over time. Pellerin (2009) acknowledged that in the engineering field, the "intellectual knowledge is insufficient to create behavioral change." The research effort was conducted not only to put forth a solution to the current engineering failure, but to recommend creative ways to enhance the engineering leadership development strategies and approaches by utilizing 3D virtual world simulation to envision the real working environment. In order to design an effective virtual leadership simulation, there are certain steps that should be followed to simulate the real working environment. These steps are explained in the investigation that guided this research.

1.3 Research Objectives

The main objective of this investigation engineering leadership by utilizing system engineering and integrate virtual simulation to develop technological leadership skills. Systems engineering based on cognitive input and situational leadership models will develop the requirements and technical specifications to create virtual worlds to teach our students the leader skills. The emphasis is on changing mental models. For the research, I have divided system engineering into technical leadership and its partner, systems management. Technical leadership centers on a system's technical plan and specialized keenness all through its lifecycle. Technical leadership, the craftsman of investigations building equalizations in a wide specialized space information, building intuitive, issue understanding, inventiveness, authority, and communications to create modern missions and investigations. Technical leadership centers on overseeing the complexity related with having numerous specialized disciplines, different organizations, and hundreds or thousands of individuals locked in an exceedingly specialized movement. Systems management process is a basic complement to, and is not a substitute for, person aptitude, inventiveness, instinct, and judgement. Innovative people must make sure beyond any doubt that they understand the method and how it works, and do not disregard it. Systems engineering estimation prepare work to use imagination and advancement to provide outcomes that outperform capacity to the imaginative individual's results that are the new properties of process, organization, and leadership. One way to comprehend systems engineering is to see it as a strategy, or practice, to recognize and make strides common rules that exist inside a wide assortment of systems. It should be noted to also keep in mind, the boundary can be connected to any system that may or may not be complex, provided systems thinking can be connected to any level. Figure 5 shows the study Investigation. The study investigation will address the investigative gaps in Leadership research and education. The research methodology will show in engineering leadership body of knowledge application of any real-life innovative science fair projects and how it can enhance the leadership of undergraduate engineering students in a practical and nontraditional way of training. The research will tie the psychological aspect to evaluate and study the behavior and mental processes which will lead to colors as they relate to the individual students and the research, the system engineering tools that will be applied, the specifications required for virtual world simulation and we will build the environment based on the specifications.

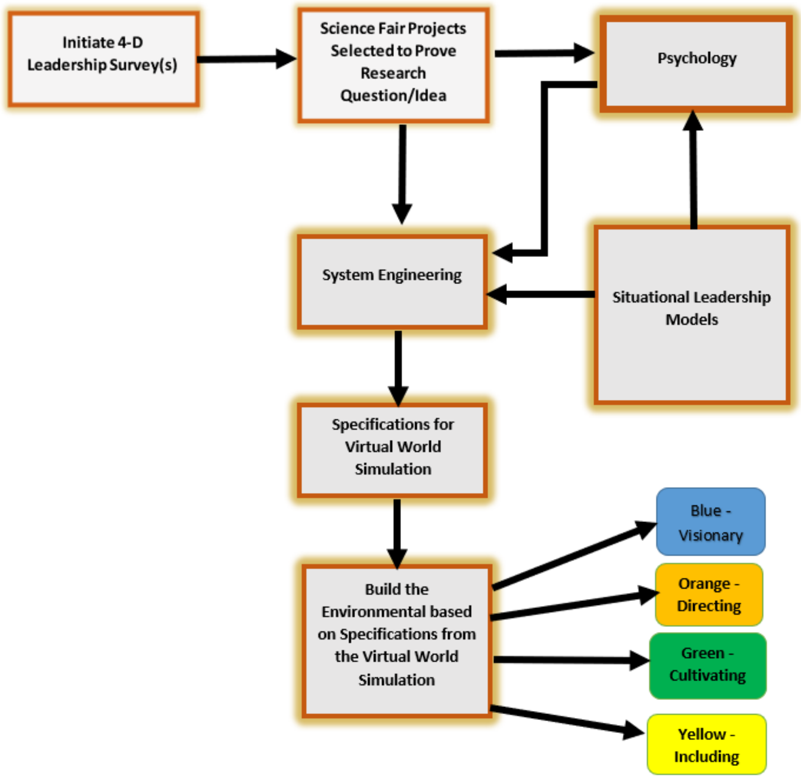


Figure 5: Using Systems Engineering to Develop Virtual Words that will change mental models and provide technological leadership skills to our students

The design of the virtual environment will be based on a carefully selected case study. The virtual environment, sometimes referred to as the "region layer," is the environment where all virtual exercise will occur and may contain the following: a level piece of land, an island, mountains, a plain, buildings, and the planet Mars, a combination of all of these, or essentially to be a tremendous sea space." (Lesko & Hollingsworth, 2013). As per ISO 9000:2000 Quality Management Principle, Principle 2, "Pioneers set up solidarity of reason and course of the organization. They should establish and keep up the internal environment in which individuals can be comprehensively included in accomplishing the organizations goals." (Cianfrani, Tsiakals, & West, 2002). To create the virtual environment for research in engineering leadership development, as the researcher I will select a case study approach to enable organizations to offer the best leadership development scenarios based on deeply investigated problems, current market demand, and customer voice and value. 4-D Leadership System was used to assess the leadership style. As noted, leaders with different leadership styles execute tasks differently. Thus, leadership assessment is important. There are many reasons for differences, and assessment provides the status of the leadership qualities of specific students. Leadership evaluation acknowledges students' leadership capabilities. It represents the strength and weaknesses of their leadership styles. The second objective is to show the connection of engineering leadership development to real substance by using the depiction of leadership, the 4-D system. Researchers have shown that some leaders do not perform well in all situations; they might lead amazingly in one situation and fail in others (Gurdjian et al., 2014). The great advantage of using the 4-D system is its skill in "improving performance within teams by changing the internal context. These processes also potentially enhance team performance across institutions by changing the context of the relationship." It is emphasized that the 4-D System can change the context, defining it as "everything, shaping the customer's perceptions of what you say and what you do." (Pellerin, 2009). Utilizing the 4-D system to qualify leadership styles enables one to call to mind leadership improvement in all four leadership styles. The third objective of this research is utilizing the 3D virtual world simulation to accomplish two major goals in undergraduate engineering students' leadership development: training leaders in several situations in simulated working environments and having the leaders execute real decisions in real cases in a simulated innovative environment. Coordinating the two can assist the leaders improve their contextual skills and change their mental models with a minimum amount of time and in a more accurate manner. The fourth objective was to complement engineering leadership development with practical steps to make the experience noticeable with minimum technological leadership miscalculations. It has been observed that 21st century engineering graduates gravitate to be unprepared when it comes to adequate leadership skills, and that places a hindrance on the engineers and the industries that hire them. Engineering leadership is considered “as the biggest gap of all the perceived gaps within the esteem of the organization versus readiness for the modern BS engineers” (Özgen et al., 2013). The final objective of the research will be to substantiate the engineering leadership development investigation. This will be accomplished by conducting a randomized pretest-posttest control experiment to examine the effectiveness of the investigation to enhance undergraduate engineering students’ leadership preparedness. The research should offer commitments in both the fields of psychology and engineering as it looks at an outdated curriculum issue and attempts to tackle it employing a logical strategy. It particularly offers commitments in the field of cognitive modeling and systems engineering creating new problem-solving strategies through the improvement of specific methodology.

1.4 Contributions

In this study, the researcher sought to recognize and exam creative techniques that might be useful in enhancing leadership development for undergraduate engineering students. The contributions of this dissertation are as follows:

The main purpose of this research is to design an investigation to understand, analyze, maintain, and develop ways to build technological leadership and change mental models in engineering students. This investigation will address methodologies and techniques allowing me to define the baseline performance on engineering leadership, determine the best practices, set specific goals, measure the impacts, and lastly assess the initiatives. By utilizing this investigation, the virtual environment will have the ability to design and create a simulated platform on a distinctive planning process and a classification of engineering leadership styles.

1. The investigation designed for this study integrates innovative science fair projects with the design of a 3D virtual world simulation environment using a 4-D Leadership System classification scheme. It is the first investigation that provides the utilization of systems engineering to design a virtual environment to build leadership skills. Systems engineering based on cognitive input and situational leadership models that will develop the requirements and technical specifications to create virtual worlds to teach our students technological leadership skills. The emphasis is on changing mental models.
2. This investigation will address methodologies and techniques allowing me to define the baseline performance on engineering leadership, determine the best practices, set specific goals, measure the impacts, and lastly assess the initiatives. By utilizing this investigation, the virtual environment will have the ability to design and create a simulated platform on a distinctive planning process and a classification of engineering leadership styles.
3. The investigation permits team leadership development for undergraduate engineering students that elect individuals as members of a team. Individuals are trained as team members and individual development is expected for students while they are successfully completing their assigned responsibilities as team members.

4. Wysocki (2002) emphasized the importance of four team success factors: (a) an equitable problem-solving capability; (b) an equitable decision-making capability; (c) an equitable conflict management capability; and (d) an equitable aptitude profile (i.e., diversity). The balanced 4-D Leadership approach realized in this research was designed to enhance the four engineering leadership styles (visionary, cultivating, including, and directive) enabling teams and individuals to be able to lead different teams and projects productively.

1.5 Dissertation Synopsis

The dissertation will commence with a literature review, distinguishing the endeavors that have now been put into this subject and what other experts have found to be conceivable arrangements to the issue of undergrad leadership development. After advance examination of the literature, certain gaps will begin and become apparent that these will be laid out and assist points of interest. After the literature gaps are determined, the model and methodology will be created and clarified, recognizing how they are best connected to the issue displayed. And at last, the conclusion will compile all this data and give various educational (college, universities, etc.,) with an improved understanding of how to create technological leadership skills.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

This chapter contains a review of the literature and research related to the problem of this study. Numerous books, articles, websites, videos and mobile applications have been dedicated specifically to the training of future leaders. Systems engineering principles have been a great asset to organizations. Systems engineering is all encompassing and integrative. It consolidates and equalizes the commitments of structural, mechanical, electrical, software, system safety, and power engineers, in addition to many others, to create a coherent entirety. From the literature, there is important work about the methodologies, best practices, and results mainly in these areas: selection of innovative science fair projects, system engineering and simulation techniques. The literature review was divided into three (3) main areas where techniques and technologies in systems engineering are applied Systems Thinking, Cognitive Systems Engineering, and Business Cases and Strategy.

At the heart of Science, Technology, Engineering and Mathematics (STEM) educational leadership lays the need to prepare students to get a handle on the technical issues and issues confronting society, create expository problem-solving capacities, being able to work successfully in groups of diverse backgrounds, societies, and scholastic disciplines. Dunn (2009) claims: according to Graham (2009), ‘over the world the mission explanations of numerous undergrad engineering degrees incorporate yearnings to deliver engineering leaders of the 21st Century’. Moreover, the National Academy of Engineering (2005) recommended in Educating the Engineer of 2020 that: “Inside the setting of the changing national and worldwide scene, the USA National Academy of Engineers enunciated a set of desires for engineers in 2020". The future engineers must be fact capable engineers who are broadly taught, see themselves as worldwide citizens, can be leaders in trade and public service, and are morally grounded.

Summers et al: (2004) states that engineers are often as possible neglected for senior administration positions; instead people with MBAs or JDs, whose academic rigor has better arranged them in communication, leadership, and management abilities, are regularly hired for these positions. Engineering Criteria 2000 (ABET 1998), the accreditation criteria established by ABET, places noteworthy accentuation on preparing graduates so that they can effectively enter into and proceed with the practice of engineering, and it is the obligation of the institution to fulfill these criteria. Typically, why support of the industry and experts in engineering education must be a fundamentally portion of the engineering curriculum (Kumar 2000). Professional practice can be characterized as the act of working specifically with employing a combination of exceedingly specialized information and aptitudes that are obtained through study, coaching, and practice (Aldridge 1994). Professional practice requires that these graduates from conventional four-year curriculum are able of planning and solving problems that cannot be found within the back of books (Kumar 2004).

The investigation of (Zafft et al., 2009) states that a leader must be engaged in a wide range of behaviors including relating to individuals, leading change, overseeing processes, and creating outcomes. The National Academy of Engineering (2004) recommends the development of innovative science fair projects approach in undergraduate and graduate curricula. Multi-media innovative science fair projects can be an effective device in investigating the nature of the world around us including its innovative investigations

(Backer, 2005). Projects have been well established methods to provide hands-on training in engineering. (Nikolic, 2002) Maxwell, Gilberti, & Mupinga (2006) suggest that multimedia innovative science fair projects are extended exercises that expose students to the complexities of problems they face in the workplace. Higher order cognitive abilities relate to the discernment that a person has procured a satisfactory portfolio of aptitudes to form a choice with an indicated period. It infers a progressed capacity to recognize, coordinated, assess, and interrelate concepts, and subsequently make the suitable choice in each problem-solving circumstance (Hingorani, Sankar, & Kramer, 1998)

Olson (2003) states that group working aptitudes are the set of interpersonal and communication skills that aid people working in a group decision-making environment. Skills of this nature incorporate listening skills, interpersonal relations skills, thought sharing, and agreement making. The more created these skills are, the more likely and promptly the student will adjust to the team environment in a real work environment.

Santhanam et al., (2008) suggests that a positive demeanor of the student includes both the student's attitude toward the subject being instructed and whether the student accepts he or she will be able to memorize the material. This incorporates passionate reaction to learning, certainty in learning new materials, obligation, achievement, and understanding of cross-disciplinary work, all of which contribute to group working abilities and higher order cognitive skills.

We need to rethink education pedagogy given that the number of students attracted to the engineering field is declining. Kirch et al. (2007) argued that women and minorities are not being attracted to engineering and computer science disciplines and the degree of inequality is among the highest in Organization for Economic Cooperation and

Development (OECD) nations. OECD brings together the governments of other thirty (30) nations committed to majority rule government and the advertise economy from around the world. That stated, there is a need for new policies focusing on education and skill attainment. Simulation process will also have an important role in order to create and assess scenarios of real problems. With application of simulation, it is possible to create more data and its usability (Xanthopoulos et al, 2012).

The Systems Engineering technique is a fundamental complement to, and is not a substitute for, person ability, inventiveness, instinct, judgement, etc. Innovation individuals need to understand the method and how to make it work for them, and not one or the other disagree nor be slaves to it. Systems Engineering estimation appears where development and imagination needs to be connected. Systems Engineering process creates an investigation to use inventiveness and development to convey the outcomes that outperform the capability of the imaginative individuals' outcomes that are the eminent properties of process, organization, and leadership (Sillitto, 2011).

Adcock (2007) states that one way to understand the inspiration behind systems engineering is to see it as a strategy, or practice, to recognize and make strides common rules that exist inside a wide assortment of systems. Hollnagel, E. & D.D. Woods (2005) states that cognitive systems engineering (CSE) could be an approach to the portrayal and investigation of human-machine systems or sociotechnical systems. This three (3) fundamental topics of CSE are how humans adapt with complexity, how work is fulfilled by the utilization of artifacts, and how human-machine systems and sociotechnical systems can be portrayed as joint cognitive systems. CSE has since its starting develop into a recognized scientific discipline, frequently also alluded to a cognitive engineering. The perception of a

Joint Cognitive System (JCS) has in specific become broadly utilized as a way of understanding how complex socio-technical systems can be described with changing degrees of determination. Both Hollnagel and Woods (2005) have more than 20 years of experience describing foundations and patterns of CSE extensively.

2.2 Technological Leadership Classification Strategies

There are several classification strategies which have been used to understand, quantify, and measure leadership style and identify personality and leadership traits. Tremendous information can be acquired about the current leadership style of the participants using tests related to these classification schemes, and they can also be utilized to quantify the advancement of leadership development for students. The most relevant of these schemes for engineering leadership development are discussed in the following subsections.

2.2.1 4-D Leadership System

The 4-D leadership system is a great endowment in the modern leadership literature. This philosophy of leadership was developed by Charles Pellerin (2009), a former director of the Astrophysics Division at NASA in his book about team building at NASA. His means to innovative leadership reasoning stems from his role in the Hubble space telescope crisis. The main problem with the Hubble telescope, launched in 1990, involved a flawed mirror which finally had to be repaired in space. He professed that the source of this malfunction was not so much a technical issue associated with the contractor but, more importantly, a negligence of leadership. The nature of NASA's relationship with this contractor was so belligerent that it obstructs the contractor from reporting this technical problem. He was appointed to lead the Hubble repair team. Although he successfully repaired the Hubble, he was extremely distressed with being associated with the original leadership problem. He made it a point of focusing his book on how to solve the problem of overlooking social context that many leaders commit while overseeing engineering projects. The 4-D System illustrated by Pellerin (2009) was based on leadership social factor. Pellerin stipulated his principal conviction that "social factors influence our behaviors, and hence influence a technical team's capacity to perform or not." In addition, Pellerin stated that a 4-D leadership system can be used as a guide "to reduce or remove social context risk from your team." (Pellerin, 2009). He further explained that social relating to people engagement factor influences behavior and perception. Defective social factors cause space calamities, airplanes to crash, and broken families. One can control their commitments to their work and family factors by overseeing their behaviors. Pellerin illustrated four types of leadership styles as shown in Figure 6:

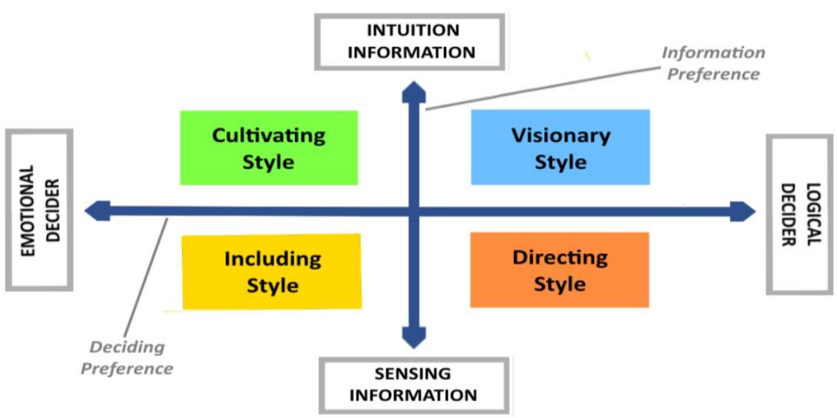


Figure 6: 4-D Leadership System.

Source. Adapted from How NASA Builds Teams: Mission Critical Soft Skills for Scientists, Engineers, and Project Teams by C. J. Pellerin (2009).

Description of Pellerin's (2009) 4-D system's contribution to leadership development as follows:

Table 1: Definition of the 4-D Leadership Systems

Blue Leadership	Is a visionary style uses logical and intuiting dimension? This style relies on thinking of future possibilities. Visionary leaders are compelling leaders and regularly create what they want
Green Leadership	Is a cultivating style relying on emotional and intuiting dimension? This style empowers significant sentiment, accomplishing a stronger world and truly cares about other individuals.
Yellow Leadership	This style depends on emotional and sensing capabilities. Someone who communicates and build relationships with people.
Orange Leadership	This is a directing style that drives its decisions utilizing logical and sensing dimension to encourage taking actions and directing others. Other actions of this style manage, plans, organizes and takes control.

As shown in figure 6, the 4-D Leadership consists of two main dimensions which are Y-axis, innate information preference (sensed information and intuition information) and X-axis, innate deciding preference (emotional decider and logical decider)

In Pellerin's (2009) book he claimed that his 4-D leadership system contribution was authenticated in Kouzes and Posner's study of leadership effectiveness, conducting the following:

(a) a 1,500- person survey by the American Management Association.

(b) a follow-up study of 80 senior executives in the federal government; and

(c) a study of 2,600 top-level managers who completed a checklist of predominant leadership characteristics. Only one question was asked: "What do you most admire in leaders?" These results were as follows (Pellerin, 2009):

- 80% of those who interviewed supported being an honest leader. This answer indicates the value of being honest to others making sure that there is inclusiveness. This description matches closely to the Yellow (including) leadership style.
- 67% of those interviewed indicated that leaders should be productive and efficient. This style of leadership most appropriately matches the Orange (directing) leadership.
- 62% of those interviewed selected the forward-looking leadership trait as the most important. This description closely matches with the Blue (visioning) leadership; and
- 58% of those interviewed believed an inspirational leader was exceptional. In this leadership style, leaders usually concern with the welfare of other people. This quality closely matches to the Green (cultivating) leadership style.

The 4-D Process is not a new categorizing tool in leadership; it is quite similar in composition to other protocols, (e.g., the Myers-Briggs), that are presently utilized for personality/temperament and individual/group compatibility training (D. Hollister, personal communication, December 23, 2015). Myers-Briggs Type Indicator created by Katharine Briggs and Isabel Briggs Myers was published in 1962; millions of individuals around the world have taken this test based on Carl S. Jung's archetypes (D. Hollister, personal communication, December 23, 2015). "The 4-D Process for Leadership Development by Charles J. Pellerin is also based on Carl S. Jung's innate archetypes." (D. Hollister, personal communication, December 23, 2015).

The 4-D test has been conducted on an abundance of occasions to both public and private agencies with the results increasing productivity for managers, supervisors and employees. Also Dr. Hollister described the 4-D as a method and apparatus providing great investigation to initiate leadership skills training to students in an undergraduate engineering program. Dr. Hollister also expressed the conviction that students must be trained in leadership to make them mindful of how leading teams of engineers may invoke crucial decisions that could have an impact on many people who depend on the products and services that these engineers are responsible for executing in the future (D. Hollister, personal communication, December 23, 2015).

2.2.2 The Myers-Briggs Type Indicator (MBTI)

The Myers-Briggs Type Indicator (MBTI) personality stock appears to make Carl Jung's theory of psychological types reasonable, important, and valuable in our day by day lives. The premise of his hypothesis is that apparently irregular variety in one's behavior is very deliberate and steady because of a few essential ways people favor to see the world and their process of making judgments based on their perceptions. Mabel Briggs Myers, and her mother, Katherine Briggs organized the first MBTI instrument in 1942. The MBTI was initially published in format comparable to today's forms in 1962. Since that time, it has become apparently the foremost productive psychometric tool in use within the world nowadays.

The MBTI instruments identify our preferences in four key domains:

1. Extraversion (E) – Introversion (I) [How we incline toward and coordinate our consideration and energy]

2. Sensing (S) – Intuition (N) [How we favor to watch the world]

3. Thinking (T) – Feeling (F) [How we incline toward creating choices]

4. Judging (J) – Perceiving (P) [How we favor to situate ourselves on life]

Refer to more information on the preferences in the Table 2 below.

Table 2 4-D as a method and apparatus providing great investigation

Where a person focuses his or her attention	**Extraversion (E)**	**(I) Introversion**
	People who prefer Extraversion tend to focus on the outer world of people and things	People who prefer Introversion tend to focus on the inner world of ideas and impressions
The way a person gathers information	**Sensing (S)**	**(N) Intuition**
	People who prefer Sensing tend to focus on the present and on concrete information gained from their senses	People who prefer Intuition tend to focus on the future, with a view toward patterns and possibilities
The way a person makes decisions	**Thinking (T)**	**(F) Feeling**
	People who prefer Thinking tend to base their decisions primarily on logic and on objective analysis of cause and effect	People who prefer Feeling tend to base their decisions primarily on values and on subjective evaluation of person-centered concerns
How a person deals with the outer world	**Judging (J)**	**(P) Perceiving**
	People who prefer Judging tend to like a planned and organized approach to life and prefer to have things settled	People who prefer Perceiving tend to like a flexible and spontaneous approach to life and prefer to keep their options open

Source. http://www.talkingabout.com.au/MBTI

Table 3. Myers Briggs Type Indicator instruments identifying our choices in four key domains Leadership styles based on MBTI personality test as shown in Figure 7, can be classified to sixteen styles. "The MBTI hypothesis has also moreover been connected in characterizing leadership and the identity of project managers." (Rodríguez Montequín, Mesa Fernández, Balsera, & García Nieto, 2013). The MBTI has been appeared to improve personnel management in numerous ranges such as distinguishing leadership styles, training employees to work harmoniously with one another, and forming great teams (Varvel, Adams, Pridie, & Ruiz Ulloa, 2004).

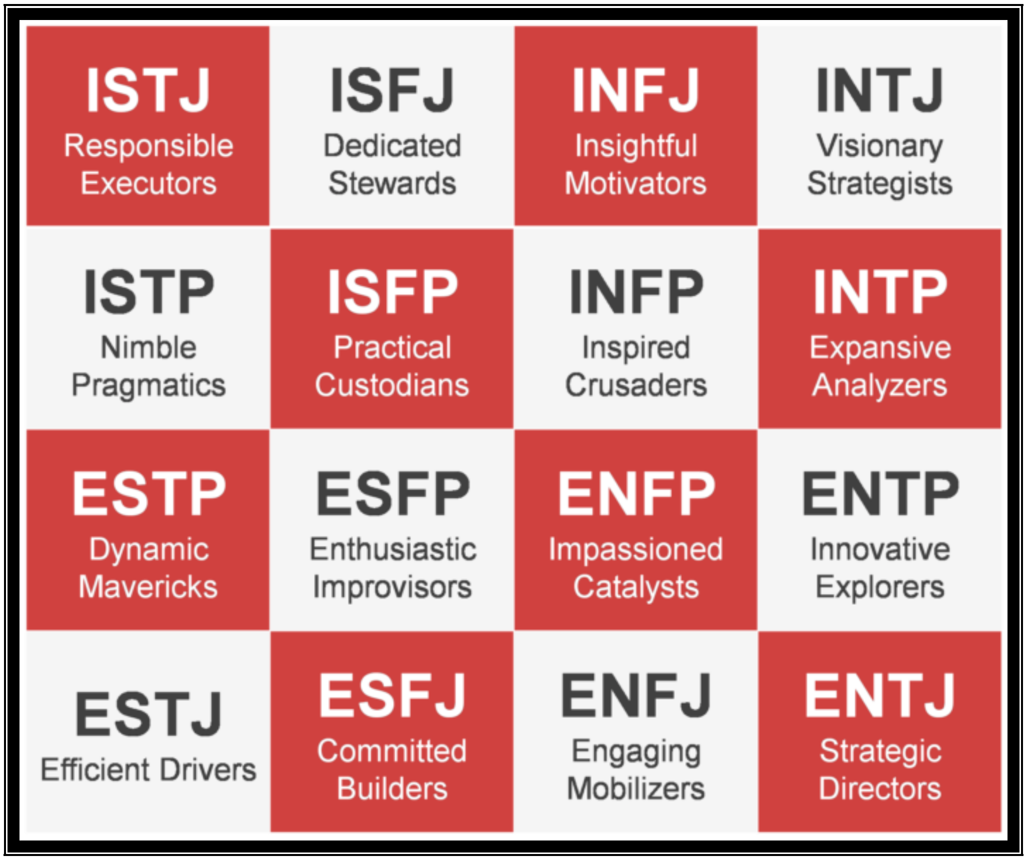


Figure 7: The Myers Briggs psychological test categorizes personalities into 16 types

Source: https://oec2solutions.com/assessment/psychometric-assessment/myers-briggs-type-indicator-mbti/

MBTI's main purpose was to form the psychological types portrayed by Jung clear, useful, and understandable (Briggs Myers, McCaulley, Quenk, & Hammer, 1985). Jung's comprehensive ideology revealed that humans utilize four essential mental capacities and forms on a daily premise. These are sensing (S), intuition (N), thinking (T) and feeling (F) (Briggs Myers et al., 1985). The MBTI was based on Jung's philosophy about perception, judgment and attitude (Briggs Myers et al., 1985) and that people are motivated to strive for excellence in their lives (Quenk, 2000). The Myers Briggs psychological test categorizes personalities into 16 types like the 4-D leadership system only in the fact that both emerged from interpreting Jung's papers (Pellerin, 2009). The MBTI 16 types vary from Jung's classification only in the priorities of Jung's functions and in the attitudes (Introversion (I), and extraversion (E) (Briggs Myers et al., 1985). Rodríguez Montequín et al. (2013) used the MBTI to assess the accomplishment of engineering teams in project-based learning. Their conclusion suggested that the leadership style related with the MBTI profile of the student playing the role of group facilitator and the members' profile combinations had an impact on the group's victory. Varvel et al. (2004) conducted a study in engineering senior design class using MBTI and Team Effectiveness Questionnaire (TEQ). They concluded that there was no statistical correlation between MBTI and TEQ. The study highlighted the importance of MBTI in training team members on the type of personality needed to help them improve communication, trust, and interdependence so as to enhance understanding and tolerance of individuals' behaviors for the purpose of increasing the team's effectiveness. Bradley and Hebert (1997) indicated that the factors that produce effective teams are leadership and effective intra-team communication. They used the MBTI in their study, concluding that, "Personality types are an imperative factor in effective team execution. Organizations that crave to create compelling groups need to analyze the personality-type compositions of these groups and help team members understand" (Bradley & Hebert, 1997)

Table 3: Myers Briggs Typology Instrument (MBTI) Personality and Leadership Styles

Source: (Briggs Myers et al., 1985)

MBTI Profile	Leadership Style Description
ISTJ	ISTJ leaders are quiet, serious; earn success by thoroughness and dependability. They decide logically what should be done and work toward it steadily, regardless of distractions. They are organized and hard workers
ISFJ	ISFJ leaders are quiet, friendly, responsible, and conscientious. They are committed to their obligations. They strive to create an orderly and harmonious environment at work and at home.
INFJ	INFJ leaders seek meaning and connection in ideas, relationships, and material possessions. They motivate people and are insightful about others. They are organized and decisive in implementing their vision.
INTJ	INTJ leaders have original minds and great drive for implementing their ideas and achieving their goals. They recognize patterns in external events and develop long-range explanatory perspectives. They are skeptical and independent and have high standards.
ISTP	ISTP leaders are tolerant and flexible, quiet observers until a problem appears, then act quickly to find workable solutions. They are interested in cause and effect, organize facts using logical principles, value efficiency.
ISFP	ISFP leaders are quiet, friendly, sensitive, and kind. They enjoy the present moment, what is going on around them. They like to have their own space and to work within their own time frame. They dislike disagreements and conflicts, and they do not force their opinions or values on others.
INFP	INFP leaders are idealistic, and loyal to their value and people. They see possibilities and can be catalysts for implementing ideas. They seek to understand people and to help them fulfill their potential. They are adaptable, flexible.
INTP	INTP leaders are quiet and seek to develop logical explanations for everything that interests them. They have unusual ability to focus in depth to solve problems. They are skeptical, sometimes critical, and analytical.
ESTP	ESTP leaders are flexible and tolerant, they take a pragmatic approach focused on immediate results. They enjoy material comforts and style. Learn best through doing.
ESFP	ESFP leaders are outgoing, friendly, and accepting. They enjoy working with others to make things happen. They learn best by trying a new skill with other people.
ENFP	ENFP leaders are enthusiastic and imaginative. They see life as full of possibilities. They make connections betweenevents and information.
ENTP	ENTP leaders are quick, ingenious, stimulating, alert, and outspoken. They adept at generating conceptual possibilities and then analyzing them strategically. Good at reading other people.

MBTI Profile	Leadership Style Description
ESTJ	ESTJ leaders are practical, and realistic with decisive, quick decisions. They like to organize projects and people to get things done with a clear set of logical standards. They are forceful in implementing their plans.
ESFJ	ESFJ leaders are warmhearted, conscientious, and cooperative. They want harmony in their environment, work. They like to work with others to complete tasks accurately and on time. They want to be appreciated for who they are and for what they contribute.
ENTJ	ENTJ leaders are frank, decisive, assume leadership readily. They quickly see illogical and inefficient procedures and policies and develop and implement comprehensive systems to solve organizational problems. They enjoy long-term planning and goal setting. Usually well informed and enjoy expanding their knowledge and passing it on to others.
ENFJ	ENFJ leaders are warm, empathetic, responsive, and responsible. They attuned to the emotions, needs, and motivations of others. They may act as catalysts for individual and group growth. Loyal, responsive to praise and criticism. They are sociable, facilitate others in a group, and provide inspiring leadership.

2.2.3 Five Factor Model of Personality (FFM)

The “Big Five,” or the five-factor model (FFM) of identify, could be a well-known measure with a comprehensive method that has been used frequently to evaluate normal personality traits (Strang & Kuhnert, 2009). FFM’s five identity measurements are alluded to as extraversion, appropriateness, conscientiousness, neuroticism, and impartiality to experience (Strang & Kuhnert, 2009). Team leadership and effectiveness can be also influenced by these traits (Clinebell & Stecher, 2003). A team’s leadership is very important, and a substantial number of researchers have confirmed that specific traits typically make for a good leader (Kichuk, 1999). The five personality traits identified by Strang & Kuhnert (2009) are as follows:

(a) Extraversion which describes a leader who is dynamic, emphatic, excited, active, and talkative.

(b) Appropriateness which depicts a leader who is grateful, excusing, liberal, kind, thoughtful, and trusting.

(c) Honesty which depicts a leader who is effective, organized, reliable, dependable, and careful.

(d) Neuroticism which portrays a leader who is edge, self-pitying, tense, tricky, unsteady, and troubling; and

(e) Openness which depicts a leader who is creative, inquisitive, contemplative, creative, shrewd, unique, and encompasses a wide range of interests.

2.2.4 Bass Classification of Leadership

Bass divided leadership style into transactional leadership and transformational leadership (Nanjundeswaraswamy, 2014). Transactional leadership occurs when the relationship between the leader and the supporters is based on the "trades" between the two by which adherents are compensated for assembly objectives or execution criteria (Nanjundeswaraswamy, 2014). It occurs when leaders reward or discipline followers depending on their performance (Bass, 1998). Transactional leaders depend on unexpected rewards, management by special case, and laissez-faire leadership (Bass, 1998). In contrast, transformational leaders are characterized by their individual influence, charisma, spiritual encouragement, and intellectual stimulation (Nanjundeswaraswamy, 2014). Transformational leaders use the four components shown in Table 4 to inspire followers (Bass, 1998; Brown & Reilly, 2009). According to Brown and Reilly (2009), Bass and Avolio have developed the most valid, reliable, and broadly utilized degree of transformational leadership, the Multifactor Leadership Questionnaire (MLQ). The MLQ utilizes the four categories of transformational leadership behavior described in Table 4, and the four subscale measures comprise the overall measure of transformational leadership (Brown & Reilly, 2009).

Table 4: The Four Factors of Transformational Leadership

Source. Brown & Reilly (2009).

Factor	Factor Description
Individualized Consideration	Gives personal attention to others, making each individual feel uniquely valued
Charismatic Leadership	Provides vision and a sense of purpose; elicits respect, trust, and confidence from followers
Inspirational Motivation	Increases optimism and enthusiasm; communicates high expectations and points out possibilities not previously considered
Intellectual Stimulation	Actively encourages a new look at old methods; stimulates creativity; encourages others to look at problems and issues in a new way

Widmann (2014) used the MLQ in his study of the impact of leadership style on the level of work engagement of information workers in an engineering organization. His findings suggested that there was:

(a) a positive and significant correlation between the transformational and charismatic leadership and work engagement.

(b) a negative correlation between laissez-faire leadership style and work engagement, and

(c) no significant correlation between transactional leadership style and work engagement of knowledge workers in an engineering organization.

In comparison to the other classification schemes described, the 4-D leadership system has a precise, accurate and an approachable way of evaluating the leadership. Pellerin (2009) stated that the 4-D coordinate system "rearranges the key components of high-performance groups and compelling leaders." Both the 4-D system and MBTI were derived from Jung's classification of personality types. The 4-D leadership system classifies leadership using four leadership styles that can be easily evaluated. In contrast, the MBTI uses a more complex 16 styles to classify leadership and personality which is not convenient to measure progress. Another important consideration in selecting an assessment system is that it accurately can assess the engineering and technological leadership for teams and projects. 4-D has the capability to select the best leader for any engineering project team. Dr. Anthony J. Calio, former vice president and general manager of the Raytheon Corporation, stated:

- The 4-D appraisal strategy, sharpened through 15 years of teambuilding with NASA venture, engineering, and management teams, has the potential to make strides with team execution in nearly any endeavor. This book emphasizes the significance of understanding social standards and social behaviors which are regularly ignored in specialized ventures, and however can play a basic part of their victory. (Pellerin, 2009)
- Also, Pellerin reported that the 4-D system has been used for more than 2000 workshop and its accuracy is more than 90%.

2.3 Engineering Leadership Development

A very typical objective of engineering programs within the United States is to create future engineering leaders. Be that as it may, exceptionally few programs really have curricular substance that particularly addresses the aptitude set of leaders. Numerous current engineering leaders created their ability through post-graduate leadership training most regularly in trade schools through the MBA or in industry settings (for example the Lockheed Martin Engineering Leadership Program (2010). The Bernard M. Gordon MIT Leadership Program has developed a white paper (Graham 2010) summarizing some of the current undergrad programs in engineering leadership around the world, and depicting a few best practices based on the prosperity of those programs. “They characterize leadership programs as those that create all or a parcel of the following general skill set:

- Initiative and decision-making
- Systems thinking
- Networking and relationship building
- Creating a compelling vision
- Teambuilding and management to completion
- Problem solving and critical inquiry." (Graham 2010)

All of the programs depicted in this white paper are either extra-curricular in nature (regularly project-based or mentoring) or planned as an aid (from a single course to a full minor) to an engineering baccalaureate program in a conventional discipline. The MIT white paper also recognized that there are numerous comparative business education programs that incorporate a "significant center on leadership." (Graham 2010). A very solid contention can be made that the expertise set described above for engineering leaders is as fitting for business visionaries as it is for corporate supervisors, VP's, and CEO's. As such we contend the connectedness and interrelationship between engineering and business, being business, can be recognized and acknowledged as vital within numerous roles in modern professional engineering endeavor. The reverberating call for adjustment, coupled with showcase necessities and accentuation on leadership in engineering education programs, leads us to propose a modern program. With that being said, we have chosen the term Leadership Engineering to describe a proposed BS-level broad-based liberal engineering program. An essential objective of this program will certainly be to create the engineering leaders of tomorrow. Be that as it may, our proposed plan is to some degree an inversion of the usual style of creating leaders from engineers. The preface for normal Engineering Leadership programs is that you just begin with an engineer and then make a leader out of him/her. In this way Leadership training is the essential focus, with Engineering as the qualifier for the sort of leaders being trained. The preface of the Leadership Engineering program is that the calling will draw future leaders (as is the case of many other professions that require post-graduate professional training, such as pharmaceutical and law), and the program is designed to deliver engineers out of those future leaders. Thus, it is a broad-based, liberal engineering program for future leaders within the public and private sectors. The 120-semester credit hour proposed program might well be partitioned into four components, as listed in Table 5. Normal engineering program plan would call for a linear, dynamic sequence of courses within general order as appeared within the table, where a student begins with a strong foundation of general education and the science and math components, builds on that foundation the investigation for engineering via the engineering topics, and after that "tops" off that knowledge base with track components in management, education, or business. This linear model nearly by its plan limits education methodologies to being deductive in nature. Sheppard (2008) contends for a spiral model of component movement, where these four components would be interlaced in a spiraling or organize design, "with all components returned at expanding levels of modernity and interconnection," and where "learning in one zone underpins learning in another" in a persistent spiral towards the degree completion. She moreover prescribes the improvement of a "professional spine" to this spiral to permit linkages between hypothesis and practice and all through the curriculum. Our program, as depicted in Fig. 8, will best be portrayed as a helical staircase. The central bolster column of the staircase speaks to the plan practicum which will serve as the "professional spine" of our program, and where linkages will be made between hypotheses created within the stair steps and proficient practice through plan. We recommend upgrading engineering design education by advancing and encouraging the utilization of problem-based learning (PBL) (Victoria University), subsequently improving students' key transferable aptitudes and their understanding of the subject substance. What makes PBL diverse from ordinary educating is that it begins with issues related to real world practice. This makes it diverse from ordinary educating where the substance is to begin with the lectures and then tackle issues with real-world content by applying solving problems in tutorials and assignments. PBL is planned to assist you to become an independent learner but it does not do this by using a "sink-or-swim" approach.

Table 5: Programmatic Components

– PROGRAMMATIC COMPONENTS	
Component Title	Credits
General Education	27
Science and Mathematics	30
Engineering Topics	45
Management Track or Education Track or Entrepreneurship Track	18
Total Program	120

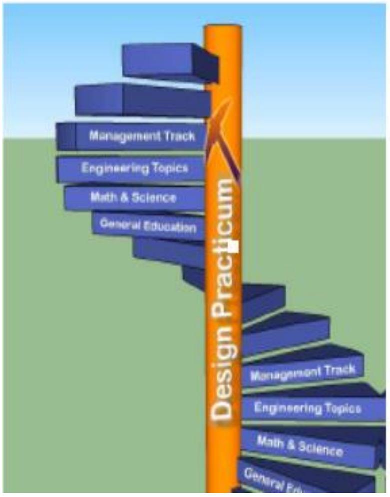


Figure 8: Helical Staircase

Instead, it gives students with plenty of support as they create the aptitudes required for learning in a PBL group. Each of the steps speaks to courses (or points inside courses) inside each of the four program components. The stair "topics" will persistently rotate through each of the four components as the students navigates through the educational programs, inevitably arriving at the objective of the Leadership degree completion. Skills instructed inside and emanating from the spine of the associated staircase incorporate an joined embroidered artwork of communication in all its different forms, inventiveness, interpersonal and group working abilities, mathematical and numerical capacity, utilize of advances, self- learning aptitudes, problem solving and commerce aptitudes, project management and proficiency aptitudes. The educational programs will too be outlined specifically around an assortment of modes of request, and experiential learning opportunities will be integrated all through the educational modules. The modes of request will go past the regular quantitative, deductive, and inductive thinking regularly utilized in engineering instruction, and in this way the instruction will incorporate aesthetic and interpretative approaches as well. The recognizing objective of the program is concurrent advancement of character, professionalism, and quality.

The utilization of numerous modes of inquiry will instill in graduates a solid sense of values, and the capacity to think critically and make associations relevantly over disciplines. The program will give in-depth and concurrent learning of center standards in leadership and engineering. The resultant graduates will have recognizing characteristics and foundation reflective of this concurrency. Our budding engineering leaders will develop through an overwhelming program of coursework and experiential learning modules. We will accelerate expertise improvement over and above specialized preparation by interweaving arranged experiences with peers and senior members of corporate, civic, and professional organizations. With a commitment to discharge the need to be the single educator and sole source of data and substance, it becomes less demanding to discover ways to encourage a process of laying a common course for all, at that point turning it over to students to form meaning. Instead of assuming that students are clean slates when it comes to leadership, we expect that each student has a set of experiences upon which we can construct. Today's students are more universally mindful than our students were just 10 years ago and superior associated to the tremendous assets available at their fingertips. What is regularly lost, in any case, may be a development for data to perceive valuable, important, and legitimate data. To address the issue of engineering substance scope, individual significance, and data literacy, we stay adaptable to construct lessons around current occasions that strengthen the core content of leadership development. For example, during the Fall 2011 semester, *Time* magazine published an article about the failure of the Nano-car, a car made in India, promoted all through the Far East and Europe (Thottam 2011). The brief article highlighted the combination specialized, social, political, and financial issues that led to the product failure. The story provided an opportunity to investigate a case study that associated real life engineering issues with recent classroom discussions of leadership skills, culture, individual communication styles, and benefits of diverse groups of conceptualizing. Employing a brief in-class self-assessment on data processing styles (brainstormer, problem solver, practitioner, and processor), we gathered students by like-style and gave them the brief, densely packed article to examine amid class. We at that point inquired them to brainstorm a list of all variables that led to failure of the car (at least 10 were cited within the article). As anticipated, the brainstormers jumped right in and created a long list of components on the white board. The practitioners and problem solvers needed to skim the article and jump in to solve the technical issue before posting all the contributing components. In the center of their group process, we paused to highlight several key focuses. The reason of the activity was not essentially to completely understand the problem and solutions for the Nano car. Or maybe, the reason was to illustrate through a pertinent and current engineering example, how their individual and group propensities play out in a semi-realistic working environment setting (e.g. conceptualizing solutions for engineering problem) and make coordinate associations to course substance. Another illustration of stopping amid the standard stream of course to take advantage of a leadership learning moment took place when we experienced a failure of classroom communications. About half of the lesson missed changes to the details and due date for an assignment that was announced in the course. Amid class the following week, we investigated the circumstance in a case study and associated it to lessons on communication breakdowns. Unique and hypothetical models of communication breakdowns were brought to life by making direct and real time associations between course substance, an event that they were encountering that related to their life, and results of destitute communication. Below is a brief description of each program component:

- **General Education component** will incorporate crucial courses in communications, humanities, arts, history, and political science. This component fulfills the common education requirements of the University and sets the establishment and setting of basic requests for the remainder of the curriculum. Students will know and understand the significance of a liberal education and its fundamentals, the interest of truth and access to information, mental and moral improvement of students, and the common well-being of society. Undergrad students must be broadly taught and technically skilled to be educated and beneficial citizens. (General Education 2010). As leaders in engineering, they will need to be able to think critically about critical issues. Students moreover must be prepared to complete undergraduate work (the steps ahead, above and around the corner) and their engineering topics and track. The common education requires a high level of information about and competence within the following areas: communication, computer utilization, mathematics, problem solving, natural sciences, social sciences, humanities, and arts. Hence the mission of common education is to supply undergraduate Leadership Engineering students with an organized base through which these needs can be met. (Graham 2010)
- **Science and Mathematics.** ABET accreditation requires at least 30 credits of science and math topics within the curriculum. We will utilize a just-in-time, applied mathematics approach to rapid understanding of calculus so students may enter engineering courses early within the curriculum. The mathematics prerequisite will incorporate statistics, and the science necessity will incorporate life science in expansion to the regular physical science topics.

- **Engineering Topics.** ABET accreditation requires at least 45 credits of engineering topics, including engineering science and design. The engineering science subjects will incorporate those required for the Fundamentals of Engineering exam, including computing basics, materials science, mechanics (solid and fluid), materials, thermodynamics, electronics, and electromagnetic applications. The engineering science subjects will also incorporate a brief track of courses in a specific engineering discipline, to prepare the student for supplemental professional graduate education in that instruction. At last, this component will provide a brief track of courses in the program of study that will start the primary year and come full circle in the fourth year with a major design involvement. The design practicum will incorporate concepts in inventiveness, advancement, and entrepreneurship. Hence, we expect generally 50-50 split between engineering science and configuration themes in this component.
- **Management Track.** The core component for the Leadership Engineering program will dwell in what we are calling the management track. The management track will plan future graduates with abilities for monetary, human assets, and project management, alongside the capacity to formulate problems, coordinated information, and think critically. Faculty from programs in the Colleges of Business Administration and Liberal Arts will work exceptionally closely with faculty from the College of Engineering to create coursework within the areas of business enterprise, management, entrepreneurship, morals, human studies, decision sciences, and technology-based critical exploration.
- **Education Track.** For students, whose expectation is to enter K-12 education after the bachelor’s degree, the management track will be supplanted by the education track. Students will take courses in the College of Education to complete the vital training for

instructor certification. The track will give graduates with the necessary encounters and accreditations to lead engineering education advancement, imperative to the long term of the US, in numerous ways. (Sheppard 2008).

- **Entrepreneurship Track.** We expect that a noteworthy number of students attracted to this program may seek commerce start-ups upon graduation from the program or soon thereafter. For students with this solid intrigued, the management track will be supplanted by the entrepreneurship track. Faculty from the Colleges of Engineering and Business will work together to create coursework in entrepreneurial practice, innovation advancement, venture development, venture law, intellectual property, and engineering economics.

The Purdue University engineering leadership development program was instituted in January 2013 and is a prototype building off other successful prototypes. (Bayless, 2010) This innovative program points to supply engineering students with numerous ways to engagement in engineering leadership, with roads for advancement of next-generation engineering and technical leadership information, and with instruments and aptitudes to explore the request of leadership, especially in engineering practice. Based upon sound leadership standards, it offers undergrad student opportunities to engage in experiential leadership experiences, faculty coaching, and specialize leadership over a variety of settings (Schell, Hughes, & Tallman, 2018). Success in the program yields an arsenal of leadership devices and experiences and a minor in engineering leadership that is recorded on the students' transcript. The engineering leadership minor targets students early in their engineering careers, not at all like a few of the other outstanding programs that engage engineering students in leadership activities amid their junior or senior years. (Engineering Leadership Development, 2012). This approach will minimize the burden on the engineering curriculum and will guarantee careful leadership training for enrolled students by utilizing the whole term of students' time in school to disperse the engineering leadership course load and professional necessities. Subsequently, the minor targets first-year engineering students with potential to engage upper-level students, graduate students, faculty, and staff in engineering leadership courses, workshops, and seminars on a case-by-case premise. Undergrad students welcomed into the program must have at least 3.0 GPA and meet with the engineering leadership program staff. Innovative capabilities of the course include a focal point on experiential learning, school coaching, and technical leadership. Within the minor, college students should engage and in at least one experiential learning. Selected from a whole lot of departments throughout campus, this revel in will serve as a basis for reflection approximately engineering management in one or more publications within the management minor. An instance of a pre-accepted experiential course gives a ten-week long, summer internship in Washington, DC in which students find out about governmental decision-making and the contributions of engineers to the political process. Faculty coaching allows students to choose a school member of their departments who can serve as an instructor to them as they complete their technical coursework and engineering management minor coursework. If college students are unsuccessful finding their own education coach, they can receive a coach from the pool of candidates recruited by means of the engineering management minor staff. One of the elements of the minor that differentiates it from traditional leadership development programs is its emphasis on technical leadership. This manner that college students research core management principles taught within business schools and learn how to translate those theories and ideas into engineering contexts shown in Table 6 of Engineering Leadership Learning Outcomes. At the completion of the management minor, college students will have sufficient publicity and revel in solidifying their understanding and abilities inside the following contexts: (1) management, (2) change; (3) synthesis; and (4) practical competence. Theses engineering management mastering consequences were inspired and changed from the gaining knowledge of effects in Cox et al.'s Engineering Professionals' Expectations of Undergraduate Engineering Students (Cox, Cekic & Zhu, (2012), to include characteristics of Gordon-MIT's Capabilities of Effective Engineering Leaders (Gordon 2011), the UCSD Gordon Center's Engineering Leadership Core Values (Gordon 2011) Engineering Leadership Center (2013), and Cox's Leadership, Change, and Synthesis Survey. Cox (2012). These getting to know results are not comprehensive. More gaining knowledge of consequences will be delivered upon further research, specifically on how to successfully check the new outcomes to be added. The importance of technical management should no longer be overlooked. In concurrence with the Gordon- MIT Engineering Leadership Program, engineering leadership is the technical management of change: the progressive conception, design, and implementation of recent products, processes, projects, materials, molecules and software systems, supported with the aid of the discovery of allowing technologies, to fulfill the wishes of clients and society. (Gordon, 2011) .

Table 6: Engineering Leadership Learning Outcomes

Leadership	• Ability to motivate and empower others to solve problems. • Ability and willingness for initiative-taking, goal-setting, and follow-through. • Ability to identify characteristics and talents of others. • Understanding of the impact of ethics and morals on leadership and professional responsibility. • Demonstrate a commitment to life-long learning.
Change	• Ability to participate in multidisciplinary, multicultural and multifunctional groups. • Ability to understand change processes and overcoming human inertia to change. • Ability to adjust objectives and priorities to changing environments.
Synthesis	• Ability to comprehend, synthesize, interpret and apply knowledge to address technical and non-technical problems. • Ability to recognize social and business factors in engineering work. • Ability to see the impact of engineering work on the broader society. • Ability to drive leadership development with personal experiences.
Practical Competence	• Demonstrate competence of practical and transferrable skills essential to leadership practice and professional interactions. • Ability to communicate using written language, verbal and non-verbal language, and electronic and multimedia tools. • Ability to articulate acquired skills and tools on a resume, portfolio and other professional mediums.

Source: asee.org/public/conferences/20/papers/7314

The curriculum includes 16 credits such as core, experiential, and elective guides grouped into 4 concentration areas and prepared to offer students with knowledge and revel in applying engineering management principles, practices, and equipment in a multicultural context. Students are required to complete seven credit hours of core guides and nine credit hours consisting of one experiential course and other elective courses in their choosing (See Appendix A). Core classes (Student Leadership Development, Planning for Leadership Development, Portfolio: Experiential Engineering Leadership and Reflection on Engineering Leadership) inside the minor will be provided in-house and permit students to work closely with faculty and staff, in the College of Engineering, within the improvement of engineering leadership portfolios and reflections with a view to show their management skills ability to future employers and graduate schools. Elective guides are a compilation of pre-approved classes from various educational disciplines. These courses are categorized into 4 concentrations (conversation; ethics; creativity and innovation; and global and societal impact) with college students taking classes in a single or two concentration regions. The selection of these concentrations is the result of research about other engineering leadership programs and availability of path alternatives throughout the university. The conveyance concentration courses consciousness on the development of students' professional abilities and engagement with technical and non-technical audiences. The ethics concentration publications align with regulatory, legal, and policy-related factors of engineering. The creativity and innovation attention publications relate to areas such as entrepreneurship. The worldwide and societal effect concentration courses explore the impact of management across numerous stakeholders and countrywide and international communities. This engineering leadership minor makes use of a habitual of empowerment and engagement about the importance of engineering leadership. Accomplished leaders and college students with engineering leadership experiences may be invited to engage in a lot of contexts. The Robe Leadership Institute recognized this plan as being a key issue in their leadership improvement experiences. (Bayless, 2010). The speakers will be scheduled strategically such that the subjects discussed in every seminar or workshop reinforces management standards and practices that students are mastering in core classes, application classes, and experiential enterprises. The selection of speakers is contingent on their management innovations in several engineering contexts (i.e., academia, industry, or government), technical proficiency, and their talents to interact an audience of often undergraduate students. Speakers need to additionally be representative of the diverse scholar population in the program and ought to expose college students to different leadership views and styles. The students will play a lively role during the seminars and workshops. They might be notified beforehand about each upcoming guest speaker and the topic of every seminar and could be required to put together questions for the speaker. Each visiting speaker could be announced by a student, which is a method used to encourage scholars to invite questions and actively engage the speaker at some point of the seminar. This also serves as a possibility for college students to improve their conversation abilities and to take possession of their management improvement. Students are required to post a reflection paper after every seminar. This mirror image will relate to key topics taught in the application along with approaches to comprise seminar ideas into their engineering leadership portfolios. The college coaching/mentoring element of this minor is a two-component initiative wherein college students could have the possibility to receive mentoring from an industry-primarily based or academia-primarily based leader in their choosing. This way, students might also have interaction proactively with folks who may or may not be in their modern expert networks. This may additionally then improve the understanding and abilities of college students to analyze from their mentors and allow students to serve as peer mentors to other engineering college students. The mentoring structure is a personal development connection between college students and their chosen mentors and mentees, which involves recurring tasks and interactions. Students' activities with their mentors and mentees are expected to be in-person, or as direct as possible, and may be facilitated through technological approach consisting of Skype, LinkedIn, or Facebook. Mentors will be anticipated to connect with their students no less than five contact hours per semester (i.e., one interaction per month). These tasks encompass, but are not constrained to, job-shadowing, attending mentors' enterprise events and lectures, professional-planning, confidence-building, and networking. Students will record their activities with their mentors and could consist of this in their engineering management portfolios. Particular attention might be made concerning students’ implementation of leadership theories and their connections of engineering leadership to their technical regions of interest and destiny profession objectives. Engineering leadership minor staff anticipates that this initiative will have interaction alums financially and technically and will assist within the introduction of a repository of future speakers and mentors for the program. At the time of the study, management changed into considered one of the main elements in enterprise and critical to any organization's existence. This makes leadership development essential in any industry (Laglera, Collado, & Montes de Oca, 2013). In their 2014 study, Gurdjian et al. surveyed 500 managers, asking them to rank the human resource department's main concerns. Leadership development was ranked the highest and mentioned as a future priority. Engineering schools have been putting forth strong efforts in teaching students both the technical knowledge and engineering theories required of engineers in the real world. Schuhmann (2010) expressed the belief that these types of skills and their competencies were no longer sufficient for future achievement. Many competencies which includes communication, project management, and leadership are becoming more salient than ever. Schuhmann described an amazing contribution in engineering leadership field which is the academic model of the Engineering Leadership Development Minor (ELDM) at Pennsylvania State University. To support Penn State's ELDM leadership model, Schuhmann argued that when it comes to developing new products, there is a great demand for the engineers' capability to work and lead groups of people from various backgrounds and cultures. Also, it was noted from leaders' experiences in the field that the future opportunity for engineers lies in their ability to exercise their leadership skills in many different areas. These areas include nonprofit and government sectors. This responsibility, however, has more relevance for graduate engineering students (Schuhmann, 2010). Schuhmann also emphasized that it is important that 21^{st} century engineers be better prepared in leadership than their 20^{th} century counterparts. There is a massive need for leaders in America to be able to overcome many crises in leadership. Numerous researchers have recognized a demand for curriculum change for the justification of producing leaders who can bring powerful results to businesses. To achieve this goal, adjustments in education should take place (Kotnour et al., 2014). One of the interesting studies in engineering leadership conducted by Olude-Afolabi (2011) revealed some facts about engineering leadership definitions compared to those of the industry. Olude-Afolabi (2011) used a system method that classified one-of-a-kind definitions of management using textual content mining by collecting records from enterprise trade journals and then using fuzzy similarity to classify one-of-a-kind expressions used within description of leadership. Olude-Afolabi (2011) suggested "that the greater phrases utilized by journals have been classified by means engineering academia as having extra leadership terms in defining leadership when compared to industry." He used the subsequent leadership terms: communication, motivation, team building, visionary, coaching & mentoring, time management, listening and innovation. Cox, Cekic, and Adams (2010) findings regarding undergraduate engineering leadership development were based on interviews with 12 engineering faculty at a Midwestern university about methods that leadership might be included into engineering curricula. Their findings suggested integration of leadership subjects into current guides and in capstone guides. They also recommended the introduction of real-life encounters, activities, and extracurricular interests in students' leadership development. Caza and Rosch (2014) examined undergraduate students from all majors who had never had leadership training, investigating their preexisting beliefs about leadership. Their findings can be used effectively to design curricula to meet the students' needs and levels of understanding. The researchers determine that scholars believed that leaders had to serve their communities, to be open-minded, to honor their values, and to be pleasant with alternates. Also, students' responses have been predictive of numerous management outcomes, including management self- efficacy, social change behavior, and perspective taking.

These findings suggest the value of better apprehension students' preexisting beliefs about leadership. In Laglera et al.'s 2013 study, 301 engineers completed an internet survey. The end result became a structural equation version that comprehensively showed a sizeable and beneficial relationship exists between transformational management style and all the factors selected for the present study: specifically, task satisfaction; job performance; organizational commitment; person-organization values congruence; and trust in management. Bayless (2010) described one leadership program, the Robe Leadership Institute (RLI), located at Ohio University's Russ College of Engineering and Technology. The RLI is a 10-week, four-hour course that has been recommended in the fall of each academic year. RLI helps engineering students form a base for their management styles and benefits them understand the numerous roles involved in being an engineering leader. RLI introduce leadership training to students through the following's activities: selection of students, leadership readings, speaker invitations, seminar structure and learning outcomes, class assignments and activities, guest speakers, and outreach. In their study, Cox, Cekic, Ahn, and Zhu (2012) conducted interviews to investigate the prospect of engineering specialist in industry and academia on leadership, change, and coalescence. The main purpose of their research was to identify constructs that engineers in academia and industry use to describe traits they consider essential for undergrad engineering students to possess. They discovered some differences in the views of industry and academic experts. They indicated that since educational and industrial tracks for engineering students are serving a common cause, the different views should be studied to enhance education of undergraduate students.

2.3.1 Team-Based Leadership Development for Engineering Students

In their study, Özgen et al. (2013) showed that the engineers of the 21st century need leadership and management skills before graduating because of the significance of these abilities. In this study, authors stated five reasons which demanded an inclusion of leadership development in engineering curriculum. These reasons are as follows (Özgen et al., 2013).

- There is a necessity for leadership skills in engineering field.
- Leadership is the largest gap in the value of organization.
- Engineering exploration consultants regularly pursue engineering managers with leadership skills.
- The National Academy of Engineering (2004) recommended that engineering curricula must provide training that prepares engineering college students for leadership positions. Leadership competencies cannot be completed by means of adding more subjects to an already complete curriculum.

This study, conducted in The Chemical Engineering Department of The Universitat Rovira I Virgili in Tarragona, Spain, was executed in a Project Management in Practice (PMP) course (an elective for fourth-year engineering students). The following leadership skills were tested to evaluate leaders' performance:

(a) consumer orientation,

(b) dedication to learning,

(c) drive for distinction,

(d) integrity,

(e) interpersonal communication,

(f) receptivity to change, and

(g) synergy.

The methodology of this study was conducted by the following steps: A total of 11 fourth-year engineering students were selected to participate in a year-long experimental study. Each leader was assigned a team of six first-year engineering students (SD = 1.98). Two data collection strategies were employed: (a) behavioral event interview technique querying participants and PMP course professors about self, team, organization, for an average of 46 minutes (SD = 9.11); and (b) a 360-degree feedback process consisting of a questionnaire about the eight competencies administered to all respondents and leaders. The questionnaire had a Likert-type scale ranging from one (1) to five (5) where 1= not developed and 5=excellent. Özgen et al. (2013) discovered that most leaders demonstrated leadership behaviors at the team leadership intensity more than at the self and organizational levels. In addition, they exhibited leadership competencies in the regions of commitment to learning, interpersonal communication, teamwork, and consequences orientation. In contrast, they did a poor job in integrity, power for excellence, responsiveness to change, and customer orientation skills. The researchers speculated that the lack of success in these competencies could be attributed, in part to several constraints: (a) the experiment was not a real-world experience; (b) the environment was not client-driven; (c) leaders did not have real responsibility. Another interesting team-based leadership development study for undergraduate engineering students was conducted by Babuscia, Craig, and Connor (2012). It focused on growing leadership activities to improve the productiveness of groups in a quick period (approximately four hours). This experiment consisted of a leadership module to enhance engineering management with the aid of conducting a couple of activities designed to enhance students' expertise of leadership education. Their experiment was applied in a Massachusetts Institute of Technology (MIT) satellite development class

(Babuscia et al., 2012). Table 7 provides an outline of the leadership module which includes the duration of activities and the objectives of each of the activities. As can be seen, the Babuscia et al. (2012) leadership model is a normal model used in providing traditional leadership development, (i.e., questionnaire and leadership lectures) in an organized fashion. The results of this experiment indicated that this approach advanced the capacity of students to have an interaction productively with one another.

Table 7: Overview of the Leadership Module

Activity	Duration	Objectives
Introduction and Initial assessment	20 minutes	• To introduce leadership instruction. • To investigate students' questions on leadership.
First lecture (interactive leadership discussion	60 minutes	• To summarize concepts on team formation, team roles and responsibilities, meeting planning, team, contract, decision making, facilitating communication, project planning. • To answer students' question on leadership. • To show students a practical example of distributed leadership model. • To show students different leadership styles.
Leadership questionnaire	30 minutes	• To understand team leader challenges and accomplishments during the development of the project. • To investigate team leaders' abilities of understanding the perception that their team members have of them. • To investigate students' interest in future activities.
Peer to peer review	20 minutes	• To learn to evaluate their own work and the work of their peers.
Second lecture (analysis of leadership questionnaire)	80 minutes	• To summarize concepts on leadership definitions, engineering leadership, approaches to leadership, distributed leadership, capabilities of effective engineering leaders, leadership styles and situational leadership.

Student's feedback	10 minutes	• Each student logs into the class evaluation website. • Each student rates the statements on leadership education.

In a first-year and senior-year engineering design direction that consisted absolutely of team-primarily based collaborative learning projects, Rosch (2015) tested the impact of team experience when isolated from other structured leadership curricula to decide if it able to aid student management development (Duliba & Felder, 2018). This study was designed only to research whether undergrad engineering students' leadership could be stronger when students engaged in classroom-based team experiences. The findings of this study suggested that only first-year students reported better ratings at the completion of the semester and only regarded to their transformational aptitudes and social normative motivation. Senior students attained no gains in any management-oriented area as related to their team experiences. Rosch concluded that "The results provide a preliminary indication that merely placing college students into teams, wherein the own motivation to prevail and ought to act interdependently, won't be sufficient to accelerate the development of their management capacity." He also confirmed that "Without a space for intentional practice informed by way of content material, merely placing college students in a surrounding wherein they interact in goal-oriented organization behaviors seems inadequate as a catalyst for management development." (Rosch, 2015) Rodríguez Montequín et al. (2013) investigated team-based undergraduate engineering. Their objectives were to study and analyze the effects of the personality traits on team effectiveness. Rodríguez Montequín et al. (2013) used the MBTI to evaluate the achievement of engineering groups in project-based learning. The research advised that the leadership style associated with the MBTI profile of the student playing the position of organization coordinator and the members' profile combinations had an impact on the group's success. Varvel et al. (2004) conducted another investigation in engineering senior design class using the MBTI and the Team Effectiveness Questionnaire (TEQ). The researchers concluded that there was no statistical correlation between the MBTI and the TEQ. They highlighted the importance of the MBTI for individuals in their training on the type of disposition of team members. They determined this could help them improve communication, trust, and interdependence to enhance understanding and tolerance of individuals' behaviors for the purpose of increasing a team's effectiveness. A research team (Crumpton-Young et al., (2010) from the University of Central Florida (UCF) set out to study leadership skills for both senior engineers who had leadership positions and had worked in the leadership field for many years and for engineering students who were currently enrolled in their undergraduate programs. The purpose of the research was to discover vital management talents that have been necessary in industry. The study revealed that the contributors believed that team building/teamwork, exclusive development/continual learning, and verbal exchange abilities were the most beneficial factors in a management position. Furthermore, the surveys helped rank the leadership characteristics the participants felt they possessed. The participants ranked characteristics which include being honorable, credible, and decided as the most beneficial. Being visionary or networking have been ranked as the least useful. Crumpton-Young et al. (2010) additionally asserted that it is essential that all universities incorporate an entire engineering leadership program to enhance abilities which includes the potential to govern a group, critical thinking, the way to be a visionary and inspirational, a good communicator, and an effective networker. Finally, the researchers concluded that by advancing the previously mentioned talents, engineers are probably able to handle the demanding situations of future engineering jobs (Crumpton- Young et al., 2010). The researchers concluded that engineers of 2020 must be equipped to work with diverse groups of engineers and non-engineers, collaborate with multiple audiences, and gain synergy among technical and social systems. Systems-based engineering issues are usually related to an increasing scale of complexity, and typically, engineers want to pursue collaborations with multidisciplinary teams of experts across multiple fields. One of the essential traits for these teams is excellence in communication (National Academy of Engineering, 2004). Working effectively with multicultural groups is a subsequent requirement that will surely continue to grow in significance as systems engineering becomes greater ubiquitous (National Academy of Engineering, 2004). Reeve et al. (2015) defined a multifaceted leadership learning program that turned into a design via collaborative team of researchers with backgrounds in engineering, education, psychology, and industry. Ultimately, the goal of this application is to turn into infusing reflective, experiential learning into technical oriented discipline. The program covers four dominions of leadership corresponding to 4-tiers of analysis: self, team, organization, and society. Also, the learning experiences include many tasks such as elective academic courses, co-curricular workshop programs, and guest lectures in core courses. Simpson, Evans, and Reeve (2012) described the Engineering Leaders of Tomorrow Program (LOT). LOT defined educational courses, co-curricular certificate programs, departmental programs, and workshops which emphasize four domains of management: self, relational, organizational, and societal leadership.

2.4 Utilizing Simulation in Education

The implementation of simulations and games began in the 1950s. Since that time, the utilization of simulation has increased exponentially in education (Showanasai et al., 2013). Simulation is the representation of components of a powerful system for the purpose of attempting to replicate the behavior of that system. According to Life, Narborough-Hall, and Hamilton (1990), the early knowledge of this behavior enables developers to install the right modifications to the design (Life et al., 1990). The chimerical environment is a concept reflecting the possibility of emulating the real environment in both structural and dynamic behavior aspects of real settings to create a laboratory equivalent to reality, and this laboratory becomes a learning substitute for the real environment (Pappo, 1998). After that, the simulated environment can be used to matriculate how to progress and perform skills through practice, acquiring information and using it in stages such as step-by-step learning (Pappo, 1998). For the imaginary environment to be useful, the real context of the skill must be provided to resemble both the structural and dynamical reality of the skill and its environment (Pappo, 1998). Simulation models reflect how one thinks about real environment behavior as well as its dynamics. Building a computer simulation requires relating two functions: modeling and programming. The modeling function contains some concepts such as system analysis and equation settings, and the programming function refers to the process of writing the computer codes (Pappo, 1998). In a computer-based simulation, there is an excellent learning environment because of the multimedia nature which can present very realistic information-loaded settings such as multi-sensory experience for users to be able to practice the targeted skills (Pappo, 1998). Simulation is an experimental educational process whereby an individual can simulate any situation to mimic the environment or interaction (Putman, 2013). The term simulation is usually relevant for educational purposes. Simulation can be defined as several activities where the best solution for some problem can be found and identified. When it comes to using simulation in research, there are huge benefits. When using simulation, the analytical approach is made simpler to respond to various research questions in any field of study for the purpose of drawing an accurate conclusion. Without using simulations, researchers might not be able to answer the research questions carefully, accurately, practically, and morally (Cheng et al., 2014). Showanasai et al. (2013) viewed the purposes of simulation as mainly to handle extremely important tasks (e.g., enhancing complicated applied abilities in selection making, enhancing teamwork, fostering abilities in higher order thinking and reflection, and studying to use expertise as a device for problem solving). In the current curricula in many universities, students have not had the chance to handle the complexity of real challenges. However, education that includes simulation would introduce real challenges in the environment to students and make them confront those challenges in both individual and team settings. Simulation has the capability to help students share the same experiences and offers opportunities to open discussions. In their study, Siewiorek et al. (2012) investigated whether involvement in business simulation gaming sessions could enhance graduate students' leadership, providing them with experiences beneficial for the development of leadership skills. They found that simulation encouraged students to take risks and explore for the sake of learning new ideas and techniques (Siewiorek et al., 2012).

2.4.1 3D Virtual Simulation

Virtual simulation is a 3D simulation whose venue takes place in an artificial environment which enables users to interact, bridge and design utilizing complimentary voice and text chat. An example of this environment is Second Life (Putman, 2013). Putman investigated the impact of conflict management techniques as well as learning patterns on the efficacy of virtual leadership development training. He concluded that virtual simulations can be incredible experiential learning the equipment for adult learners to exercise the management proficiency of conflict management. Putman used virtual leader (vLeader) in his study. "vLeader is one of the most advanced virtual simulations and was therefore a good choice for this study" (Putman, 2013). The vLeader simulation is an intelligent avatar, developed by Simulearn Inc. which was formulated to provide participants the opportunity to implement their relationship constructing and influencing skills in a practical gaming environment (Elattar, 2014). In vLeader, students practice and assimilate skills such as verbal and nonverbal communication, team building and collaboration, gain and use of influence, motivation and persuasion (Sidor, 2007). In this software, "students are given the opportunity to practice divergent leadership styles in a guarded environment, can practice strategies and tactics in the appropriate exercise of power and have an impact on as they manipulate an idea to awareness in this virtual world" (Sidor, 2007). The central principle of the vLeader mechanism for management interaction in associations is through enterprise meetings (Sidor, 2007).

The vLeader simulation is composed of five (5) modules that simulate meetings with different tasks and increasingly complex scenarios to be explored for each module (Putman, 2013). The virtual leader approach for leadership is that "Through these meetings, leaders exercise the art of management as they attempt to influence characters to provide the proper work to further the visions of the organization" (Sidor, 2007). In such meeting settings, participants interact and communicate only with the intelligent avatar (whose name is Oli) not with other real people through avatars. When interacting with Oli, a participant has five (5) options:

(a) support/oppose an idea.

(b) support/oppose a person.

(c) be neutral about an idea or ask a question.

(d) do nothing–listen; and

(e) switch topics–refocus the conversation.

It is probable for solutions implementing artificial intelligence and virtual reality to enrich the soft skills such as engineering leadership for both teams and individuals by using either an agent or an avatar. Avatars are managed by humans to be a virtual representation of them. An agent is a performance of an entity that includes artificial intelligence making the domination by a human unnecessary (von der Pütten et al., 2010). Thus, the difference among an avatar and an agent is that agents are controlled by means of computer algorithms, and avatars are controlled by means of humans (Fox et al., 2015).

Fox et al. (2015) concluded in their investigation that avatars have been extremely persuasive because they gave the permission to achieve more potent responses than agents when collaborative and/or formidable responsibilities are required. These researchers also observed that they should "acknowledge that the immense viewpoint of altruism in a digital representation can be omnipotent sufficient to expand social responses within virtual environments." When it involves interplay with humans in the virtual world, avatars have verified to generate a better response rate than bots and intelligent agents (Hasler et al., 2013). This may be crucial because it relates to leadership schooling in team-based environments which are comprehensive in engineering. Callaghan, McCusker, Lopez Losada, Harkin, and Wilson (2009) investigated how virtual worlds may be interspersed to create experiential-based learning experiences in engineering education. They additionally exhibited the tracking and anticipated recording procedures of the consumer interactions within the virtual world. Their culmination became obtainable to merge the relative strengths of virtual learning environments and the immersive/tremendously interactive nature of virtual worlds to consummate first rate learning experiences for college students. Also, it is far comparatively optimum to track, record, and examine users' synergy and advances inside virtual worlds. von der Pütten et al. (2010) identified two main studies (the Ethopoeia idea and the Threshold Model of Social Influence concept) in which the function of behavioral realism in explaining the social influence of virtual characters was discussed. Both studies compared avatars and agents (agent-avatar paradigm). The Ethopoeia idea is a phenomenon that permits people to reply to computers obviously and unconsciously like the way they do to other people (von der Pütten et al., 2010). The human brain was developed many years ago when the best actual human and actual places existed. During that time, human beings had been allowed to show social behavior in a real environment. In coping with everyday life, the human brain creates impromptu responses. Therefore, human beings still usually accept both people and places as authentic. This automation of reaction takes place socially and naturally because the emblems of media or the situations remain real on this process. Thus, by way of the nonexistence of a tremendous deterrent, the human brain continues to simply accept media as actual people and places (von der Pütten et al., 2010). The Threshold Model of Social Influence idea relies upon on a function known as social verification. This function incorporates two factors behavioral authenticity and organization. These elements take into consideration to be continuous elements fluctuating from low-to-high in each agent behavioral realism and avatar behavioral realism. The Threshold of Social Influence concept is most effectively feasible while the extent of social verification is modestly excessive. When the factor of the business enterprise is high (i.e., when the user knows that the virtual character is a portrayal of a human being), then the aspect behavioral realism does no longer have to be excessive in order for social verification to take place and for social effects to occur. (von der Pütten et al., 2010) von der Pütten et al. (2010) engaged in empirical research to examine the two ideas and to mediate which turned into more accurate in translating the effect on the human behavior element in managing the virtual world. They concluded that "the Ethopoeia concept by Nass and Colleagues is more suitable as a technique to provide the social consequences we discovered than the Threshold Model of Social Influences by Blascovich and colleagues" (von der Pütten et al., 2010). In 2014, Lin and Wang explored the effects of the human behavior component, people's behavioral patterns, and their essential motivations for avatar creation in the virtual world. They discovered that (a) 73% of users had multiple (1 to 16) avatars; (b) 35.6% of the participants delineated making their avatars look like other species or non-organic creatures; and (c) 93.4% of the users had a first-rate avatar engage with others in the virtual world, as a minimum sometimes, if not maximum of the time. Lin and Wang (2014) identified 4 major motivations for users to create their avatars in the virtual world: virtual exploration, social navigation, contextual adaptation, and identity representation. Figure 9 illustrates the capacity of avatars to take on an almost real human appearance.

Figure 9: An example of an avatar appearance in the virtual world

Leaders have recognized the importance of virtual simulations in education. They have found that it helps in reducing the cost and time in preparing future leaders with little complexity. Conine (2014) noted that numerous researchers have recommended simulation- based education as an effective method of enhancing students' educational experiences. Education that includes virtual simulation can familiarize students to real challenges in the virtual environment, granting them to accost those challenges in both individual and team settings. Virtual simulations can also emulate the actual day-to-day functions of a business and require workers to engage with their leaders using remote communication (Mihajlović & Apostolovska, 2018). Companies such as Microsoft, Dell, and General Electric have recognized the usefulness of these practices. Examples were the collective effort of Microsoft and TRI Corporation to formulate experiential learning by developing their first virtual business simulations. They recognize the benefits in helping meet the companies' goals (*Virtual Leader Leadership Styles Workbook*). Due to the educational benefits that can be acquired, virtual simulations have been used as pedagogy in many occupational settings, such as medicine, rehabilitation, baseball, and firefighting (Williams-Bell et al., 2015). Virtual world simulation is utilized in aviation pedagogy, software engineering, military and nuclear power systems training, and healthcare (Williams-Bell et al., 2015). Some virtual world platforms used are Second Life, OpenSimulator, (2014) Active Worlds, and Onverse (Lemheney et al., 2016). Virtual world simulation uses the virtual world such as Second Life or OpenSimulator to simulate the real-life scenario and allow trainees to practice in live, virtual and interactive settings using avatars to represent the real people. Virtual reality is the presentation of the computer-generated data in a way that those who use it perceive the presentation as having similar characteristics of a recognized world (Lemheney et al., 2016). Due to the principle role of virtual simulation in education, Lemheney et al. (2016) have used 3D virtual simulation in their study as a novel way to rejuvenate high-risk medical scripts targeted for office-based predicaments. Showanasai et al. (2013) defined the virtual world as the "simulated environments with virtual resemblance of lively actors and their physical surroundings where they could interact in interactive activities thru computer-generated tools." Virtual simulation can provide students with shared, simultaneous experiences and offers opportunities to permit discussions that might otherwise not occur. Virtual simulation encourages students to take more risks and explore while learning new ideas and techniques (Sequeira & Morgado, 2013a). The virtual world is a form of simulation where via the internet the real world can be simulated in a three-dimensional, computer-based, immersive environment such as the 3D virtual world of Second Life (Siewiorek et al., 2012). The simulated 3D virtual world environment furnishes opportunities for a user's engagement with the 3D simulated environment and with other users simultaneously in the environment via a user's avatar (their virtual alter ego) along with other features such as text-based chats, voice-based chats or fluctuation between different simulated geographical areas. This allows users to vocalize themselves very adversely from what they might in the real world (Hudson, Taylor, Kozachik, Shaefer, & Wilson, 2015). Simulations developed in 3D virtual worlds, sometimes called virtual world simulations or virtual reality simulations, offer trainees many advantages in their learning process such as being able to safely make and identify their mistakes. Providing them with the same experience in a live real-world situation would be difficult due to cost, time constraints, and ethical considerations (Cruz-Benito, Therón, García-Peñalvo, & Pizarro Lucas, 2015). In their study, Cruz-Benito et al. (2015) introduced serious games and virtual simulation applications that may be utilized for training in the fire service. In 3D virtual world simulated environments, users participate and interact using avatars (Williams-Bell et al., 2015). “The avatar is a virtual representation via which the person interacts with and relates to others inside the virtual environment” (Lin & Wang, 2014). Hooi and Cho (2014) tested a research model, exploring the effect of perceived avatar-self similarity on self-disclosure via different theoretical constructs inclusive of self-awareness, self-presence, and identifiability. Results indicated that avatar similarity can affect self-disclosure, but the effect is mediated by way of variables of identifiability, self-awareness, and self-presence. In their research, Kahai, Jestire, and Huang (2013) examined the outcomes of interventions, transactional and transformational management on cognitive attempt and outcomes during collaborative learning inside a virtual world. They observed that transformational leadership extended cognitive effort, and transactional leadership reduced it. Once researchers were able to design an accurate computer simulation, it became possible to create a form of virtual reality (Chorafas & Steinmann, 1995). Thereafter, only well- designed simulation software would be needed to imitate any real-case scenario. The real-world perception can be obtained by combining sophisticated 3D graphics with virtual reality (Siewiorek et al., 2012). Chorafas and Steinmann (1995) discussed the ways in which virtual solutions can enhance concurrent business and engineering processes. They elaborated on the importance of the interaction between simulated and real facts and the combined positive impact of a 3D visualization, a real time response, and interaction in 3D in bringing real-world experience to a laboratory setting for improved learning. The development of virtual world environments began with the use of computer gaming. The use of such software has since shifted toward online social networking sites (Chorafas & Steinmann, 1995). Even though there will be nonetheless not enough research-based knowledge to show the impact of video games on leadership training, the current studies have shown that simulation games can enhance studying associated to complex problem-solving as well as offer consequences and comments in actual time (Lesko & Hollingsworth, 2013). "Simulation game is a simplified simulated experiential environment that contains sufficient verisimilitude, or phantasm of reality, to include actual-world-like responses through those participating inside the exercise." (Siewiorek, Gegenfurtner, Lainema, Saarinen, & Lehtinen, 2013). Also, simulation gaming can be used widely within training of leadership and other professional abilities that require working environments (Showanasai et al., 2013). Virtual worlds have been efficiently used as equipment for educational, simulation and training purposes (Siewiorek et al., 2013). Virtual worlds are synthetic, computer-generated simulated environments where consumer interaction is generally made via avatars, that is, a detail of the simulated environment which embodies the human user. These might also normally expect a textual or graphical form, including full three-dimensional (3D) representation. (Sequeira & Morgado, 2013a) In this project, OpenSimulator (OpenSim) was used to simulate undergraduate engineering students' leadership environments. It is like Second Life (2013). OpenSim and Second Life are both 3D graphical settings where users' access is through the web in a form of graphical representation of an avatar that can walk, fly, and drive a vehicle, and teleport to simulated environments to interact in various activities (OpenSimulator, 2014). Communication is not only synchronous and asynchronous. The virtual environment can also be dynamically changed by all users to build within it (Alrayes & Sutcliffe, 2011). Avatars can interact with each other freely as well as join other groups; they can buy land, build homes, and sell their products to other users of the program (Alrayes & Sutcliffe, 2011). OpenSim is an open source that was developed by and a group of enthusiastic volunteers. By using Linden Lab's released code of their client application, the communication protocol was reverse engineered, and that contributed to the creation of OpenSim which is a simulator that mimics the working in Second Life Grid and allows Linden Lab's own 3D viewer to be used to create and visualize content in a similar way to Linden Lab's grid (Lesko & Hollingsworth, 2013). Linden Lab created and maintained many virtual worlds such as Second Life (Sequeira & Morgado, 2013b). OpenSim is a platform used to function as virtual world environment. It helps a multitude of independent virtual regions which can be related to a single centralized grid, and it is able to be used to create a non-public grid that stays accessible only interior to a finite network investigation (Alrayes & Sutcliffe, 2011). The benefit of OpenSim is that it can be run by Windows and Linux-based working environments in addition to and it supports each MySQL and MSSQL database technologies. The number one coding for OpenSim is developed usage of C# with a .Net investigation (Lesko & Hollingsworth, 2013). Linden Scripting Language (LSL) is a simple language, like Java, which allows users to attach behaviors to an object. The programming code is compiled into an executable file. This folder is then run within a virtual machine inside the simulator. (Sequeira & Morgado, 2013b). OpenSim can be deployed on any computer able to run Microsoft and the content can be saved and restored using an XML-based file format known as Open Archive (OAR). OpenSim is mostly used by researcher to build stand-alone projects which are often inaccessible by the general audience. (Brashears, Meadows, Ondrejka, & Soo). Both Second Life and OpenSim use the exact same viewers and present the same 3D contents. The only major differences are that OpenSim is a complimentary and open source server-side application which can be equipped on any CPU to run a personal virtual world. OpenSimulator-based grids are run by independent commercial operators and are not interconnected with the Second Life Grid (Sequeira & Morgado, 2013b). The functioning space or domain in OpenSim is the visible, virtual working area within the avatars interact. It is a square piece of virtual landscape that can be further advanced to include such topologies as deserts, mountains, roads, houses, lecture halls, oceans, and other virtual space (Sequeira & Morgado, 2013b). Multiple regions then construct what is typically called to as a grid. The advantage of the grid is the availability of organizational structure to the many areas by coping with the relative function of each vicinity inside the virtual world and also handling such services as permissions, stockpile and customer access (Lesko & Hollingsworth, 2013). The virtual environment, sometimes referred to as the domain layer, "is the environment in which all virtual activity takes place and may include a flat piece of land, an island, mountains, a plain, buildings, a mixture of all of these, or candidly be a widespread ocean space." (Lesko & Hollingsworth, 2013). A virtual setting is different than the traditional setting that take places in a tangible facility such as a classroom or a workplace where the interaction happens face-to-face. It is the setting that happens in an indefinite space of the internet and face-to-face interactions are absent (Lesko & Hollingsworth, 2013). In virtual settings, organizations use virtual teams due to the substantial opportunities gained by teaming, and workers are connected virtually. An obvious example of this is that companies are literally working around the globe and around the clock. The secret ingredient behind the tremendous benefits of virtual worlds is simplicity, accuracy, and availability of virtual technology. "Virtual teams depend on technology" (Lueke, 2004). Technology provides the linkage of participants' ideas and information as well as the environment in which participants coordinate activities and build bond of trust (Lueke, 2004). Virtual teams mainly use the technology to communicate with each other. They use digital media to broadcast and control their work. In virtual teams, at least one of the team members should be position in a specific vicinity or in one of a kind time zones (Lueke, 2004). Virtual teams in a global business simulation are small groups who manage their work with electronic communication (Krumm, Terwiel, & Hertel, 2013). Virtual groups are individuals or teams who work remotely using a mixture of communications and technologies to perform their tasks (Conine, 2014). Team members interact and manage their tasks using the technology without the need of meeting face-to-face as in traditional settings. Some engineers consider a virtual team as a great option in dealing with day-to-day work activities due to the fact that working from home is a relief from choosing clothes, finding parking spaces, being exposed to air pollution and facing daily traffic. Others who found the virtual team not to their liking complained about loneliness, being disconcerted, and a lack of project visibility (Phillip & Johanna, 2008). The virtual team must be built based totally upon understanding the constraints of the virtual team and technology. By embracing this understanding, the team will be able to ignore the disadvantages of the method of communication and focus on the team's goals (Phillip & Johanna, 2008). Kimble (2014) suggested that virtual leaders and teams should use their skills, behaviors, and patterns to link what he called the "virtual gap" and try to eliminate the impact of being separated by enhancing collaboration and communication. In addition, he offered some recommendations to close the "virtual gap." During the start of the team formation, team members should meet face-to-face to frame relationships and study group members' effectiveness. Also, the members should share electronics and internet websites in order to enhance team cooperation and openness. He suggested choosing communication technologies that are suitable for and agreeable to all team members and rotating the time of virtual meetings in order for each member to have a good meeting times and bad meeting times (Lepsinger, 2012). "As virtual simulations maintain to evolve, a lot of their challenges-- from management problems to communication limitations can be resolved through advances through technology and as more youthful generations grow into leadership roles" (Lepsinger, 2012).

2.5 Research Gaps

The literature and research reviewed in this chapter was associated with engineering leadership development. Pertinent topics were research efforts in engineering leadership development, team-based leadership development for engineering students, 4-D leadership system and other classification schemes, and the use of simulation (especially 3D virtual world simulation) in education and training. An extensive gap was identified inside the literature in that there was no extensive study of engineering leadership planning for undergraduate students with innovative science fair projects that could be utilized and executed in team-based classroom settings. Because of the great Due to the great significance of teams, most, if not all, organizations use some structure of team-oriented work; and more than 90% of higher-level manager's ranked teamwork to be central to organizational success (Morgeson, DeRue, & Karam). The first gap in this area was that team-based leadership development for undergraduate engineering students was lacking in traditional leadership development programs in that there was a lack of real life examples to allow engineering students to experience real life leadership challenges. Traditional leadership development has not been found to be an effective way of developing leadership. Özgen et al. (2013) identified weaknesses in his competency-based educational model for leadership development in a team-based leadership development setting. He attributed his lack of success in fostering development to factors such as a lack of reality, a non-client-driven environment, and that leaders had no real responsibility. He conducted his model in a lecture room, and actual clients have been absent from the lecture room environment. To cope with this problem, the actual patron expectations may be enhanced by using transforming contemporary integrated layout tasks into actual industry settings (Özgen et al., 2013). In the present research, the investigation was based on well-designed 3D virtual world simulation environment and the industry and customer-orientation settings were intended to resolve the problems identified in Özgen et al.'s research. Rosch (2015) examined the effect of team experience without introducing any structured leadership curricula. He concluded that, "The results offer an initial indication that actually placing college students into teams, in which they possess motivation to succeed and must act interdependently, may not be sufficient to accelerate the improvement of their management capacity." He also showed that "Without a space for intentional practice knowledgeable by means of content material awareness, simply establishing college students in an environment in which they interact in goal-oriented organize behaviors seems insufficient as a catalyst for management development." This means that team activities that occur in a traditional curriculum typically have a minimum impact on leadership enhancement for undergraduate engineering students. Babuscia et al. (2012)'s leadership model using a questionnaire and leadership lectures was based on traditional leadership development. In addressing the first gap (i.e., a lack of team- based engineering leadership development for undergraduate engineering), there has been no demonstrated way to teach it (with the respective consequences). The second gap is that the 3D virtual world simulation provides a potentially comprehensive environment that has not yet been exploited in a systematic manner to enhance the leadership development for undergraduate engineering students Also, having the virtual environment designed based on innovative science fair projects so as to represent real industry, thereby allowing engineering students to visualize, interact and lead based on a simulated virtual innovative environment was not yet explored in the literature. The third gap was identified in comparing the various classification schemes. The most complete system was found to be the 4-D leadership system. The 4-D system was originally designed to detect the leadership failures in engineering and technological teams along with the unique classification of leadership styles that always appear in engineering projects. As per Pellerin (2009), engineers can be classified using four categories of leaders: (a) visionary; (b) directing; (c) including and (d) cultivating. Pellerin demonstrated that leaders can act differently due to their previous leadership styles and that having a leader with a different leadership style than appropriate for a project. He stated that the 4-D coordinate system "simplifies the key activities of high-performance teams and effective leaders." The 4-D system and MBTI were derived from Jung's classification of personality types. 4-D leadership system classify leadership to four leadership styles that can be easily evaluated. In contrast, MBTI classifies leadership and personality to 16 styles which was inconvenient to measure progress in this study. Another important consideration regarding choice of leadership system is its ability to accurately assess the engineering and technological leadership of teams. The system should have the ability to select the best leader for any engineering project team. According to Pellerin, a former vice president and general manager of the Raytheon Corporation, stated: The 4-D assessment methodology, honed through 15 years of teambuilding with NASA project, engineering, and management teams, has the capacity to enhance group overall performance in nearly any enterprise. This book emphasizes the significance of understanding cultural norms and social behaviors which can be often omitted in technical projects, and yet can play an important role in their success.

Thus, not using the 4-D system in the undergraduate engineering leadership development was a second identified gap. 4-D systems classification has been used in the engineering and technological with great success and have, according to Pellerin (2009), an accuracy rate of almost 90% in predicting the leadership style of a leader. It also can classify the strength of the leadership style from 4-D able to 1-D able to show the possible range of improvement for each leader's leadership style. The 4-D system can easily identify effective leaders in a practical and meaningful way. The leaders who are 4-D able, meaning they can lead with four leadership styles (i.e., visionary, directive, cultivating and including), are considered effective leaders. The classification allows one to easily and accurately identify weak leadership styles and improve them based on the 3D virtual leadership simulation scenarios. The fourth gap was identified based on confirmation in the literature review that there was no established and validated investigation that could assist undergraduate engineering students in improving their leadership skills. The literature of engineering leadership was revealing in that the contributions to this important field were rare and limited. The efforts of prior researchers can be classified as either contributions that merely highlighted the importance of leadership development in the engineering curriculum or suggested improving existing engineering skills. An example of that was Özgen et al.'s (2013) suggestion that stronger engineering leadership skills are needed in the workplace compared to those required in prior years. Other research efforts indicated the need for leadership in general but did not present specific solutions based on tested and validated investigations. For example, the work of Crumpton-Young et al. (2010) presented the design of the Engineering Leadership Development Minor (ELDM) at Pennsylvania State University. Due to the lack of prior specific methodology and investigations that might guide engineers in developing their leadership engineering skills, the investigation put forth in the present research will fill a gap in this area of research and literature. Table 8 displays some of the essential research articles studied as part of the review of literature and research. As reflected in the table and summarized in this review, there are great benefits in using virtual simulation to educate and train professionals and students, but no studies have been conducted utilizing virtual simulations to enhance undergraduate engineering students' leadership development. The researcher aimed to develop an investigation and provide a fresh approach to enhance and elevate engineering leadership development for undergraduate engineering students. Figure 10 shows the research gaps that were addressed and the contribution to engineering leadership training that was made in the present research. Using the 4-D leadership system, the 3D virtual world simulation in team-based engineering leadership development made this dissertation's investigation unique in its approach to improving the preparation of undergraduate engineering students.

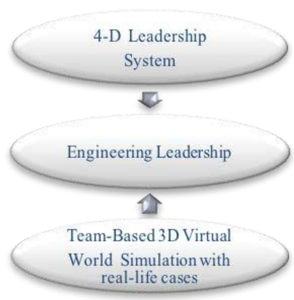


Figure 10: Study investigation: Conveying research gaps in engineering leadership

Table 8: Engineering Leadership Literature Gaps

	Technological Leadership Classification		Virtual Simulation			Engineering Leadership Development for Undergraduate Students	
Researchers	Systems	Avatar	Agent	Other	Team	Individuals	Others
Study Research Investigation	4-D	√			√	√	
Schuhmann, 2010						√	
C. Pellerin, 2009	4-D						
Hartman & Jahren, 2015					√	√	√
Farr and Brazil, 2009							√
Froh, 2003							√
Ozgen et al., 2003					√		
Kotnour, Hoekstra, Reilly, Knight, & Selter, 2014							√
Crumpton-Young et al., 2010					√	√	√
Olude-Afolabi, 2011							√
Babuscia, Craig, and Connor, 2012					√		
Cox et al., 2010							√
Caza and Rosch, 2014						√	
Varve, Adams, Pridie, and Ruiz Ulloa, 2004	MTBI					√	√
Elattar, 2014			√			√	
Rosch, 2015					√		
Rodriguez Montequin et al., 2013	MTBI				√		
National Academy of Engineers, 2004					√	√	
Laglera et al., 2013							√
M. Andrew, Life, 1990				√			
Pappo, 1998				√			
Bayless, 2010							√
Cox, Cekic, Ahn, and Zhu, 2012							√
Putnam, 2013			√				
Shownasasai et al., 2013				√			
Vo der Putten et al., 2010		√	√				
Fox et al., 2015		√	√				
Hasler et al., 2013		√	√				
Lin & Wang, 2014		√					
Conine, 2014				√			
Sequeira & Morgado, 2013		√					
Hudson et al., 2015		√					
Cruz-Benito et al., 2015		√					
Williams-Bell et al., 2015		√	√				
Hooi & Cho, 2014		√					

Lemheney et al., 2016		√					
Chorafas & Steinmann, 1995				√			
Siewiorek et al., 2012				√			
	Technological Leadership Classification		**Virtual Simulation**			**Virtual Simulation Engineering Leadership Development for Undergraduate Students**	
Researchers	Systems	Avatar	Agent	Other	Team	Individuals	Others
Lesko & Hollingsworth, 2013		√					
OpenSimulator, 2014		√					
Kahai, Jestire, & Huang, 2013		√					
Callaghan, McCusker, Lopez, Losada, Harkin, and Wilson 2009		√					
Alrayes & Sutcliffe		√					

CHAPTER 3: METHODOLOGY

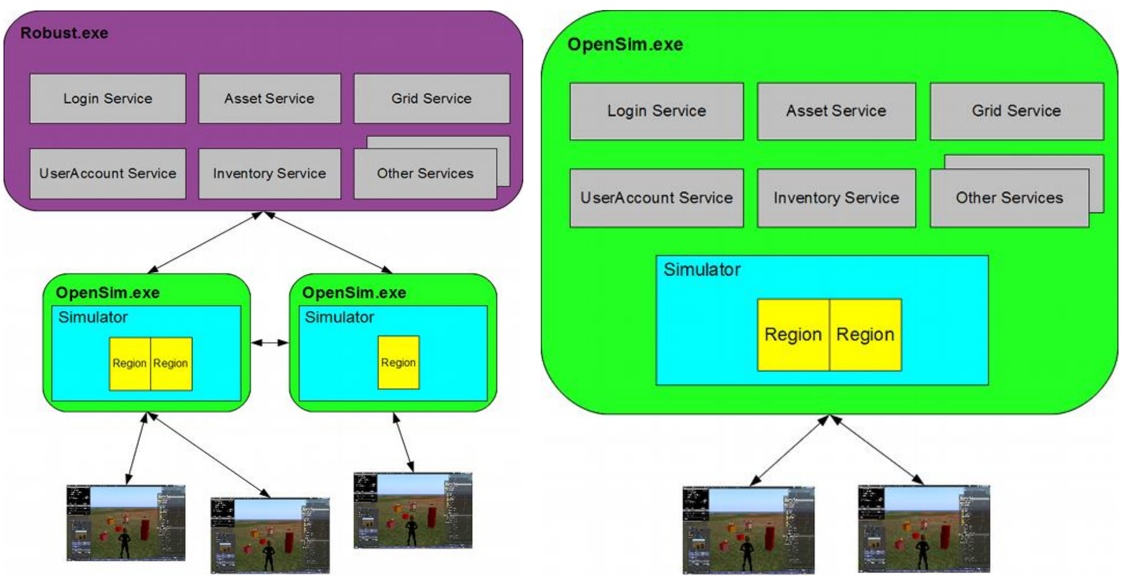
3.1 Introduction

In this chapter, the research strategy is presented to affirm the fundamentals utilized in the development of this research. All the research design techniques aligning from the inception typical research idea to the more comprehensive methods of data collection, analysis, and validation will be presented to illustrate the research flow utilized in this study. A coherent methodology is surmised to accomplish the mission and the objectives of this contribution within the engineering leadership development field of study.

3.2 Research Methodology

The research methodology will show in the leadership body of knowledge the application of any real-life innovative science fair projects and how it can enhance the leadership of undergraduate engineering students in a practical and nontraditional way of training. The research will tie the psychological aspect to evaluate and study the behavior and mental processes which will lead to colors as they relate to the individual students and the research, the system engineering tools that will be applied, specifications required for virtual world simulation and we will build the environment based on the specifications. Our main research objective is to design an investigation to understand, analyze, manage, and develop ways to build technological leadership in engineering students through Cognitive Modeling methods and Systems Engineering. The research emerged from an interest regarding the limited pedagogy in undergraduate development of engineering technological leadership. This concern propagated more concerns such as having the ability to use the best technological and engineering leadership classification strategy for assessing engineering leadership development endeavors. This theory emerged into more meaningful methods during the researcher's review of the literature and related research. Due to an insignificant quantity of peer reviewed articles and several books concerning engineering leadership and the deficiency of a substantial explication for the current engineering leadership development failure, the problem is likely to persist, and more money will be pointless on inefficacious traditional leadership development. The subsequential step in the research methodology, the literature review, disclosed an obvious gap. The goal is to select a virtual leadership simulation for my research that will be endorsed by my advisor, a psychology professor (cognitive and human aspect), a virtual world designer, and a cast of team leaders to ensure the virtual simulation activity is effective and fulfilled the virtual means of developing technological leadership for undergraduate engineering students. The plan is to develop a case study in Virtual Simulation to represent the different leadership styles is to build a virtual environment which will enhance and provide a robust tool to simulate and serve as the ecosystem for leadership. The case study selected will have characteristics to cover multi-engineering disciplines concepts, the ability to have a customer-based representing future request by the current customer; being technical savvy and applicable to engineering concepts, manage in a team-based environment; user friendly, sensible and appealing to meet the student's educational level; and growth toward innovation and creativity. Once the script(s) have been obtained based on the case study selection compilation and examination, identifying the best simulation types as well as the optimum leadership classification strategy for engineering students will be completed. This design of the virtual world simulation will be methodically executed to embody both the case study characteristics and the required leadership style. The leadership style for the engineering students will be evaluated before and after the experiment. The evaluation will assess the effectiveness of leadership styles for team and individuals. Pellerin's (2009) 4-D Leadership System will be utilized before the experiment to understand the current students' leadership styles. To validate and assess the impact of the experiment, examination of the leadership style after conducting the virtual leadership experiment will be performed. Leaders with different leadership styles complete tasks differently. There are many reasons for differences, and the assessment provides the status of leadership qualities related to specific students. The assessment will disclose students' strengths, weaknesses, capabilities, and leadership styles.

The proposed platform is to use virtual world simulation is Open Simulator (OpenSim). OpenSim has been used and adapted by technological and engineering companies such as NASA and Intel. (Hebbel Seeger, Reiners & Schaffer, 2013). This platform will allow engineering students to simulate in an innovative real-world scenario with interactive settings utilizing avatars as digital representation of themselves. Figure 11 displays OpenSim region (mini grids) and the full OpenSim grids architecture.



Source. Adapted from OpenSim Architecture (2016)

Figure 11: OpenSim regions (mini grids) and full OpenSim Grids Architecture.

There are many similarities between OpenSim and other various platforms comparable to Second Life and Military Open Simulator Enterprise Strategy grid (MOSES), I plan to utilize OpenSim based on the following advantages: Provides its users controls and features in two (2) ways. Standalone applications and robust mode. The distinction between the standalone regions (mini grids) and complete grids is the configuration including regions (run via simulators) and a backend information service. The standalone mode runs both the domain simulator and all the input services in a single process. When OpenSim.exe is utilized, some of the regions may be run in a single machine. In the grid form, the information services are not included in the server, but they are executable called Robust.exe to allow all services to run on an entirely separate machine. In grid settings, OpenSim.exe can run on different machines as shown in Figure 11. It is an open-source server platform that allocates users full authority of the server and Second Life is a proprietary software platform. It can be deployed on any computer capable of running Microsoft and the content can be saved and restored utilizing XML-based file format known as Open Archive (OAR). OpenSim is editable and flexible, whereas Second Life is only accessible. It has a feature to back-up information and the servers can be set up in any secure situation. (Hebbel Segger et al., 2003). It gives more freedom to control the implementation environment, whereas there are restrictions in Second Life. A great system mostly used by researchers to build stand-alone projects which are often inaccessible by the general audience (Brashears et al., 2003)

3.3 Research Idea

Psychology played a role in my research as it applied to individual cognitive differences. Cognitive style would apply to how a person perceives, interprets, and uses information. How methods to perceiving and assimilating data, making decisions, fixing problems, and ultimately relating to others. Cognitive tactics are choices that are not always rigid, however most human beings tend to have some of these desired behaviors of thought. An intellectual model can constitute causal or time relations among events and is able making this statistic to be acquired by different cognitive subsystems through mental simulation. Norman (1983) observed that "it need to be possible for human beings to 'run their models mentally" (p.12), and Gentner stated that "mental models often permit intellectual simulation: the experience of being able to run a mental model internally, so that one can examine it will behave and what the outcome of the manner will be." Rumelhart et al. (1986) provided a complete evaluation of the relation between mental models and simulation with the aid of describing a view of mental models and sequential thought primarily based on the parallel disbursed processing (PDP) paradigm. This approach stated that cognitive system consists of two (2) forms of processing units:

- an interpretative ideology which obtains input from the universe and produces a process.
- a portrait of the ideology which obtains the action produced with the aid of the interpretative structure as input and predicts the manner the input must consequently change. (Figure 12)

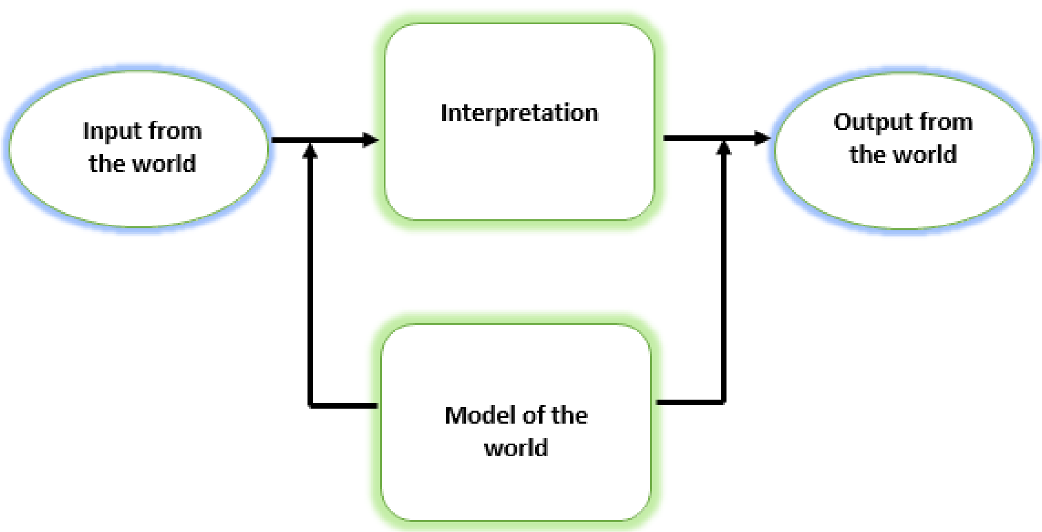


Figure 12: A clear depiction of the PDP model of mental models

Source: (Rumelhart et al. 1986)

The term “mental model” is also utilized in the research investigating the mental representations human beings form to recognize in the fashion of texts and diagrams. For example, acquiesce to Hegarty and Just (1993) investigated participants’ notion processes regarding gears, pulley systems, and hydraulic devices. Hegarty and Just therefore proposed a dynamic view in which people run an intellectual model of the system in their heads to apprehend the working of these systems. Hegarty (2004) reviewed the proof and concluded that mental simulation is a strategy accessible to people to inference about mechanical systems. Hegarty also underscored a key difference among visual imagination and intellectual simulation, by way of stating that visual creativeness is based totally upon the holistic inspection of an intellectual picture of the moving system and mental simulation is based totally on the following:

- the piecemeal simulation of the events.
- some information, each visual or otherwise (as an example a mass of density).
- and the illustration of the related motor actions.

It is also critical to note consistent with Schwartz and Black’s (1996) findings that participants knowing verbal rules to infer a movement rely on those as opposed to simulation so that it will remedy the issue quickly. Figure 13 summarizes the interaction between mental model and mental simulation in keeping with these ideas.

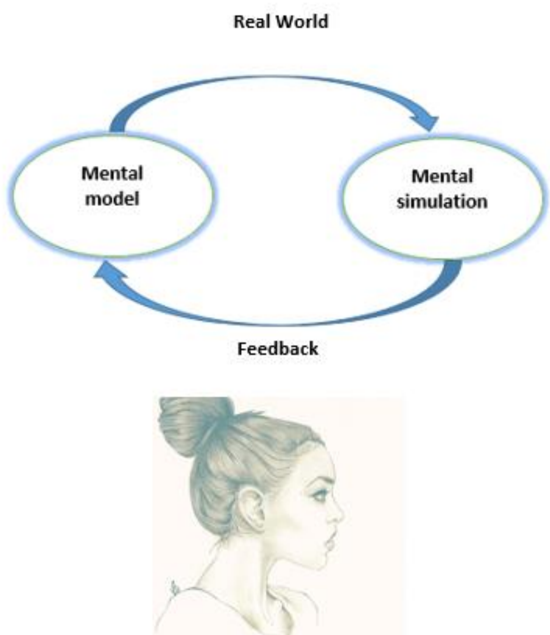


Figure 13: The synergy between mental model and mental simulation

3.4 Literature Review

Engineering leadership development endeavors have not received as much investigation compared to other leadership development initiatives. Although efforts have been compiled to develop leaders in traditional leadership areas, there has been a lack of consideration to engineering leadership. In the literature review, I focused on three main areas directly related to this dissertation: (a) leadership classification systems; (b) engineering leadership development; (c) team-based leadership development, using simulation (especially 3D virtual world simulation) in education and training and (d) system engineering principles and cognitive modeling with the support of psychology to test students' attitudes and the potential to change mental models. Systems engineering method is an important complement to and is not an alternative for, individual skill, creativity, intuition, judgement etc. Innovation people need to recognize the system and the way to make it work for them, and neither forget about it nor be slaves to it. Systems Engineering measurement indicates in which invention and creativity want to be applied. Systems Engineering technique creates an investigation to leverage creativity and innovation to deliver outcomes that surpass the functionality of the creative individuals' results which are the emergent assets of procedure, organization, and leadership (Sillitto, 2011). By presenting the literature review in these areas, the research gaps have been identified. Furthermore, literature review proved that this contribution is not only the first of its kind in this area of knowledge but also highly needed to solve the current engineering leadership development problems. By applying Systems Engineering, it will provide and discernment of social systems explicitly and improved them in the similar manner engineering principles are applied.

3.5 Research Gaps

After analyzing and reviewing the literature, the major gaps in the literature and related research were established. The first gap was that there were inconsequential reports of team-based leadership development for undergraduate engineering students, and those acknowledged necessitated real-life examples to allow engineering students to exploit real life leadership challenges. In this dissertation, a team-based approach has been utilized to ensure that students employ their leadership by creating an organization in the virtual world with mission, vision, and goals. The second gap was identified through a correlation of classification schemes. The most complete system is the 4-D leadership system. The 4-D leadership system was originally designed to detect the leadership failures in engineering and technological teams but also to address the exceptional classification of leadership styles that incessantly appear in engineering projects. Engineers, according to Pellerin (2009), can be classified using four forms of leadership: (a) visionary; (b) directing; (c) including and (d) cultivating; and leaders can act contrastingly due to their previous leadership style. The 4-D system has been used, with almost 90% accuracy, in envisioning the leadership style of leaders of engineering and technological. It also can systematize the strength of the leadership style from 4-D able to 1-D able to show the plausible range of improvement that could occur in leaders' styles. The 4-D system can be used to easily identify effective leaders in a practical and coherent way. The leaders who are 4-D able, (i.e., they can lead with four leadership styles--visionary, directive, cultivating and including), are effective leaders. The classification permits someone to easily and accurately recognize an unconvincing leadership style and improve it based on the 3D virtual leadership simulation scenarios. The third gap was identified in the literature analysis. No studies were establish concerning the utilization of 3D virtual world simulations for enhancing the undergraduate engineering students' leadership development team-based development. The literature review also exposed that there are great advantages in using virtual simulation to educate and train professionals and students. The fourth gap identified was in the lack of an investigation other than the traditional pedagogy format, (i.e., regular lectures and reading assignments). Alternative investigations have not been tested or validated.

3.6 Modified Research Idea

Though there are many literatures associated with management, in a popular sense, the researcher learned via the literature review system that engineering leadership has not been reviewed with the assistance of different researchers. Engineers have contributed interminable tremendous contributions to society. Engineering leadership is defined as "the potential to lead a collection of engineers and technical personnel chargeable for creating, designing, developing, implementing, and comparing products, systems, or services"

(Crumpton-Young et al., 2010). Leading teams of designers to consummate certain goals is not always an easy mission and should not be taken lightly. Comprehensive, specialized, and focused management training must be supplied as to enhance the training of engineering college students to consist to leadership abilities and attributes. Specifically, in carrying out the literature review, the researcher determined that the engineering management body of knowledge lacks a clear and sensible methodology compared to different kinds of leadership. Generally, engineering leadership development has not been executed well in academia, as there is no innovative and validated investigation that is dedicated to training engineers to improve their leadership skills based on real innovative science fair projects and in teams. Simulation can provide the infrastructure to build this new investigation. Engineering leadership is essential and highly necessitated to be able to be effective in dealing with customer relations, making decisions, and working as members of a team (Crumpton- Young et al., 2010). One of the paramount success factors for team members and team leaders is having a balanced set of personal, management, and leadership skills (Wysocki, 2002). Therefore, the key is realistic leadership and team-based development.

3.7 Investigating the Best Technological and Engineering Leadership Development

There are several leadership classification assessment schemes that can be used to discover and measure the leadership style. The main objectives of obtaining the leadership styles for engineering students are to make sense of their leadership background and be able to calibrate their current leadership style. Four (4) leadership classification schemes were investigated in the literature review:

- 4-D Leadership System
- The Myers-Briggs Type Indicator (MBTI)

- Big Five Personality Traits
- Bass Classification of Leadership

3.8 Types of Simulation

Simulation was used in this project as an apparatus to enhance preparation in engineering leadership. Simulation is an experimental educational approach where an individual can simulate any situation to parody the environment or interaction and a great tool for education and training (Putman, 2013). Cheng et al. (2014) expressed the belief that without utilizing simulations, researchers might not be capable of answering research questions fervently, accurately, practically, and honorably. Showanasai et al. (2013) recommended simulations as extremely important to enhancing (a) complicated applied competencies in resolution making and (b) synergy. There are different types of simulations such as discrete event simulation, agent-based simulation, system dynamic simulation and virtual world simulation. For this study, it was vital to have teams working together to achieve certain engineering goals. Thus, the virtual environment that impersonates real life using avatars as virtual representations was found to be the optimum type of simulation to be used in developing engineering leadership in undergraduate engineers. Virtual world is a genre of simulation where, via the internet, the real world can be simulated in a three-dimensional, computer-based, immersive environment such as the 3D virtual world of Second Life (Hudson et al., (2015). There are many names are being used interchangeably with virtual reality such as virtual environment, artificial reality, and virtual worlds (Bamodu & Ye, 2013) and multiple-user virtual environment (MUVE); massively- multiplayer online game (MMOG); immersive virtual world (Girvan, 2013). The simulated 3D virtual world environment provides opportunities for a user’s engagement with the 3D simulated environment and with other end users simultaneously within the environment via a user's avatar (a virtual alter ego) alongside other features consisting of text-based chats, voice-based chats, or movement between different simulated geographical areas. This permits users to deliberate themselves very adversely than they may in the physical world (Cruz- Benito et al., 2015). Virtual world simulation was chosen for use on this research because of its having been prosperously employed as tools for educational, simulation and education use (Sequeira & Morgado, 2013a). Virtual simulation has the capability to provide students with shared, simultaneous experiences and offer opportunities to open discussions, and it also encourages students to take more risks and explore while learning new ideas and techniques (Siewioreket al., 2012). 3D virtual worlds offer trainees many advantages in their learning process. They are able to safely make and identify their mistakes in simulated settings, gaining the same experiences as they would in a live real-world situation without the difficulties due to cost, time constraints, and ethical considerations (Williams-Bell et al., 2015). Virtual environment is the synthetic sensory experience that communicates abstract components to a participant, and it is the intersection of three environments: visual environment, auditory environment and haptic/kinesthetic environment (Tolga, Capin, Magnenat-Thalmann, & Thalmann, 1999). The system where multiple geographically distant users are interacting in common virtual environment is called Networked Virtual Environment [NVE] (Tolga et al., 1999). Figure 14 presents a graphic display describing the integrated NVE where NVE provides an input and receives output from a participant. The participant is a real person who is participating in NVE with an avatar (Tolga et al., 1999).

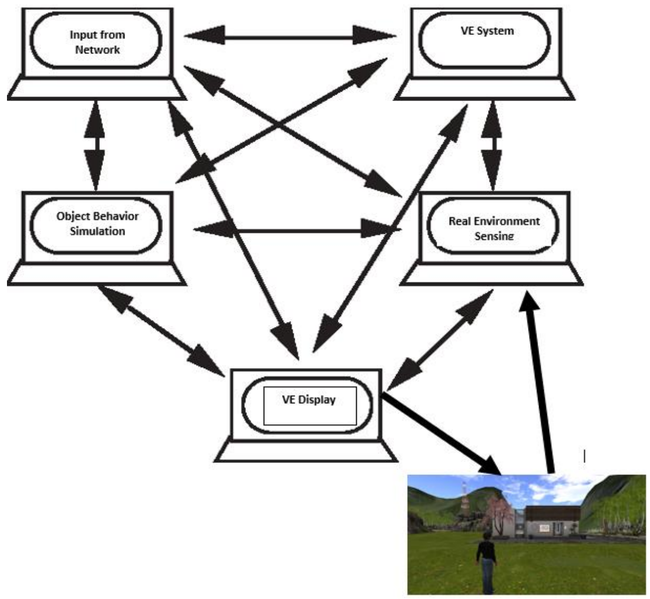


Figure 14: Integrated networked virtual environment (NVE).

Source. Adapted from Tolga et al. (1999).

Virtual reality system software program is a set of gear and software program that used to design, increase, and cultivate virtual environments and the database (Bamodu & Ye, 2013). The features and characteristics of the virtual world simulation are displayed in Figure 15.

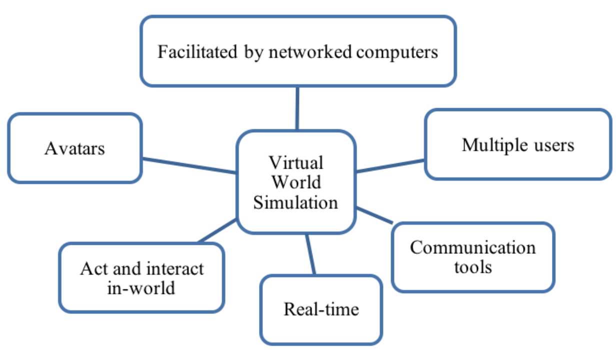


Figure 15: Virtual world simulation features and characteristics

Source. Adapted from Girvan (2013).

Virtual world architectural result contains four (4) explicit components: (a) a simulated environment; (b) an end-user client; (c) a group of collaborative resources available from within the virtual world environment; and (d) a web infrastructure to captures and helps the virtual world solution (Lesko & Hollingsworth, 2013). The main differences between 3D graphics and virtual world are shown in Table 9 (Chorafas, 1995).

Table 9: Comparison of 3D Graphics and Virtual World Features

Components	3D Graphics Features	Virtual World Features
Agents	Agents are passive and nonexistent	Agents are active and participating
User Participation	User is a spectator	Presence and role playing can be immersive or not immersive
Multimedia	Mainly graphics with text	Full multimedia such as sound and other stimuli
Data Feed	Still images (online or batch)	Online real space with wide bandwidth and live images
Networking	Deferred or online	Networked solution with no time delay with wide bandwidth and gig stream desk area networks DAN)

Source. Adapted from Chorafas (1995)

There is a potential for solutions implementing artificial intelligence and virtual reality to enhance the soft skills such as engineering leadership for both teams and individuals by using either agents or avatars. Unlike Virtual Leader, an intelligent-avatar created by SimuLearn for leadership environment (Elattar, 2014), the 3D virtual world is a simulation where the real world can be simulated in a three-dimensional, computer-based, immersive environment such as Second Life (Hudson et al., 2015). Virtual world is a simulated 3D virtual world environment which provides opportunities for a user's engagement within the 3D simulated environment and with other end-users simultaneously in the environment. This occurs via a user's avatar along with other features comparable to text-based chats, voice-based chats or movement amongst various simulated geographical areas, allowing users to specify themselves very asymmetrically than they might in the physical universe (Cruz-Benito et al., 2015). In the 3D virtual world simulation, users access the game through the web in a form of graphical representation of an avatar capable of walking, flying, and driving a vehicle, and teleport to simulated environments to engage in a variety of activities. Due to these characteristics of the 3D virtual simulation, the virtual environment must be designed according to the simulation objectives.

3.9 Case Study Selected to Proof Research Question/Idea and Respective Scripts

Using a case scenario approach to building the virtual leadership environment makes an experiment a powerful tool to mimic the real business world and affords students a logical, enjoyable and meaningful leadership activity time. The selected innovative science fair projects were required to have the following features:

1. Technological- and engineering-based
2. Can be conducted in team-based setting
3. Covers multi-engineering disciplines concepts
4. Logical, simple and appealing to meet the students' educational level
5. Customer-based case study that represents a future demand by the current customers
6. Has room for innovation and creativity

3.10 Design of the Virtual World Simulation

After successfully obtaining the scripts based on the case study selection and analysis, and identifying the best simulation type as well as the best leadership classification scheme for engineering students, the design of the virtual world simulation took place using a series of steps which are characterized in the following section. To achieve the researcher's main objective, to enhance the engineering leadership development, the design of the simulation needed to be carefully implemented to reflect both the case study characteristics and the needed leadership styles.

3.11 Building the Virtual World Simulation Environment

In this step, the 3D virtual world simulation software was selected that would be used to implement the case study scenarios. Using this software enables virtual simulation environment scenarios to be built not only to mimic the real-life example but also to match a logical and step- by-step leadership approach to allow students who finish their leadership simulation activities to achieve certain leadership goals. The virtual world leadership simulation selected for this research was validated by three engineering management professors, a psychology professor, a virtual world design artist, and the team leaders to ensure that the virtual world simulation activity was effective as a virtual means of developing engineering leadership in undergraduate engineering students.

3.12 Tools from System Engineering to Assist with Development of Virtual World Simulation for Leadership

Systems reasoning has its foundation inside the field of system dynamics, founded by means of MIT professor Jay Forrester (1956). Professor Forrester identified the necessity for an improved manner of testing new thoughts related to social systems similar much like the way we can test ideas in engineering. By applying systems reasoning, it will allow me to recognize social systems explicitly and enhance them in a similar way that we use engineering principles. Traditional analysis specializes in separating fragments of what is studied, whereas systems reasons specializes on how the facts is being studied interacts with other ingredients of the device. As it relates to my research, it is the set of elements that have interaction to administer behavior. Instead of disengaging minor parts of the system being studied, systems reasoning will expand and keep in mind large numbers of interactions as difficulty of this is being studied. The results, I am predicting could be strikingly one-of-a-kind than those generated by means of traditional sorts of analysis, especially when what is being studied is dynamically complex and might have a high-quality of feedback from different assets each internally and externally. The character of systems thinking makes it extremely effective on maximizing difficult types of issues to solve, particularly those involving complicated issues, the ones that rely upon an awesome deal of dependence on beyond or on the behavior of others, and people that could stem from useless coordination among the ones involved.

Bryan (2006) observed one of the greatest tools to assist the researcher with perceiving things systemically affectionately known as the Iceberg Model. The iceberg model is a structured manner of looking at and understanding systems and will help think through any of the complicated issues. The advantages will help to move my focus away from activities and symptoms toward structures, questioning and belief. It will assist me to promote shared thinking or "mental models" within groups and communities which will sell consistency and aligned action. It will also assist to recognize wherein leverage points are within the system. Those regions in which least effort produced maximum results. The systems perspective is a powerful method of helping leaders benefit from an expertise of the underlying structures, thinking and ideals that in the long run shape their organizations.

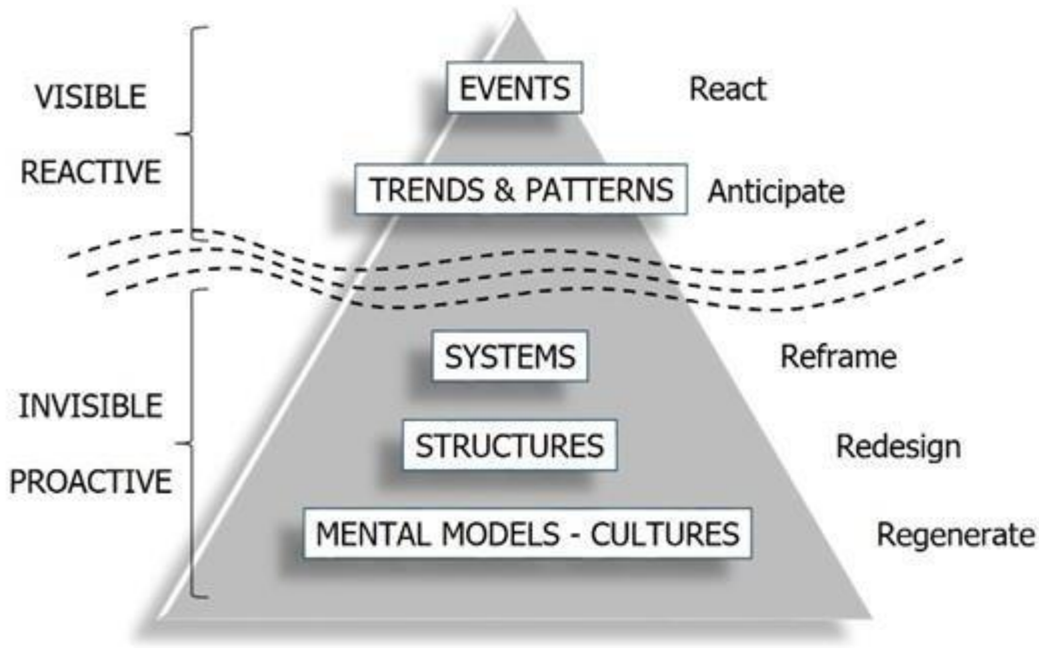


Figure 16: Systems Thinking Iceberg Model

Source: (Bryan et al., 2006)

The 1st thing that is noticeable about the "Iceberg Model" as illustrated above in Figure 16 is that about two-thirds of an iceberg is under water, because the captain of the Titanic swiftly discovered. Most of the iceberg remains hidden from observation, underneath the water. This is also actual of the systems we engage with on an everyday basis, a whole lot of the structure and questioning that produces their outcomes remain hidden underwater. The key to navigating and changing systems is to look and apprehend the entire system. Navigating thru the numerous layers of the iceberg, we find the following:

At the surface grade of the iceberg, we can easily observe events that are happening. Observable events may explain the question "what actually happened?" Linear thinking reasons us to visualize the world as a sequence of activities. Not a bad manner to observe the universe, however, it does not provide a leverage way to introduce change. There is this situation of a fixation on activities which can often result in attributing motive and results in a superficial way, limiting our information and therefore our capacity to introduce change. Connecting the events, we begin to understand traits and styles. This will offer a deeper level of know-how and improved leverage giving a deeper level of insight. At this point, we perhaps may bear in mind that this event has occurred before. After a trait and style has been identified, our next step is to look for the dynamics that created the trait. There is a few interpretation and theorizing needed to expand and recognize the structure. It may additionally require that we create a hypothesis as to what is causing the trends. The structure creates the foundation, which supports the trends and patterns resulting in activities. Structure is very important as it will deliver us a deeper expertise of the system and can assist to anticipate a system's conduct. Systemic systems are frequently held in place because of ideals, the way we understand things, thinking or "intellectual models". These beliefs are usually challenging theories residing in the minds of leaders on what we may constitute as desirable or inferior quality and superior service to our customer. These beliefs may additionally affect interpersonal dynamics inclusive of how we approach conflict, leadership, or the best manner to introduce an alternate. Through the research, changing the way the corporations think, beliefs and mental models may hopefully transform the organizations behavior and results. As I circulate down the Iceberg, I can gain a deeper understanding of a system and at equal time gain an elevated leverage to determine if there is a need to interfere and change the system and its results. To benefit from a deeper understanding of the system as it relates to management, I will need to exercise shifting the student's thinking from events to structures to beliefs, by enhancing what types of questions I will pose to them. Also, I will need to incorporate a theory or speculation as to what the structure might be and beliefs motivating the structure. This will allow me to test with distinct methods of changing the system. Human-factors engineering and related areas, which includes cognitive systems engineering will focus on integrating the human activity into systems analysis, intellectual modeling, and design. It will also help with clarifying the transaction of a system which can greatly upsurge productivity and reliability by designing it easier for the humans being in the system to perform effectively. Situational management mental models and simulations will be very important means for creating and analyzing the systems. The models will offer mathematical constructs that describe the overall performance of the subsystems. Interactions of the various subsystems combined with any constraints inside which the system operates may influence the overall performance of the total system and represent the overall system model. Using these mental models and simulations, it becomes possible to analyze the predicted performance of a system if systemic modifications are made.

3.13 Design of Experiments

To appraise the effectiveness of the 3D virtual world simulation in enhancing engineering leadership development, the design of experiment, both experimental and control group are carefully selected through a randomization process. In this experiment, the experimental group's leadership style was tested. After that, it was subjected to the experimental treatment (the 3D virtual world simulation) and then observed again. The control group's leadership style was also tested, and the group was isolated from any influence of the treatment. Instead, the control group received instruction using traditional engineering leadership development methods (i.e., lectures, reports, and presentations). Students in the control group worked in teams, preparing, and presenting a leadership innovative science fair project. This type of design is very accurate in detecting the effects of the treatment and also enables researcher to avoid two issues associated with experimental design: (a) determining whether a change has taken place after the treatment and (b) eliminating confounding variables.

3.14 Analysis

Validating the effectiveness of the researcher's approach to enhancing engineering leadership can be achieved by checking and testing the research hypothesis (i.e., to examine if the 3D virtual world simulation is able to create a 3D virtual innovative environment that permits engineers to practice leadership, communication, and decision-making virtually). In this study, the participants' leadership capability may well be enhanced. The effect of the simulation was measured using the chosen leadership classification scheme. Statistical analysis tests were used to examine the null hypothesis to evaluate the differences between scores of the experimental and control groups and between the teams within each group.

3.15 Conclusions

After completing all the experiment steps and procedures and having students conducting the 3D virtual world leadership activity, conclusions were drawn situated on the outcomes of the virtual world leadership experiment. The results were further discussed to confirm the feasibility of the 3D virtual world simulation in enhancing the engineering leadership development for undergraduate engineering students and contribute recommendations for future research. Based on the current structure and traditional courses, to implement leadership into the curriculum, I would have to do major redesign. Even if I were to make a slight or minor modification to the curriculum, I would take away from ABET requirements for the course(s). My plans are to utilize the curriculum of the Senior Design course and its extensive component of Experiential Learning to help college students mature towards more complicated thinking; towards being better able to make good decisions on unintelligible real-world engineering problems. Experiential learning is perhaps the best method of training and development. Absent real-world experiential learning, simulation can provide a viable alternative and enhance pedagogy in the traditional face-to-face classroom lecture styles used in most colleges and universities. Virtual environment simulation-based education would not only compliment traditional ways of teaching but also supports collaboration and student engagement. Virtual environment simulation additionally bridges the gap between content knowledge and experimental learning, and it could engage users by creating an impression of being present in a selected environment (Bhide, 2015). The University of Central Florida College of Engineering and Computer Programming offers accredited undergrad degree programs in a variety of engineering disciplines. As a degree requirement, each year fourth- and fifth-year engineering students enroll in a multi-disciplinary senior design course sequence. (Senior Design I & II). The experience of the course (studio style) is that it adopts a routine approach to student engagement that is hands-on, professor facilitated, and college student focalized (Little, 2001). Accordingly to Ohio State University's Material Science and Welding Engineering curriculum (2011 Self-study), Accreditation Board of Engineering and Technology (ABET) Criterion Three Program Outcomes and Assessment states that engineering programs need to exhibit that students achieve the subsequent set of attributes upon graduation (ABET. 2005):

(a) A capability to apply expertise of mathematics, science, and engineering.

(b) A potential capacity to design and conduct experiments, as extraordinary as to research and interpret data.

(c) A potential capability to design a system, component, or method to meet covet needs within sensible constraints including economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.

(d) A capability to function on multi-disciplinary teams.

(e) A capability to identify, formulate, and remedy engineering problems.

(f) An understanding of professional and ethical responsibility.

(g) An ability to communicate effectively.

(h) The broad education required to apprehend the effect of engineering solutions in a global, economic, environmental, and societal context.

(i) A recognition of the need for, and an ability to have interaction in life-long learning.

(j) A knowledge of modern issues.

(k) A capability to use the techniques, skills, and current engineering tools essential for engineering practice.

In accordance with the above criteria, there is a progression inside the curriculum where essential scientific and other knowledge acquired inside the foundation courses and is adapted in later engineering courses through a well-interspersed experience. Based on a course appraisal and evaluation, the purpose would be to have UCF program educational outcomes (scholar learning expectations) describe what college students are expected to realize and be capable of doing by the end their experience. The outcomes are as follows:

- An outcome to provide an explanation for the product development improvement process within the context of the product life cycle. To be able to perform a crucial evaluation of requirements, engineering specifications and the relationships between them.
- An outcome to integrate concept from a broad range of courses which may also have a lab component and co-op experiences to the explication of an engineering design problem.

- An outcome to exercise a rigorous design process that may additionally consist of ideation, analysis, synthesis, implementation, and test in opposition to engineering specifications
- An outcome to document the product development activities and to effectively communicate technical discipline specific information both orally and written.
- An outcome to work efficaciously in a multi-disciplinary team environment, communicate and make tradeoffs inside and across disciplines to meet project requirements.
- An outcome to provide an explanation for the impact of a project schedule, its essential paths and what budgetary constraints can be impacted if the completed engineering design is not accomplished and effective.
- An outcome to perform a self-evaluation of skills, aptitudes and preferences towards project roles and their responsibilities. Also determine the societal impact of design selections and the ethical engineering design decisions.

Table 10: Relationship interpolated course learning objective and ABET (a) through (k) criteria. Recommended UCF Course Learning Objectives Outlined to ABET Attributes (a-k)

Recommended UCF Objective (abbreviated)		**ABET Defined Attributes**									
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
Product development process		X	X						X		
Critical analysis	X				X				X	X	X
Integrate theory and apply	X				X				X		
Employ a rigorous design process		X	X		X				X		X
Document product development							X		X		X
Effectively communicate							X		X		
Work effectively in a team				X					X		
Execute engineering design		X	X					X	X		
Self-assessment				X					X		
Societal impact and ethical engineering design						X			X	X	

3.16 Future Research

Because of this study, subsequent researchers should have a clearer vision in expanding the development of engineers as leaders, using improved techniques and efficient approaches. This experiment has, however, been limited by time constraints and resources available. There is without exception room for augmentation; research is consistently evolving, and many state-of-the-art ideas may generate greater results. Future work to include but not be limited to more experiential learning, gaming, meditation, and modeling.

3.17 IRB Approval

Prior to initiating this research (i.e., pretest leadership assessment), the proposal for the research was evaluated and approved by the Institutional Review Board (IRB) of the University of Central Florida. An informed consent was distributed to all participants to further familiarize them with the study, its objectives, methodology, risks, location, and the duration of the experiment. All participants were guaranteed that confidentiality and anonymity would be preserved throughout the research.

CHAPTER 4: DEVELOPMENT OF AN INVESTIGATION

4.1 Introduction

This chapter encloses a discussion of the methodology utilized to construct the investigation and examine its elements. Initially, the researcher determined a failure of prevailing methods utilized to establish engineering leadership in undergraduate engineering students. The methods did not assimilate real-life industry examples or relevant conditions. Literature review and significant research were then abstracted to identify gaps. After the gaps were analyzed, the research idea was further adjusted to encompass simulation to be utilized in the leadership development. This chapter specifies the methods and procedures related to: (a) amendment of the investigation, (b) exploration of the best technological and engineering leadership classification scheme, (c) advantages of using the 3D virtual world simulation equated to a specific development environment, and (d) features of the investigation.

4.2 Reexamine the Investigation

Based on the literature gaps, it was determined that an integrated investigation was required to develop leaders in engineering. It was indisputable that the investigation must include the following three (3) attributes:

1. The classification strategy must be suitable for engineering that provides for evaluation and promote the development of education/training materials.
2. The classification strategy must endorse team collaboration and individual development.
3. The classification strategy must warrant the creation of a suitable environment for leadership development. While experiential learning in a real-world setting is the

first choice for the development of engineering leadership, in its absence, simulation is a very substantial alternative candidate.

4.3 Investigating the Optimum Technological and Engineering Leadership Classification Strategy

Several classification strategies have been used to discern and measure leadership style and determine intrinsic personality and leadership attributes. These classification strategies affirm tremendous knowledge about leaders' personality and leadership styles. "Perhaps one reason that personality has been used as an investigation for understanding leadership is because behavior is a function of personality--what people do is a function of who they are" (Strang & Kuhnert, 2009). Also "another reason for the employment of personality theories in leadership studies is because personality has a trait-like nature: personality is consistent across adulthood and has longitudinal predictive power" (Strang & Kuhnert, 2009)

The most notable strategy discussed in the literature review were (a) the 4-D Leadership System, (b) the Myers-Briggs Type Indicator (MBTI), (c) Big Five Personality Traits, and (d) Bass Classification of Leadership.

The leadership style classification strategy chosen for use in the current study was based on the following criteria: (a) the ability to categorize engineering leadership using leadership classification styles that tie meticulously to existing innovative and technical project approaches, (b) the ability to evaluate engineering leadership styles for engineering-based project phases, (c) the ability to recognize the effects of leadership types on engineering and technological teams and projects, and (d) the ability to realize the technological leadership frame of reference and recommend the appropriate leadership styles in that circumstance.

Based on the identified selection benchmark, the 4-D leadership system was chosen for application in this research. The 4-D leadership system emulates engineering-based project phases from the earlier stages of brainstorming and design, to the development of a specific prototype and the marketing of an actual product, which includes its maintenance and modification. The 4-D leadership system's distinctive methodology of classifying the information objectivity and deciding prospective is incomparable in discerning the nature of engineering creative thinking and intrusive decision making. Pellerin (2009) indicated that some technical projects need a certain type of leadership and that if a leader's style is incompatible, the team and the project will fail. Pellerin further explained, illustrating the advantage of each leadership style of the technical teams, stating: What is that Greens and Yellows leaders contribute to technical project teams? Green and Yellow leaders rooted values and relational skills benefit people collaborating. They also offer important diversity in judgment that improves decisions. An Orange leader excels in tasks that necessitate management abilities as in planning, organizing, directing, and controlling. Blue leaders are considered visionary who excel in tasks where concept mastery and creativity matter most. Pellerin (2009) specifically classified the best leadership within the same engineering project design and implementation, providing the following example: Imagine constructing a house or adding a room to your house. Your desire would be to have a Blue innovative architect having free-range during the planning phase. Naturally, you would prefer to have your Orange manager who is also a builder, inspect and review your design to substantiate efficient and achievable construction. Once the design is finish, you would ultimately turn the job over to your Orange manager for the construction phase of the project.

The 4-D leadership system was originally designed to categorize technological and engineering projects and assist to identify the best leader for a specific project. In his book focused on NASA's teambuilding skills, Pellerin (2009) designed the 4-D leadership system to prevent engineering leadership failure. During Pellerin's tenure as a manager at NASA, he witnessed the Hubble telescope failure in its first mission. The failure of the Hubble was attributed to leadership rather than a technical issue. Pellerin argued by applying a rigid and forceful leadership style would cause the contractor to meet the schedule, stay within the budget and have a successful project. His book captured technical audiences because technical reasoning developed the processes it exemplifies.

The 4-D leadership system has an apparent, accurate and manageable approach in evaluating leadership. Pellerin (2009) stated that the 4-D coordinate system "simplifies the key components of high-performance teams and effective leaders." Both the 4-D system and Myers-Briggs Type Indicator (MBTI) originated from Jung's classification of personality types. The 4-D leadership system correlates leadership applying four (4) leadership styles that can be competently surveyed. In contrast, the MBTI uses a more robust system of sixteen (16) styles to identify leadership and personality that is not as conducive to assess progress. Another essential consideration in choosing an assessment system is its aptitude to meticulously evaluate the engineering and technological leadership for teams and projects. 4-D has the capability of selecting the best leader for any engineering project team. Dr. Anthony J. Calio, former vice president and general manager of the Raytheon Corporation, observed: "The 4-D assessment methodology, honed through fifteen (15) years of teambuilding with NASA project, engineering, and management teams, has the potential to improve team performance in almost any enterprise." Pellerin (2009) articulated the importance of discerning cultural norms and social behaviors which are seldom unnoticed in technical projects, and yet can play a crucial role in their prosperity. Also, Pellerin proclaimed that the 4-D system has been used for more than 2,000 workshops and it had a track record of more than 90% veracity in envisioning leadership styles. The 4-D Leadership System is not a novel classification apparatus in leadership. It is quite complementary in configuration to other protocols such as the Myers-Briggs Type Indicator (MBTI) that are currently on the market for application in personality/temperament and individual/group compatibility training (D. Hollister, personal communication, December 23, 2015). Both the 4-D Leadership System and the MBTI are based on Jung's paradigms. The 4-D test has been executed on copious occasions by private and government agencies according to Pellerin (2009), which has led to extensive productivity for managers/supervisors/employees. The 4-D is a method and tool that furnishes a useful investigation to institute leadership skills training to students in an undergraduate engineering program.

4.3.1 4-D Engineering Leadership Trial Study

Discerning and taking into consideration a suitable leadership classification scheme for engineering students, the researcher administered a trial study in two engineering programs in the central Florida area of the United States. The motivation of the trial study was to become comfortably acquainted with the 4-D leadership system. Approximately 110 undergraduate engineering/technical students took the 4-D leadership test and the results are illustrated in Figures 17, 18 and 19.

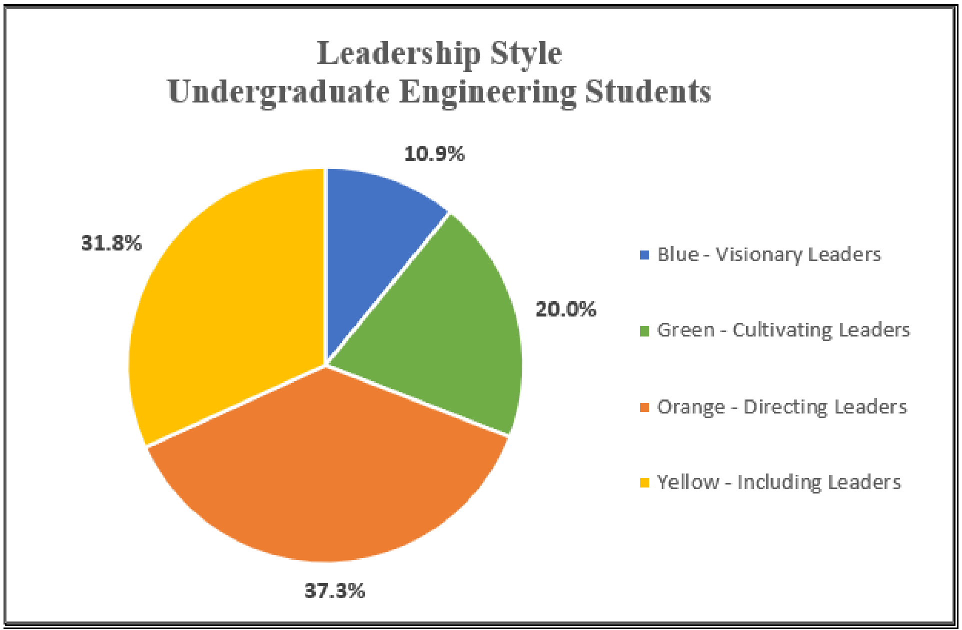


Figure 17: Pilot study: Leadership Style of Undergraduate Engineering Students

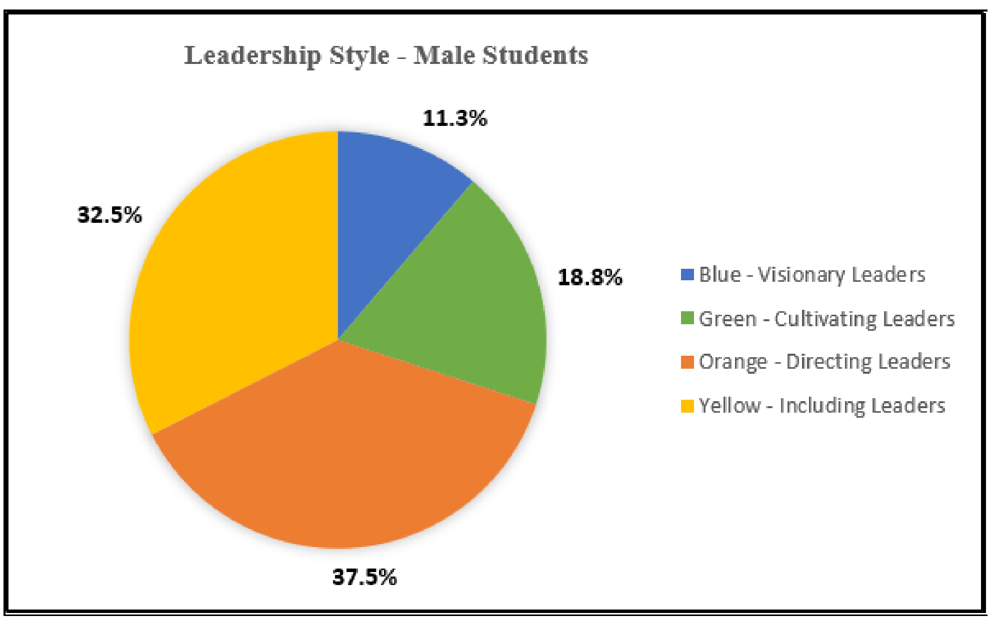


Figure 18: Pilot study: Leadership Styles of Male Engineering Students

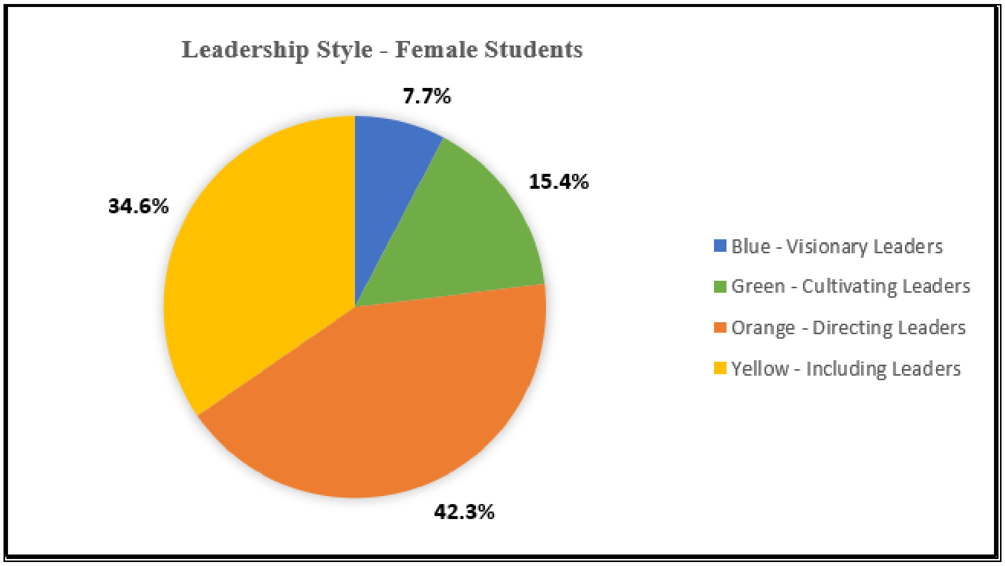


Figure 19: Pilot study: Leadership Styles of Female Engineering Students

The results of this trial study displayed less inclination for visionary leadership for undergraduate students correlated to the other three leadership types. Figure 18 displays that male students had a higher proclivity than female students toward directive leadership style by almost 5%. In comparison, female students tended to use including leadership more than male students by 2%. In general, in the relevant area studied in this trial study, undergraduate engineering students had a partiality to be more systematic (directive) in their approach to problem solving. This indicated the commitment for development to create effectual leaders.

4.3.2 Effective 4-D Leadership Style and the Phases of a Technological Project

Engineers function in teams. Therefore, team leaders must be persuasive and efficient. Pellerin (2009) stated emphatically that teams must be well-rounded (to be effective) to perform well in complex engineering projects. Pellerin stated that “early phase” project teams should be mostly blue. These creative idealistic builders execute trade studies comparable which are alternatives to out-of-the-box thinking. He also indicated that “Great scientists and engineers are usually logical deciders.” Pellerin revealed the theory that innovation, creativity, critical thinking and observing the holistic picture are visionary leadership skills; and beyond developing these skills, engineers would perform only technical skills in the decision making and strategy-creation procedures. Pellerin’s (2009) classification of leadership styles are shown in Table 11. Pellerin also observed that directive (Orange) leadership style is essential in “taking action--organizing and directing others.” Directive leaders have the capacity to move the performance ahead expeditiously with discipline, process, and assurance of outcomes. The relevance of Yellow (including) leaders happens when the relationship and teamwork imply the utmost. He stated, “I believe including leaders are the best leaders of the largest and most complex project teams. The Green who exhibits a cultivating personality performs best in jobs where caring about people matters most. They frequently provide training and coaching” (Pellerin, 2009). Being able to achieve all the leadership styles in a team or on an individual basis in a balanced manner is considered the best and effective leadership.

Table 11: Pellerin's (2009) Classification of Leadership Styles

Leadership Style	Leadership Dimensions	Technological Leader Strength and Capacities of Teams and Individuals
Visionary Style (BLUE)	Information: Intuition → Deciding: Logical	Logical and intuiting (also called the visioning dimension) depends on thinking about the future. Visionary leaders are influential leaders and usually initiate the things they want. They specialties are invention, creativity, patent, and design.
Cultivating Style (GREEN)	Information: Intuition → Deciding: Emotional	Emotional and intuiting (also called cultivating dimension) promotes positive feelings and accomplishing a world that is prosperous, and sincerely caring about each other and a sincere concern for humanity.
Directing Style (ORANGE)	Information: Sensing → Deciding: Logical	Logical and sensing (also called directing dimension) stimulates taking charge and directing others. Planning, organizing managing, directing, and controlling, productive and efficient are some actions of this type of leadership.
Including Style (YELLOW)	Information: Sensing → Deciding: Emotional	Emotional and sensing (also noted as the including dimension) relies on the emotional capabilities which come from relationships and how we communicate with other people. Fostering the communication and relationships with others and conflict intolerant.

4.4 Preliminary Experiments with Virtual Reality

The researcher participated in a research with Almalki (the leaser of this research - A Holistic Framework for Effective Engineering Leadership Development Using 3D Virtual World Simulation). A virtual reality system was developed and chosen to be the virtual world platform and tested with OpenSimulator (OpenSim). The objectives were to develop a green house. In this virtual leadership activity, each team has a region where all team members actively negotiate with their leader (CEO of the smart home company) to choose the best vision, mission, and goals for their future company. Each of the possible four visions, four missions, and eight goals are reviewed during the selection process. To begin the decision negotiation circle activity, all members of the team stand on their team's name square and start by considering the Vision #1 statement. The team repeats the following process to choose the team's vision, mission, and three goals as shown in Figure 20.

Figure 20: Sample of vision statements used in the virtual simulation activity

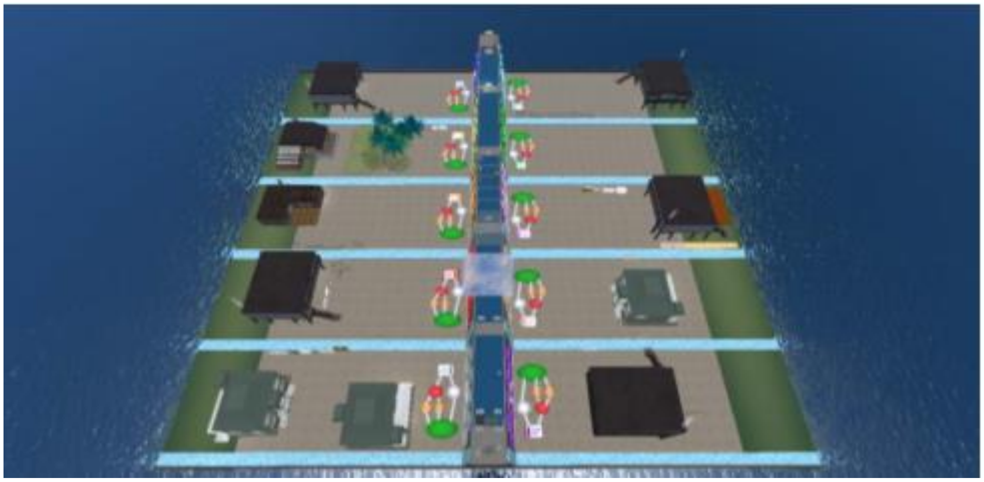


Figure 21: Top view of the virtual simulation area

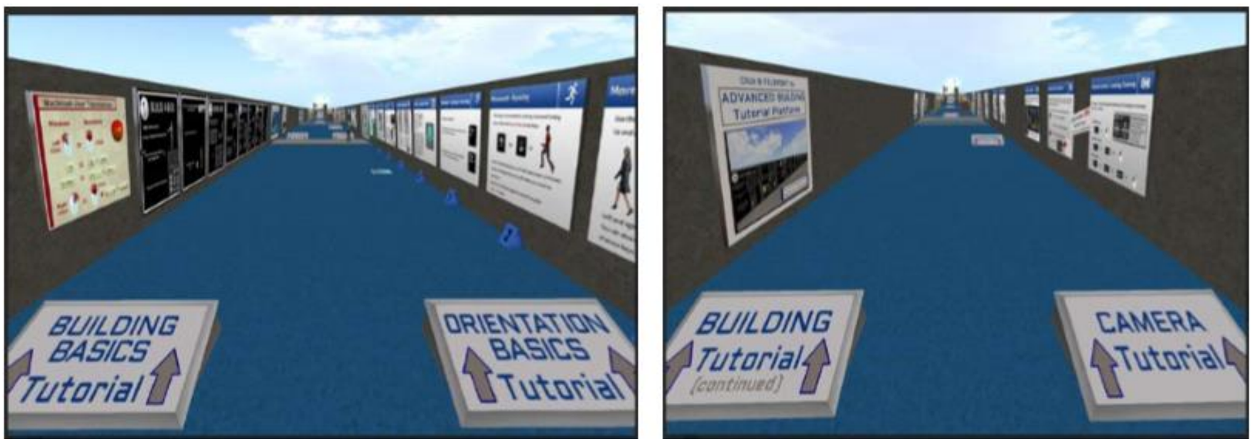


Figure 22: Virtual world tutorial and training

Figure 23: Team 9 virtually shopping for a house based on their vision, mission, and

goals

There were some modifications made to the investigation to include systems engineering and a virtual environment where students use similar concepts, however, they would select a science fair project and brainstorm how they would work effectively as a group and individually to complete the assigned talk in the environment. (This data is not included in Almalki's work)

A total of 160 undergraduate engineering students were randomly invited: 80 in the experimental group and 80 in the control group. Only 84 students voluntarily responded to participate in this project: 42 in the experimental and 42 in the control group. All members in both were randomly selected. In this experiment, both groups (experimental and control) were given the exact same pretest. After the pretest, the experimental group was subjected to the experimental treatment which included 3D virtual leadership simulation. In contrast, the control group was isolated for the 3D virtual world treatment and received traditional engineering leadership development using the typical method of conducting leadership case study as a team, case study analysis lectures, report, and leadership solution presentations. The null hypothesis and the research hypothesis for teams and individuals were applied as follows:

Null Hypothesis: H_0: 3D virtual simulation will not enhance the leadership to become more effective.

Research Hypothesis: H_1: 3D virtual simulation will enhance the leadership to be more effective.

Hint, Effective Leadership Indicator (ELI) is the standard deviation between the leadership styles; and the smaller the ELI the more effective the leadership is.

H_0: μ(ELI)after−μ(ELI)before = 0

H_1: μ(ELI)after−μ(ELI)before < 0

Where μ(ELI)after denotes to the mean of ELIs posttest results team/individual. μ (ELI)before is the mean of ELIs of the pretest results team/individual. By the above test, the researcher was trying to determine if virtual leadership simulation enhanced leadership. The paired t-test was used to test the null hypothesis within the same group.

The independent t-test was used to evaluate the score difference between the experimental and control groups.

H_0: μ(ELI)after−μ(ELI)before = 0

H_1: μ(ELI)after−μ(ELI)before ≠ 0

The effect of the 3D virtual world simulation to both the team and individuals' leadership was examined. Also, the effect of the 3D virtual simulation on the traditional leadership development represented by the control group was examined. The statistical analysis determined the significance of each method in enhancing the engineering leadership development. As shown in Table 12, there was a significant statistical evidence that the null hypothesis must be rejected for the experiment group because the p-value (.010) was less than the significance level (.05). Regarding the control group, no significant change occurred between the pretest and posttest. These analyses proved that the 3D virtual leadership simulation was more effective in enhancing engineering leadership. As shown in Table 13, the same findings were determined to be true between the control and the experiment group using an independent t-test. Snapshots of the virtual environments are shown in Figure 24,-

28.

Table 12: Analysis of the Average Team Leadership Skills:

4-D Leadership System - Paired t-test

	Experiment Group		Control Group	
Paired t-test To assess the before and after within the same group	**Pretest**		**Pretest**	
	Mean (SD)	0.1418 (0.0578)	Mean (SD)	0.1200 (0.0656)
	Post-test		**Post-test**	
	Mean (SD	0.0885 (0.0675)	Mean (SD	0.1525 (0.0607)
	Difference		**Difference**	
	Mean (SD)	-0.0533 (0.0594)	Mean (SD)	0.0325 (0.0622)
	Significance, P-Value	T-Value = -2.84 P-Value = 0.010	**Significance, P-Value**	T-Value = 1.65 P-Value = 0.933

Table 13: Analysis of the Average Team Leadership Skills:

4-D Leadership System - Independent t-test

		Experiment Group Mean (SD)	Control Group Mean (SD)	Significance, P-Value
Independent t-test to evaluate the score difference between the Experiment and control	**Pretest**	0.1418 (0.0578)	0.1200 (0.0656)	T-Value = 0.79 P-Value = 0.441
	Post-test	0.0885 (0.0675)	0.1525 (0.0607)	T-Value = -2.23 P-Value = 0.039

Figure 24: Team Decisions Smart Home View 1

Figure 25: Team Decisions Smart Home View 2

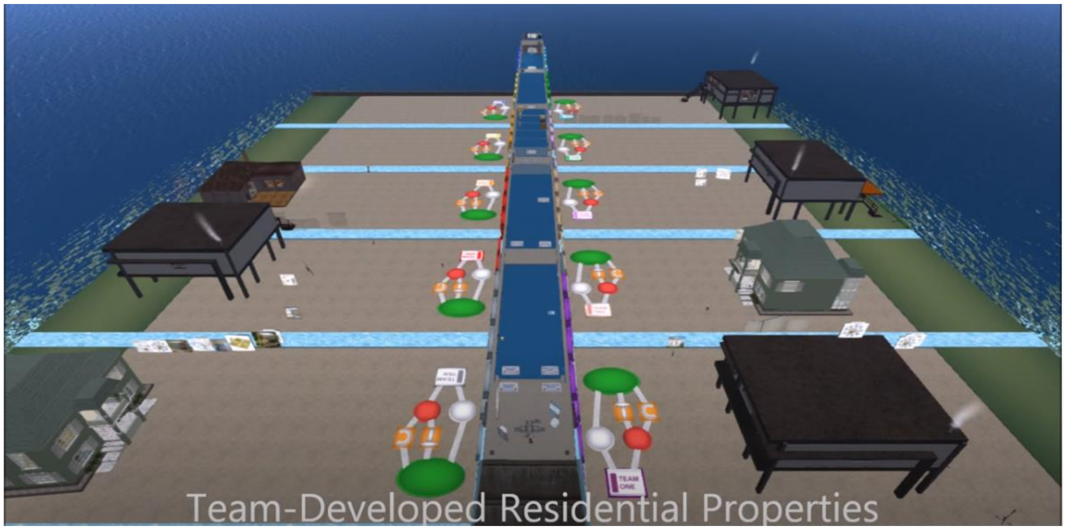


Figure 26: Overview of The Virtual World 1

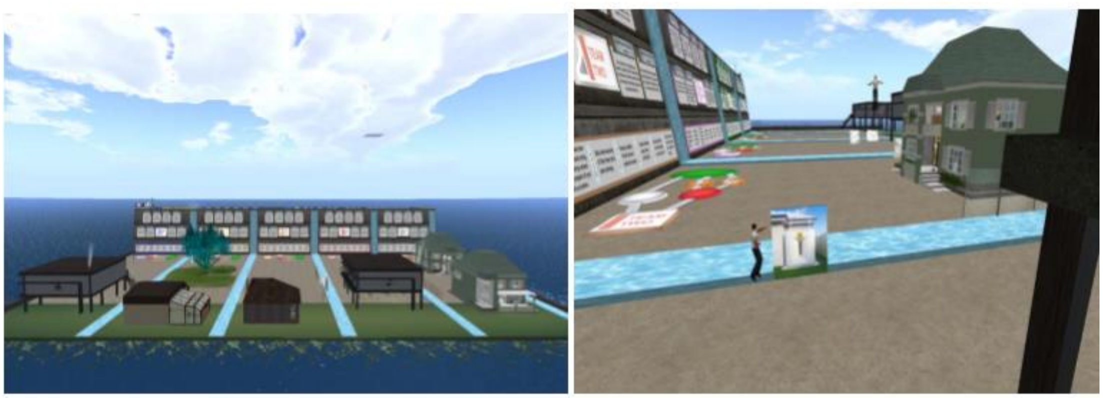


Figure 27: Overview of The Virtual World 2

Figure 28: Overview of The Virtual World 3

4.5 Senior Design Test

Senior design is the capstone course for the Industrial Engineering bachelor's degree at the University of Central Florida. We conducted surveys by having the students complete the 4-D system leadership foundation test was used to identify the leadership style/color for undergraduate engineering students. In the Senior Design course, students were assigned companies to meet with throughout the semester to design a project related to their specific discipline and report out in both written and verbal presentation their findings. We were expediting changes, however, no changes occurred. This was done in two (2) consecutive terms.

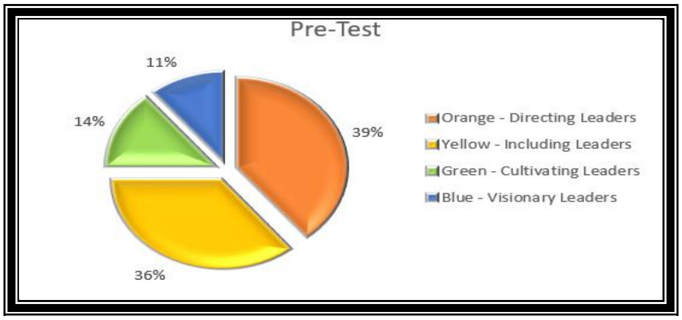


Figure 29: Pre-Test results of the 4-D survey

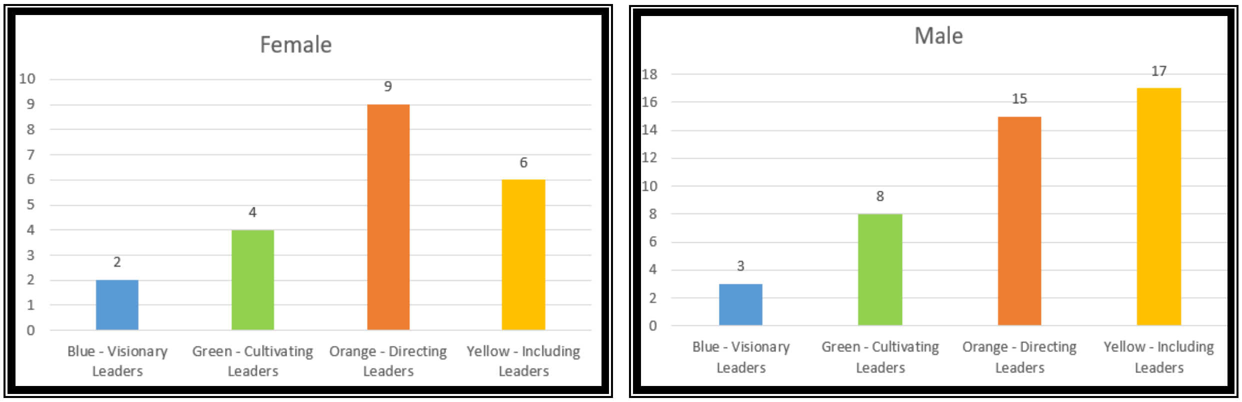


Figure 30: Pre-Test Male and Female results of the 4-D survey

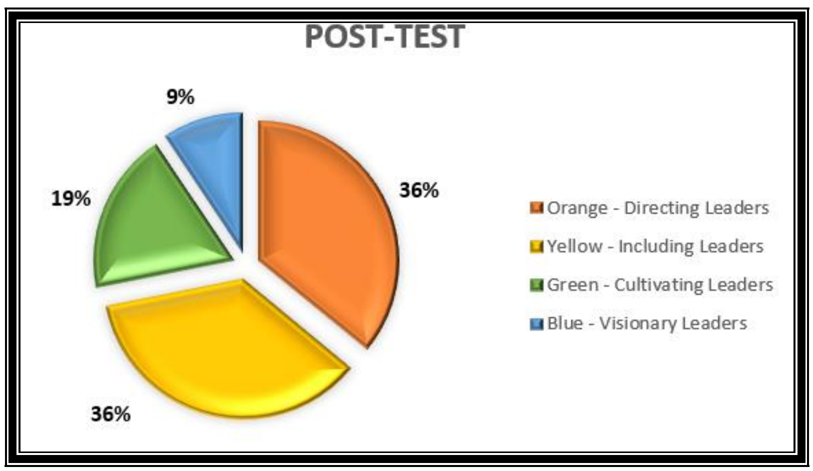


Figure 31: Post-Test results of the 4-D survey

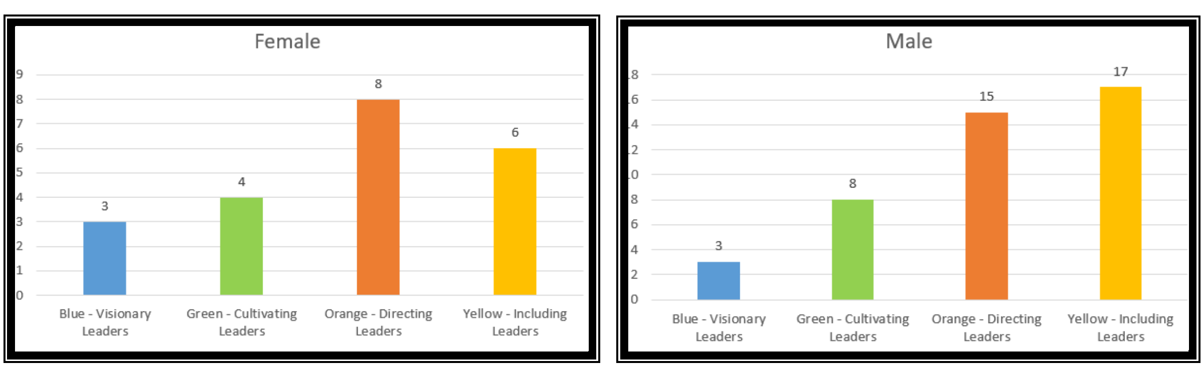


Figure 32: Pre-Test Male and Female results of the 4-D survey

Table 14: Results of 4-D Leadership Surveys (Pretest and Post-test)

	Pretest		Posttest				
	Mean	St Dev	Mean	St Dev		2 sample t-test	
Emotional	3.63	1.45	3.6	1.5		p = 0.91	t = 0.12
Logical	3.4	1.5	3.41	1.57		p = 0.97	t = -0.04
Intuited	2.58	1.51	2.61	1.6		p = 0.91	t = -0.11
Sensed	4.49	1.5	4.44	1.59		p = 0.86	t = 0.18

As shown in Table 14, there was not a significant difference in the scores for the Emotional Decider pretest (M = 3.63, SD = 1.45) and post-test (M = 3.6, SD = 1.5) conditions; t (64) = 0.12, p = 0.91. There was not a significant difference in the scores for Logical Decider pre-test (M = 3.4, SD = 1.5) and post-test (M = 3.41, SD = 1.57) conditions; t (64) = 0.04, p = 0.97. There was not a significant difference in the scores for Intuited Information pre-test (M = 2.58, SD = 1.51) and post-test (M = 2.61, SD = 1.6) conditions; t (64) = 0.11, p = 0.91. There was not a significant difference in the scores for Sensed Information pre-test (M = 4.49, SD = 1.5) and post-test (M = 4.49, SD = 1.5) conditions; t (64) = 0.18, p = 0.86. This is evidence for the need to develop and create effective leaders.

4.6 Summary

The prospective investigation that take advantage of a well-perceived methodology and was delineated to provide more practical leadership development for undergraduate engineering students was introduced in this chapter. The 4-D leadership system chosen to be utilized to categorize the engineering leadership over other leadership classification schemes was explored. The results of the 4-D leadership system pilot survey that was conducted to check the effectiveness of this strategy and evaluate the leadership styles for undergraduate engineering students was also shared. Finally, the implementation of the virtual world simulation that have been victoriously used as a mechanism of education and pedagogy were identified.

- A classification strategy should be appropriate for engineering to yield assessments and support the development of the education and training material. The 4-D leadership system was determined to be the utmost relevant for engineering leadership development.
- The classification strategy should support team and individual development, and the 4-D leadership system was equipped to be pertinent in this regard.
- The classification strategy should manufacture an environment that supports leadership development. In the nonexistence of experiential learning, application of virtual world simulation, which incorporates a set of innovative science fair projects, is most auspicious.
- The chapter mentions two (2) other studies, one done with a previous dissertation from Dr. Almalki where after completing all the experiment steps and procedures and having the students conducting the 3-D virtual leadership activity, conclusions were drawn based on the results of the virtual world leadership experiment. Because of Dr. Almalki's study and the researchers with his mentor in Senior Design, subsequent researchers should have a clearer vision in expanding engineers as leaders, using improved techniques and efficient approaches.
- This set the motivation for the work of this dissertation.

CHAPTER 5: SYSTEM ENGINEERING AND VIRTUAL WORLD DEVELOPMENT

5.1 Brief Introduction

This research uses the Systems Modeling Language (SysML) to design and support the development of a system by using best practices and opinions of experts. By applying the conversion of requirements into useful information for the development of the virtual world is one of the prime objects of the tools used in the process. Being aware that some systems may be complex, the purpose is further augmented with a desire to represent the information retrieve from SME's to make sure that it can be accessible and comprehensive. The importance of representation as it relates to the system is to make sure that it is easily understood primarily with the fact that as the stakeholder, we want to make prompt and appropriate decisions directly related to understanding the available information. Therefore, this chapter presents SysML and the best practices utilized in order to build the Virtual Environment.

5.2 Systems Engineering (SysML)

SysML was chosen because of its universal purpose and graphical modeling language to capture and convey information about the system and the guidelines receive from the SME's to produce specifications for the virtual world environment. Another reason for the selection of SysMLwas due to its ability to consider a large number of input variables, operational scenarios in a repeatable, controlled environment. Another benefit of SysML is the use of a standardized modeling language that imposes a standard convention, so it does not matter which diagram the stakeholder is looking at, the meaning of each symbol on the diagram is unambiguous. It is also essential to make sure that there is consistency across all the views, mainly since the system inevitably changes over time.

In this research, we utilize systems engineering to capture guidelines from psychology and concepts of technological leadership. These guidelines are converted into requirements and technical specifications (using SysML) of virtual simulation environments (built-in OpenSim). Then, this virtual simulation environment is used to test subjects and see potential changes in leadership skills.

5.3 Subject Matter Expert (SME) Guidelines

It is vital to acquire the knowledge of a subject matter expert (SME) to build the virtual simulation environment in OpenSim. The psychologist (SME) perspective provided information on how knowledge is represented and organized in long-term memory, and this was very important related to the research primarily because it has implications for interface design and the design of the group tasks within the virtual world environment. The discussion of how to make use of relational knowledge to solve specific problems in the virtual world in the form of mental models provided great recommendations on how the elements are within the virtual world environment. It was crucial to extract the domain knowledge from the psychologist (SME) and represent that knowledge. The SME also demonstrated greater flexibility in their use of mental models than do novices. The SME explained that the user of the system could perceive an environmental input to a physical system, “run” the mental model of system dynamics based on that input and predict system output, which is likely confirmed by the system response to the actual output as displayed in Figure 33.

The mental models may sometimes be inaccurate, which is why it is advantageous to create a correct mental model by explicit training on the underlying causal structure and principles operating the system and procedures used to manage the system in its visible controls and displays. The SME expressed emphatically that training through a mental model has benefits.

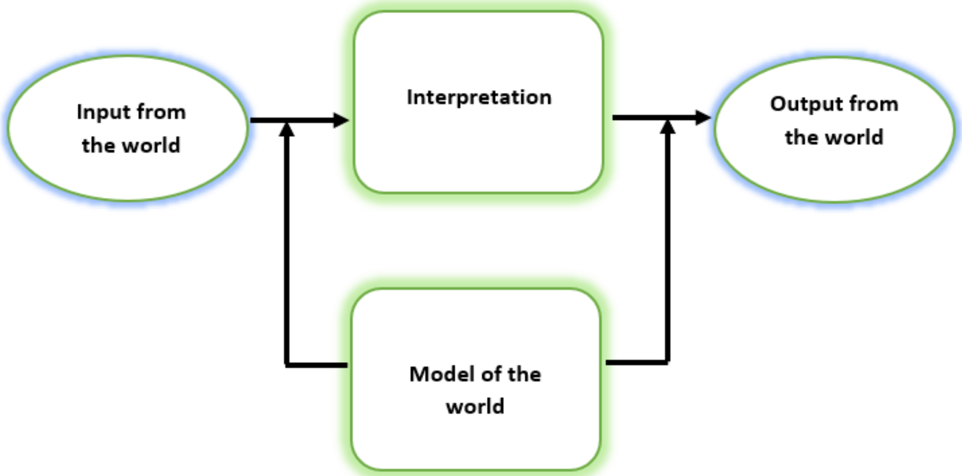


Figure 33: Model of the world with input interpretation with output.

Another SME that was extremely important to the research is a system engineer who provided me a wealth of information and guidelines regarding SysML. One of the great benefits of using SysML is the ability to easily see how changes or scenarios affect the system within the virtual world. To maximize this benefit, keep consistent variables, actors, and links throughout the model. The SME encouraged to follow simplicity. Like writing software code, it takes longer to create an elegant and easily understood model, but in the long run, it is worth it and stressed to document everything. The system model must be kept up to date through the entire lifecycle of a product, and it must be very well documented to be maintainable.

The SME's guidelines stressed the importance of not skipping steps. What seems tedious when developing the model (e.g., repetition) is vital later in design, and the first step is always requirements. The system must have a well-derived requirements tree that lives along with the model. In addition, it is often the most innocuous use cases that end up causing trouble. To simplify sequence diagrams, the SME recommended using "Alt" configurations for when an action has alternate paths. And of course, everything is iterative- so when updating the model, remember to touch all parts of it (starting with requirements) to ensure concurrency.

5.4 SysML Utilization

Modelio (https://www.modelio.org/) was the platform to be used to create our SysML diagrams to support the design of the virtual environment. The diagrams of SysML have been created to convert desires and requirements into a set of system product and procedure descriptions, produce statistics for decision-makers and furnish input related to the Virtual environment. The technique is tailored sequentially one stage at a time, enumerating additional detail and definition with every level of development. The output of every application diagram is the input to the next procedure of the Virtual World environment.

One of the diagrams is the activity diagram. An activity diagram is a form of a behavior diagram; it is a dynamic view of the system that conveys sequences of behaviors and events occurrences over time. Activity diagrams have strengths and weaknesses that may be perceived as attractive based totally on the requirements of the select audience. Activity diagrams can express complex control logic higher than sequence diagrams and state machine diagrams. An activity diagram is especially good at communicating the movement of objects, matter, energy, and statistics via a behavior, with a focus on how the items may be accessed and modified within the execution or that behavior during system operation.

Frequent utilization of an activity diagram in SysML includes but is not limited to:

- Activity diagrams are generally utilized as an analysis tool to understand and demonstrate the desired behavior of a system.
- Activity diagrams are regularly used to create graphical use case specs, which tend to be more concise and less ambiguous than the conventional text form of a use case specification.
- Also, an activity diagram is likewise a conventional technique to dissect a single-use case specification, either a text specification or an activity diagram, and subsequently for generating a set of sequence diagrams, one per pathway (scenario) displayed in Figure 34.

The activity diagram in Figure 34 was developed to meet the requirements and specifications to build the virtual world environment to test and assess behaviors and attitudes. After obtaining the guidelines, converting them into requirements and specifications using SysML of virtual environments constructed in OpenSim will provide me deliverables based on the assessments to observe the potential changes in leadership skills.

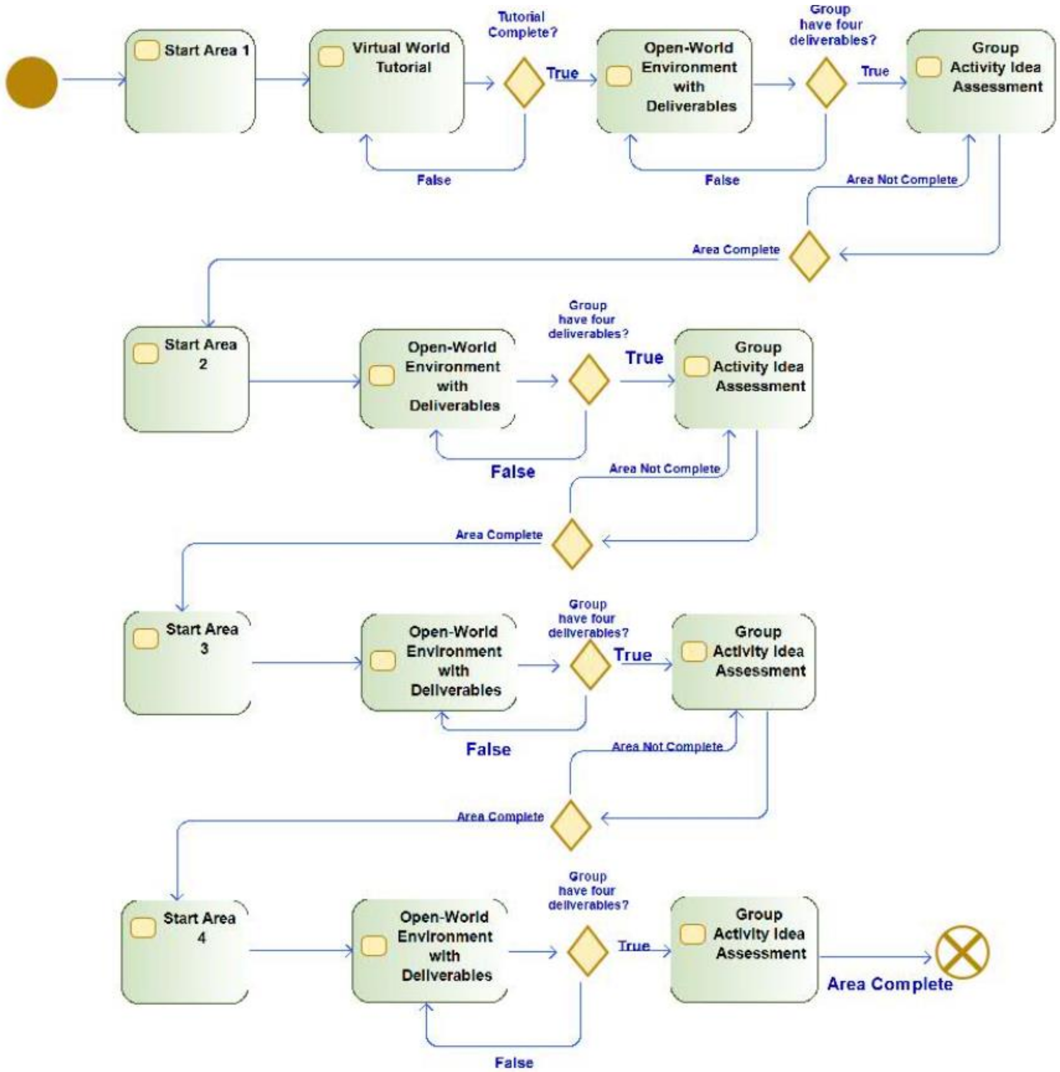


Figure 34: "Activity Diagram" depicting the different areas and their sequence

This activity diagram developed in Figure 34 shows the various areas within the virtual world, deliverables, and activities associated with each area of the environment and the effectiveness of each group's activity assessment being completed before moving to the next area. There are four areas recommended by the SMEs, starting with a tutorial, the number of deliverables, and the group activity idea assessments. This level shown in Figure 34 can have other nested levels. These four areas the results with discussions with the SMEs. Four regions to stimulate visionary ideas and behavior, discipline, creativity, team engineering culture, and self-reflection (meditation) were modeled.

Another necessary diagram from SysML is the case diagram. The use of a case diagram (notation: oval/ellipse) represents as displayed in Figure 35, a system arrangement with an external system user, referred to as an Actor (notation: designated by a stick-figure). These cases are every so often considered high-level functional requirements.

Case diagrams indicate communications amongst system transactions (Use Cases) and external users (Actors) within the context of a system boundary (Subject; notation: designated by a rectangle). Actors may additionally constitute wetware (persons, organizations, facilities), software, and hardware systems. Defining relationships and the system Actors is an effective informal manner to define system scope. The purpose of Use Case diagrams is to supply a high-level view of the subject system and indicate the critical system requirements in non-technical terms for all stakeholders, including clients and project executives, as well as architects and engineers.

The stakeholders of Figure 35 include the moderator, user, and the developer of the virtual world environment. When developing the case diagram, the independence of the researcher as the moderator, the user (test subjects), and the developer of the virtual world must have the capability of collaborating in the virtual environment.

The user (test subjects) and the virtual environment must react sensibly to a significant level of activities. These levels of activities will assist the moderator in verifying the guidelines provided by the psychologist and concepts of technological leadership to test the behaviors and attitudes of the user.

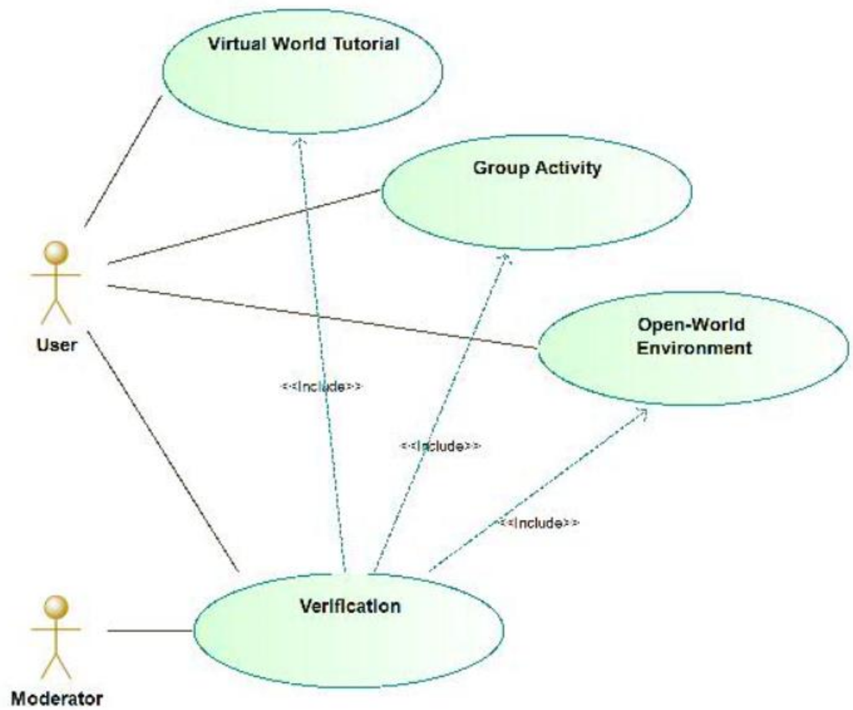


Figure 35: Case Diagram that includes the moderator and the user.

Figure 35 shows the relationship and communications with the researcher (user) and the OpenSim developer (moderator) and how the development of the Virtual World environment is executed with tutorials, group activities, and everything is verified and validated before the execution of commencing the virtual reality experience. There were several case diagrams developed that include other relationships.

SysML uses the concept of the block as the fundamental unit structure to symbolize hardware, information, personnel, software, procedures, and facilities. A Block diagram is used to represent a system. The block diagram in Figure 36 constitutes the Avatar classes, deliverables describing the datatypes, networking, and simulation class (es) integration into the Virtual World, and both input and output Event Manager class (es). The structure proceeds from Area1 through Area 4 in the Virtual World to disseminate video data type(s) output.

We need to be assured the flow of various classes (avatar, OpenSim Virtual World Integration, Networking, and Simulation, the input and out EventManager(s)) are sequentially aligned and providing deliverables and video datatypes to each area of the Virtual World. Any interruptions to this flow may have a potential impact on the classes and datatype(s).

The system must advance from Area #1 (Innovation Theatre) to Area Room #4 (Think Tank Brainstorm Room) in the Virtual World environment to disperse the video datatype(s).

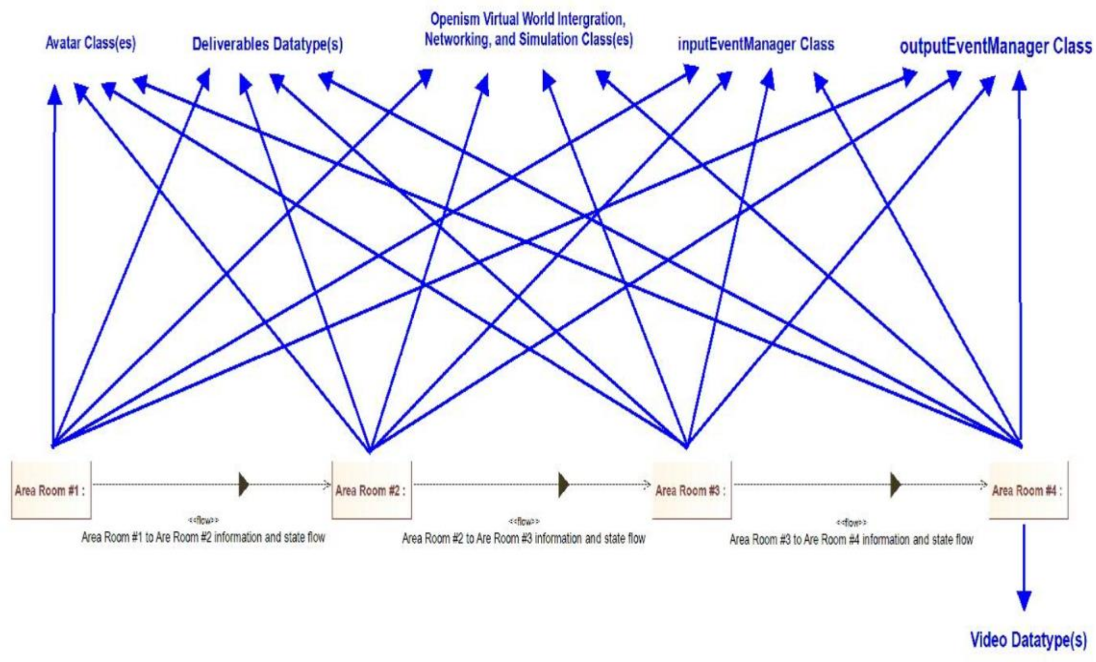


Figure 36: This Block Diagram displays the different relationships between the avatar classes and other vital elements.

Figure 36 displays the different relationships between the classes of the avatar, deliverable, Opensim Virtual World integration and networking, and simulation and inputEvent and output eventManager executes the video datatype(s). Blocks can be defined further to show devices, software, and hardware.

The Sequence diagram in Figure 37 is used to show the interaction among the users, screens, objects, and entities with the system. Sequence diagrams are excellent as displaying which objects communicate with other objects, and what messages trigger those communications. A message (notation: designated by using an arrow) represents verbal exchange from one object to another, with the expectation that a beneficial behavior will ensue.

Messages may be synchronous (notation: open arrowhead) or asynchronous (notation: designated by black-triangle arrowhead). The sequence diagram is a dynamic behavioral diagram that suggests collaborations amongst distributed objects or services through sequences or messages exchanged, along with corresponding (optional) events.

The sequence diagram within the Virtual World must assimilate with the user, objects within the environment, the server, and all group activities. The virtual tutorial provides an abundance of information to each user (avatar) that enters the Virtual World environment. If this tutorial is unsuccessful, the experience may be compromised according to the guidelines and specifications created for the Virtual World environment, thus, having the user repeat the tutorial to confirm and understand the importance of communication between objects through progression or exchanging messages and interrelated events.

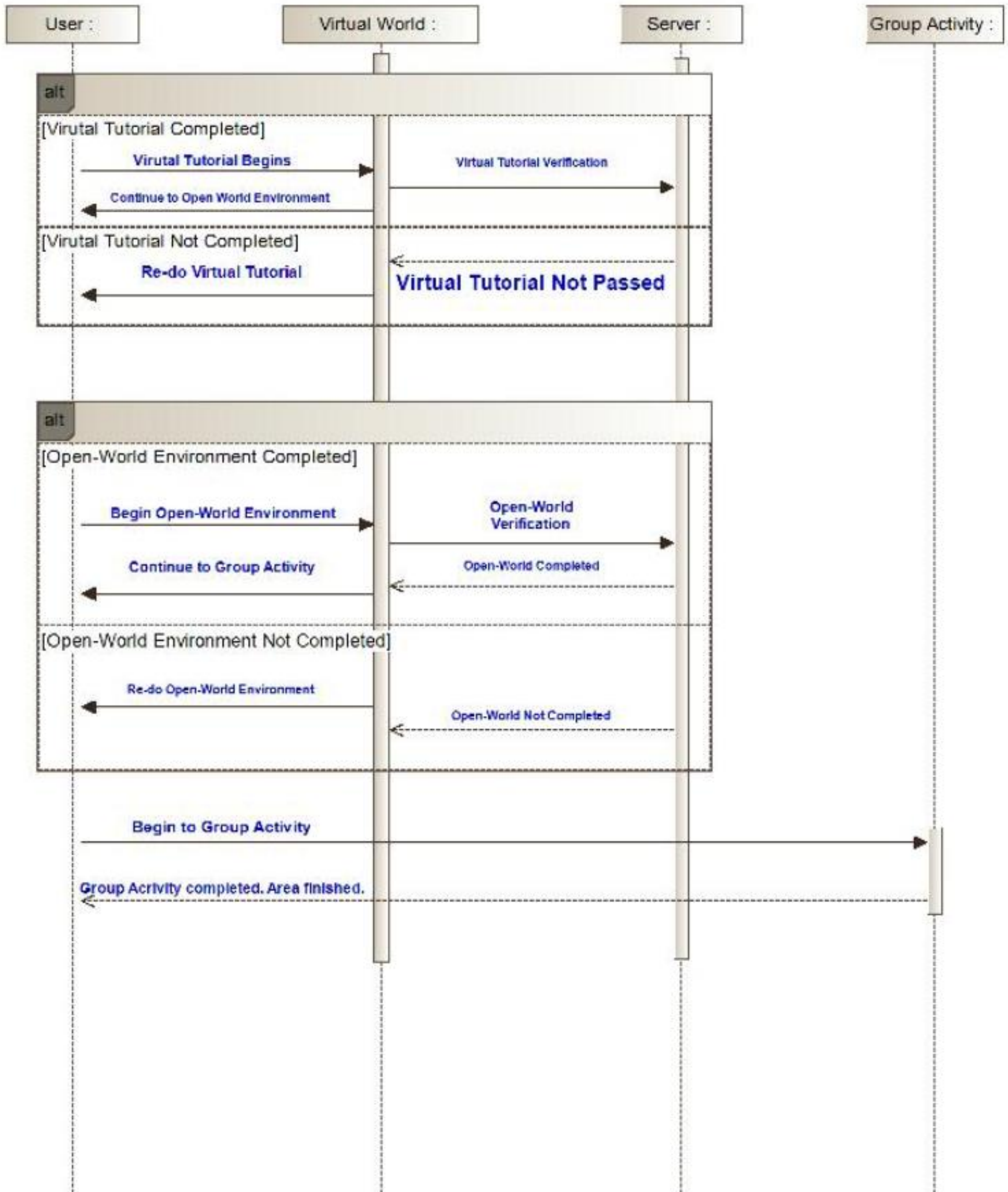


Figure 37: Example of Sequence Diagram developed to show the respective sequences of user, virtual world, server, and group activities.

Figure 37 shows the sequence of the user, virtual world, server, and group activity and how they interface with each other via communication. This diagram shows the interactions (in particular order) among the users, screens, objects, and entities with the system. Its benefits are exceptional by showing via notation and ensuing behavior and its interaction with another object within the world.

Figures 38 and 39 show products of these diagrams already transformed into a virtual world and ready to be used by this research. The different areas to be described later in this chapter focus on the team with the respective guidance and the utilization of inspirational icons such as Steve Jobs.

Figure 38: Description of Virtual Environment Innovation & Creativity in Leadership Path and Map.

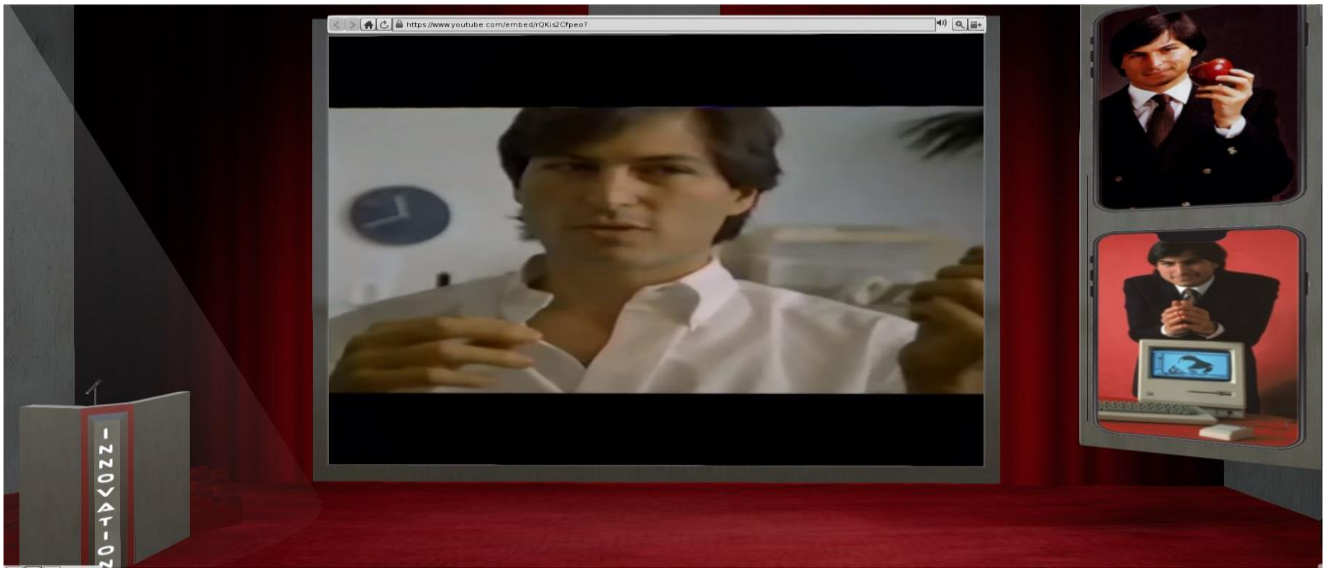


Figure 39: Description of Virtual Environment Steve Jobs Innovation Theatre

5.5 Utilization of 3D Virtual World Simulation for Engineering Leadership Development – Best Practices/Lessons Learned

For engineers to convey the intricacy of real-life scenarios to feasible techniques, they may utilize simulations. With the state-of-the-art science and technology in the computer-aided design (CAD) tools and human-computer interface (HCI) field, physical world components become accessible to replicate in a virtual environment (VE) or computer-generated or virtual world. The most recent communication services and multi-media encapsulated in virtual world platforms empower engineers to envision the natural physical environment in enhanced and advanced methods that sanction them to advance their research and design.

Experiential learning is the optimum technique of training and development. Notwithstanding real-life experiential learning, simulation provides a feasible alternative and is exceptional to the traditional face-to-face (classroom/textbook/lecture) modality utilize in many colleges and universities. Virtual environment simulation-based education not only complements conventional modes of teaching and reinforces information exchange. It also bridges the gap between content knowledge and experiential learning, and it can captivate users by creating a sense of being present in an environment (Bhide, 2015; Lemheney et al., 2016).

Best Practice 1: Avatars and the Networked Virtual Environment (NVE) Architecture

One of the best practices is to use avatars with flexibility and the Networked Virtual Environment (NVE) architecture. Using avatars as a human portrayal to interact, discover, move, and discover other people, places, and virtual projects and technology grants engineers to utilize the exhaustive benefits of the virtual world experience. Avatars are the only elements that can engage in NVE. NVE is a system where multiple, geographically distant users interact in a typical virtual environment (Tolga et al., 1999). Figure 40 describes the integrated NVE where NVE provides input and receives output from the participant who is a real person participating in NVE via an avatar (Tolga et al., 1999). The concept of NVE is used in our virtual environment.

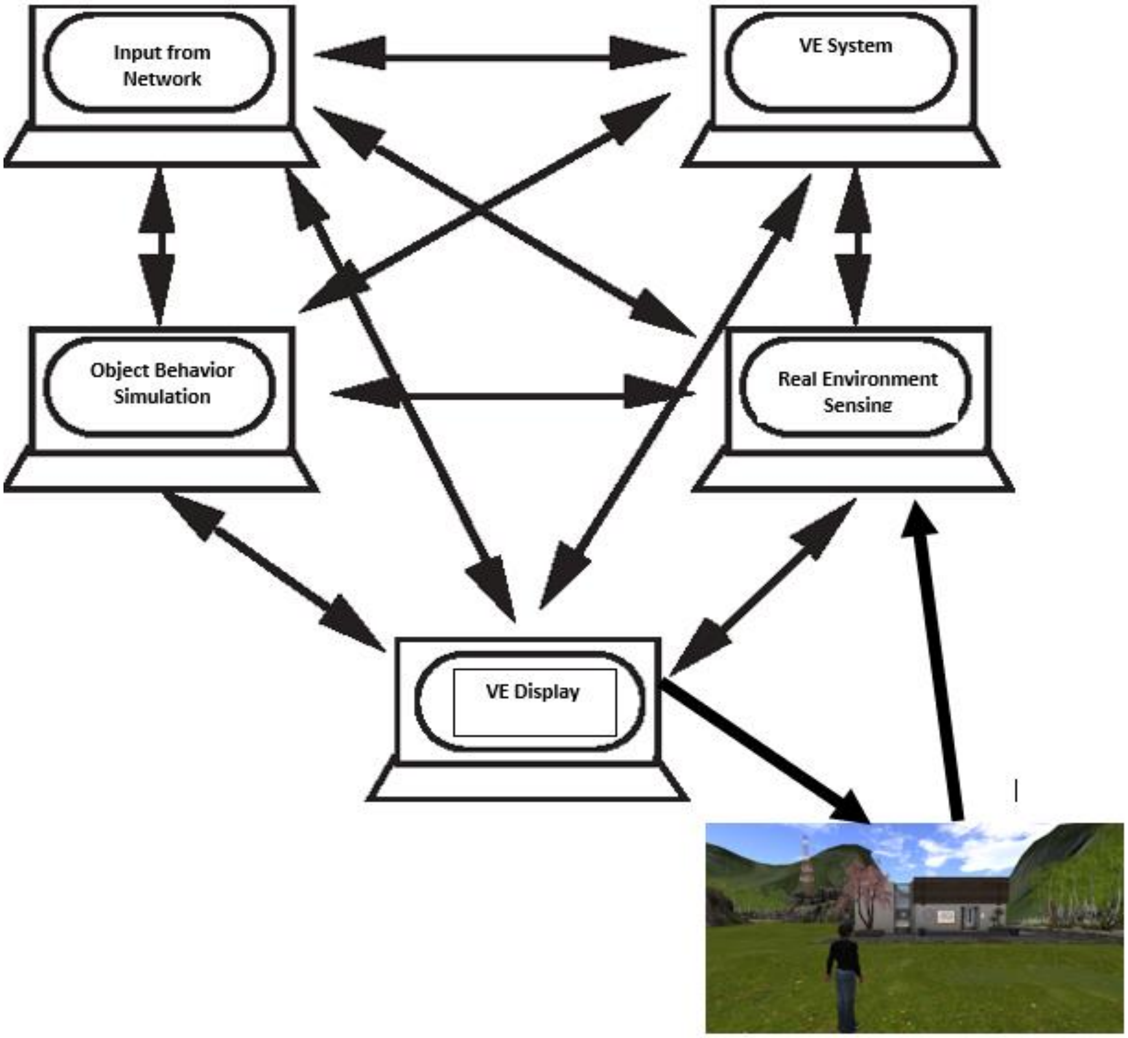


Figure 40: Integrated Networked Virtual Environment (NVE)

The avatars must have some crucial functions. The avatar(s) representation that is created in the Virtual World environment should have determining features in NVE. The avatar should be to know who else is present in the same Virtual Environment, and this should be done continuously. The position, orientation, behavior, identification, visualization of other's interest focus and actions, and the social representation of themselves are essential.

Best Practice 2: Authenticity of the Virtual World

The virtual world needs three (3) exclusive attributes to make it exceptional and more authentic. For instance, users may access personal computing resources, websites, models, and others. Secondly, avatars interact with the users, communicate, move, and change the virtual environment itself. Finally, virtual worlds, like virtual reality, are assembled in a dimensional analogy. Figure 41 shows three significant concepts from which the virtual world simulation has been developed (Martia-Isabel, 2005).

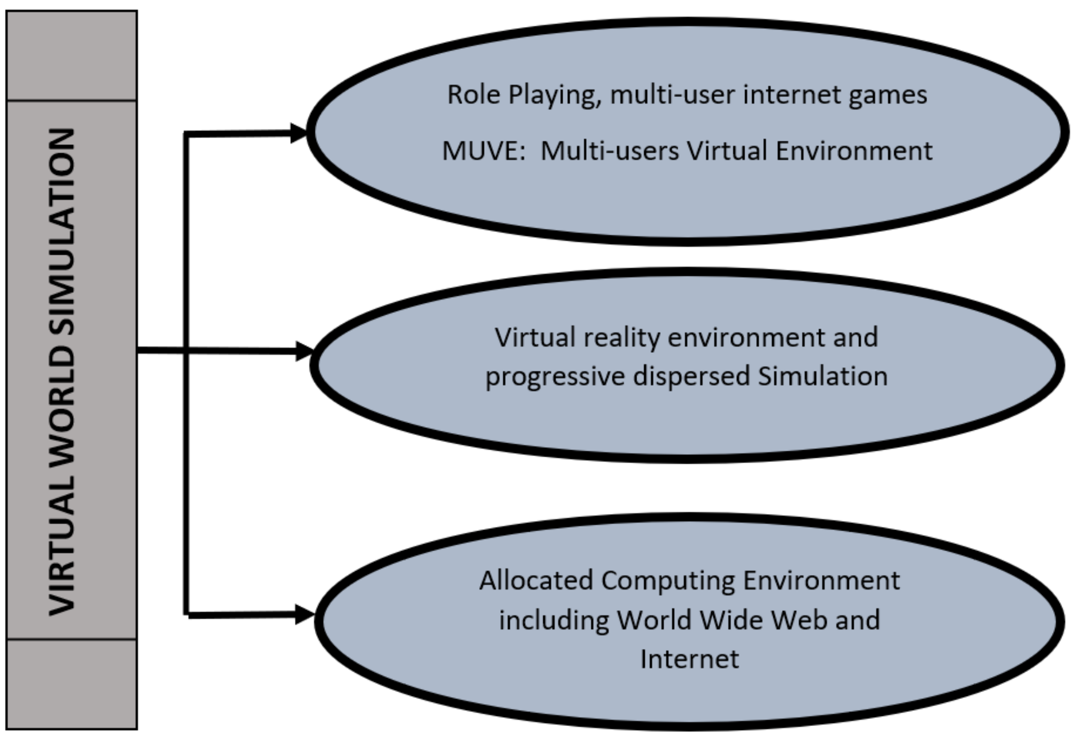


Figure 41: Original concepts behind the Development of Virtual World

Figure 42 shows how our virtual world developed is capable of having the right level of authenticity (as approved by MSEs). Our environment allows the avatars to access websites, interact, communicate, move, and change the virtual environment.

Figure 42: Team Color Track – Teleport Landing Area in Virtual World

Best Practice 3: Computation, Interaction, Geometric Model, and Presentation

Table 15 and Figure 43 comprise a portrayal and a vivid display of the virtual world as an interspersed system in which users meet, interconnect, and consort in a shared virtual platform. Comprehending these elements can illustrate the utilization of teams. In the disengaged simulation model, a virtual environment consists of four (4) components: computation, interaction, geometric model, and presentation (Stuart, 1996). Functionality comes from the application components and the different and integrated elements empowering the user. Our virtual world has this functionality and the parts with their integration.

Table 15: Description of Virtual Environment Application Components

Application Components	Characterization
Computational Model	Examining and updating the state of the computational model to send to the geometric model.
Interaction component	Managing user inputs and coordinating output to the users.
Geometric model	It receives input from both computation model and interaction model and convert them to a suitable data for display.
Presentation component	Rendering images, synthesizing audio, generating display.

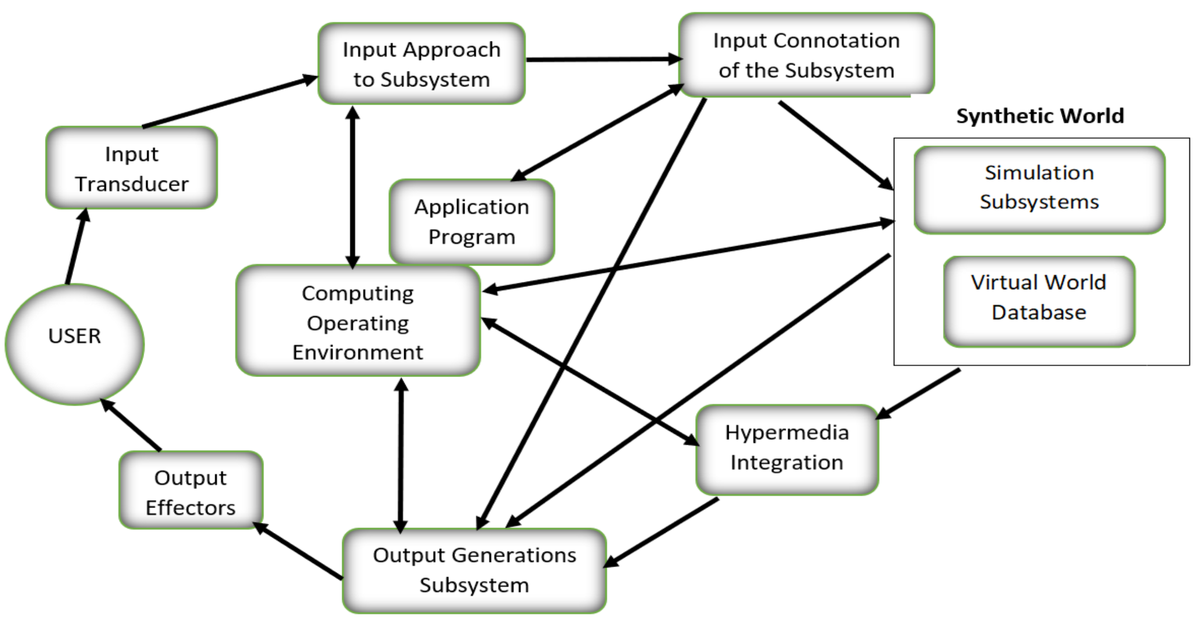


Figure 43: The Virtual World illustrated as an Integrated System

Figure 44: Entrance to Steve Jobs Innovation Theatre

Best Practice 4: Scenes and Actors

Another essential lesson learned is where Maxwell (2014) described the virtual world as scenes and actors. Scenes are data configurations that reserve and manage entities (avatars and objects) and their assets. Actors are sets of simulation engines leading on the scene, and each simulation engine is termed an actor, as shown in Figures 44 and 45. Physical actors or engines simulate the object's behavior. Script actors or engines accomplish scripts to compel an object's behaviors. Client management restores the scene as designated by user inputs and sends updates to users to rejuvenate their views (Maxwell, 2014). This perception of scene and actors appear to have the aptitude for use in the development of engineering leadership as demonstrated by Figure 45.

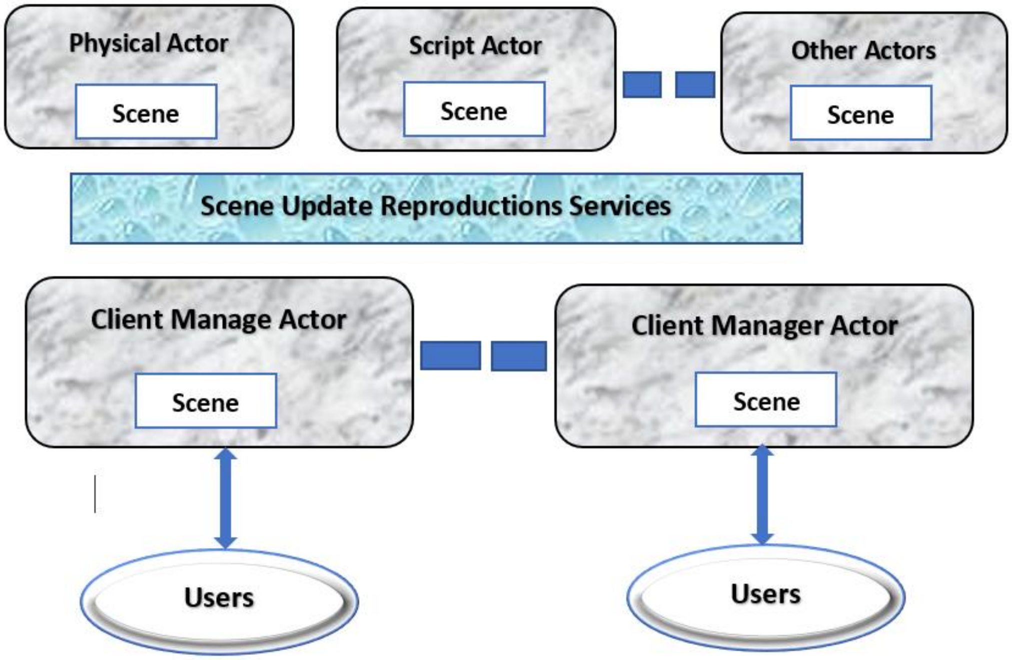


Figure 45: Virtual World Simulation: Scenes and Actors

5.6 Virtual World Simulation Applications and Advantages

The main objective of this dissertation was to complement the engineering 4-D leadership to an adequate and stabilized level whereby all students would appreciate all four leadership styles to be able to manage, lead, and communicate productively in all disciplines of engineering and technological tasks. The researcher used virtual world simulation in this experiment because of the following advantages:

1. It supports opportunities for humans' interaction within the 3D simulated environment, providing students with shared, simultaneous experiential learning and offering opportunities for open discussions and engagement.
2. Virtual world simulation encourages taking new risks and probing while learning unique ideas, skills, and techniques. This advantage grants engineering

students to exploit their decision making without any substantial consequences. Virtual world simulation furnishes engineering students with active learning as opposed to passive learning experiences.

3. Virtual Leader simulations where the real world can be simulated in a fully immersive environment allowing students to utilize their graphical depiction, an avatar who can walk, fly, and drive a vehicle. Students can teleport to different engineering simulated environments and engage in a variety of exercises with other coworkers, teams, and other virtual world participants. This research is essential, particularly in leadership education, in team-based environments that are ubiquitous in engineering. One can also visualize the real-world discernment by integrating and combining experienced 3D graphics with virtual reality to generate learner-centered experiential-based pedagogy. This improvement allows engineering leadership trainees to engage and actively learn while conducting their virtual engineering leadership activities.

4. There are significant advantages to virtual world simulation. It has been used in training of the most sophisticated aviation technology, software engineering, military and nuclear power systems training, and healthcare. Human avatars can collaborate with any object in the simulation environment without prior setup by a scenario designer.

5. Since the virtual world training environment can achieve the highest levels of operational integrity, virtual world simulation has an excellent productive learning environment. It can embrace collaborative learning with multiple participants. Virtual solutions can augment concurrent business and

engineering

6. Virtual solutions can enhance concurrent business and engineering procedures by elaborating on the significance of the synergy between simulated and real facts and the combined decisive impact of a 3D visualization, a real-time response, and interaction in 3D in bringing real-world experience to a laboratory environment for improved learning (Chorafas & Steinmann, 1995).

5.7 Virtual World Leadership Simulation Activity: Preparation and Experiment

Because the expected result of this research was enhancing engineering leadership, an appropriate way to measure the effectiveness of this investigation was by conducting an experiment utilizing a science fair project. The purpose of the process was to measure the change in leadership skills based on the classification scheme selected. The experimental group was subjected to the experimental treatment, which was a 3D virtual leadership simulation. Figure 46 below describes the activities of the experimental group. These activities are going to be described in more detail in Chapter 6.

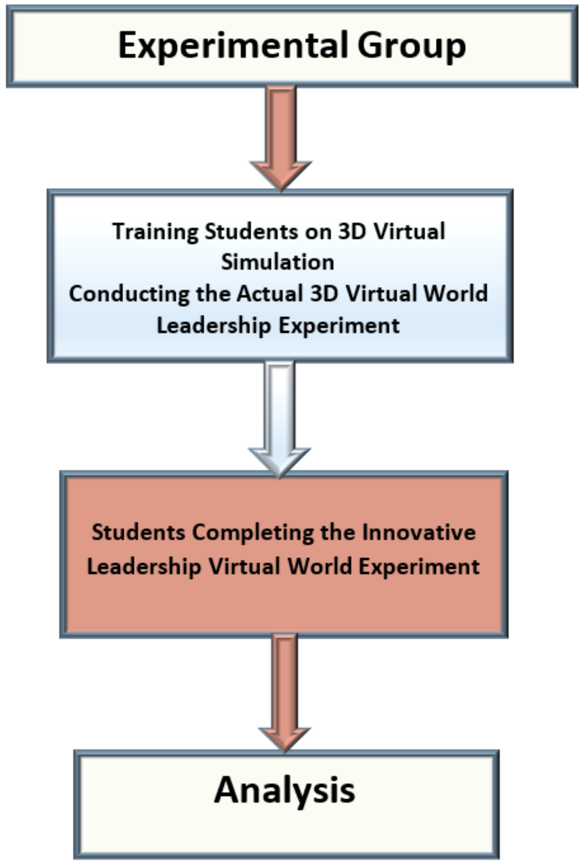


Figure 46: Activities of the experimental group

CHAPTER 6: EXECUTION, RESULTS, AND ANALYSIS

6.1 Introduction

The investigation establishes a manner to develop an environment for leadership development that may be an excellent exchange for experiential learning. The closest technique to experiential learning is the usage of simulation. Virtual world simulation is the most suitable approach, mainly when used with a pedagogical project. An experiment incorporating science fair projects will be conducted to validate and measure the prospective of this investigation.

6.2 4-D Leadership System: Effective Leadership Indicator (ELI).

In this project, the leadership style for engineering students was assessed before and after the experiment. To be able to examine the effective leadership style for teams and individuals, the 4-D Leadership System was utilized before the experiment to comprehend the current students' leadership styles. After engaging the virtual world leadership experiment, the leadership style was inspected again to assess the influence of the experiment. As shown in Figure 47, the 4-D Leadership System consists of two fundamental dimensions, which are Y-axis, innate information preference (sensed information and intuition information) and X-axis, natural deciding preference (emotional decider and logical decider).

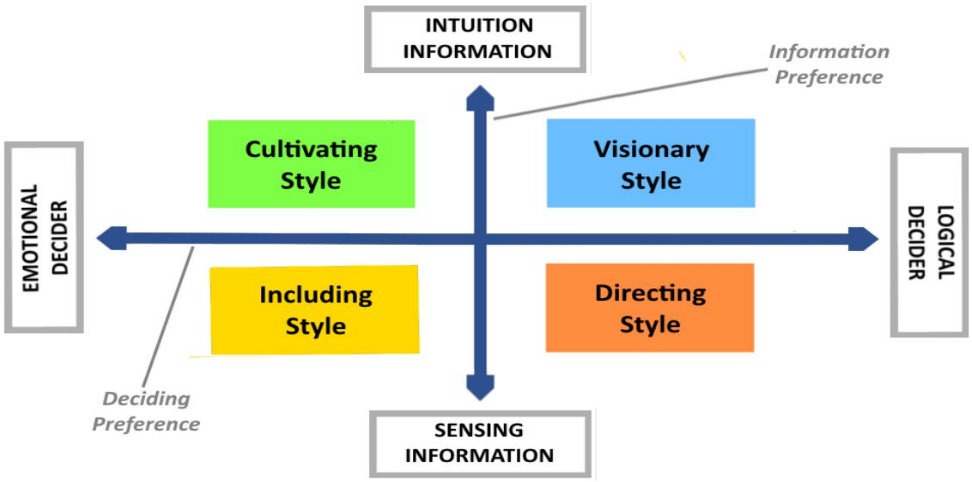


Figure 47: 4-D Leadership System

The percentage of each dimension was calculated for every student. After that, the average of all team members' leadership percentages was calculated after the experiment. The minuscule the divergence between the 4-D Leadership System, the nearer the leadership to be robust and well-rounded, due to the fact of all leadership styles are toward the average score. Thus, the standard deviation is the indicator for group and individuals to have effective and well-rounded engineering. In this study, it is termed an effective leadership Indicator (ELI).

6.3 Using Leadership and System Engineering to design the 3D Virtual World Simulation

As discussed in Chapter 5, the investigation relies on the input and valuable information from subject matter experts (SME's) in Systems Engineering and Psychology to be incorporated into the virtual world simulation. For the science fair project selection, there are some general conditions to make virtual leadership activity more beneficial for engineering students. The choice of science fair projects was based on the following features:

1. It is technological and innovative engineering.

2. It can be conducted in team-based settings.

3. It covers multi-engineering disciplines concepts.

4. It is logical, simple, and appealing to meet the students' educational level.

5. There is a room design in the virtual world for innovation and creativity.

After investigating the students' background, education, leadership style (based on the 4- D Leadership System pilot study) and the virtual world and gaming capabilities, it was found that the use of the science fair projects development and brainstorming would be a great approach for undergraduate engineering students in the Management/Communications and Ethics engineering class. Furthermore, the science fair project complexity was carefully assessed to allow for the following criteria for participating students. They (a) were either juniors or seniors, (b) represented in electrical and computer systems engineering disciplines, and (c) had no prior experience with virtual world gaming and simulation. Due to these facts about the undergraduate students, the virtual simulation activity was designed to be simple, thorough, and comprehensive. The comprehensive concept of this project enables all students from various majors to participate in the event. Figure 48 displays a snapshot of the environment.

Figure 48: Innovative & Creativity in Leadership Virtual Environment

6.4 Virtual World Simulation Platform: Open Simulator

Open Simulator (OpenSim) was chosen to be the virtual world platform that allows engineering students to experience the virtual leadership environment that was specifically designed for this research. The environment created using this platform simulates the real-life industrial scenario to allow engineering leadership trainees to practice in live, virtual, and interactive settings using their avatars as a digital representation of themselves. Figures 49 and 50 display OpenSim regions (mini-grids) and the full OpenSim grids architecture.

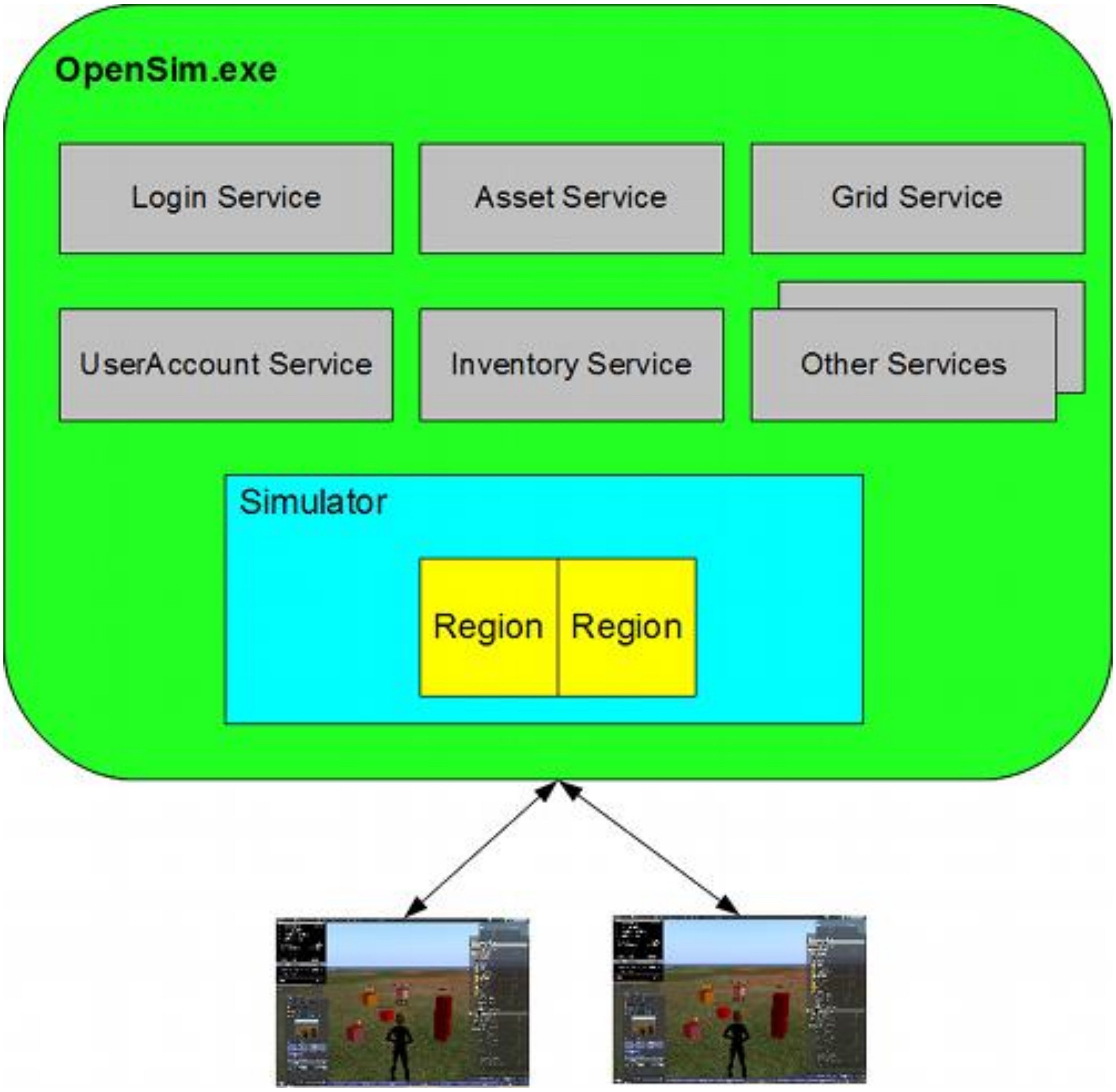


Figure 49: System Architecture of OpenSim: Standalone mode vs Grid mode

Source: (illustration adopted from opensimulator.org)

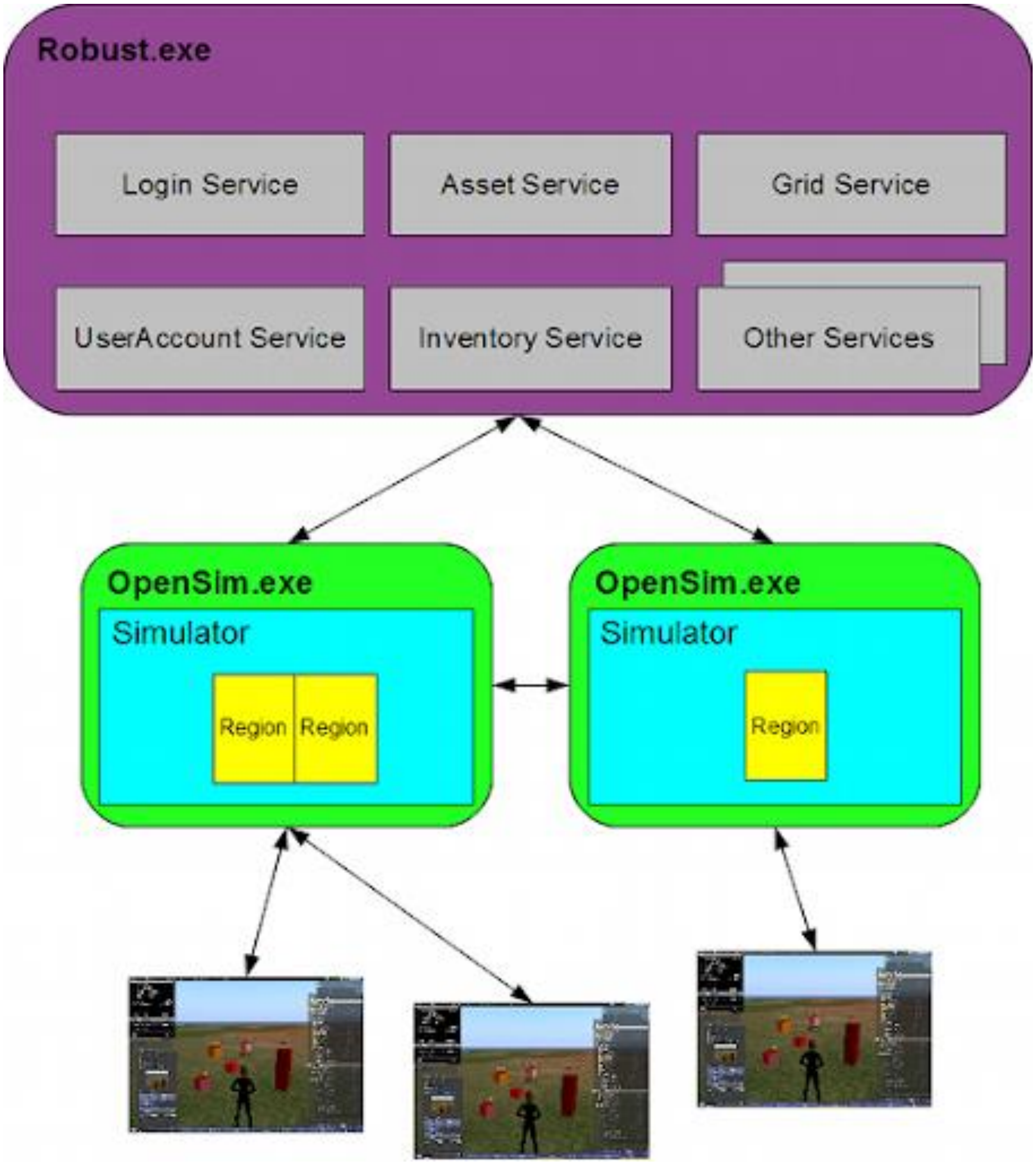


Figure 50: System Architecture of OpenSim: Standalone mode vs Grid mode

Source: (illustration adopted from opensimulator.org)

Even though there are many similarities between OpenSim and different platforms such as to Second Life and Military Open Simulator Enterprise Strategy grid (MOSES), OpenSim was selected over the rest due to the following advantages:

1. The open simulator is a modular virtual world server solution, based on Second Life protocols, thus allowing the use of Second Life viewers. Opensim supports flexible service architecture, enabling various grid services to be run within a single process or using multiple processes. These processes can be distributed across a network, allowing load balancing for high scalability. Opensim provides two (2) basic architectures, a standalone, or a ROBUST grid configuration. In this research project, a standalone OpenSim region has been used. The difference between standalone OpenSim regions (mini-grids) and full OpenSim grids is that an OpenSim standalone OpenSim region contains all required simulation and data services with a single process (OpenSim exe).
2. OpenSim software is an open-source server platform that grants users full control of the server, and Second Life is a proprietary software platform (private server control feature).
3. OpenSim software has been used and adapted by technological and engineering companies such as NASA and Intel" (Hebbel Seeger, Reiners, & Schäffer, 2013).
4. OpenSim software can be deployed on any computer able to run Microsoft and the content can be saved and restored using an XML-based file format known as Open Archive (OAR).
    a. OpenSim software is editable and flexible but Second Life is only accessible.
    b. OpenSim software has the feature of back-up and security.
    c. OpenSim software gives more freedom to control the implementation environment, but there are many restrictions in

Second Life. Also, OpenSim software is frequently used by researchers to build stand-alone projects which are often inaccessible by the general audience. (Brashears et al., 2003).

d. Its servers can be set up in any secure situation (Hebbel Seeger et al., 2013).

In this dissertation, OpenSim software platform has been used through DreamLand Metaverse, leading OpenSim software hosting. The training environment was constructed in a 250 x 256 square meter single OpenSim region of approximately 16 acres, as shown in Figure 51. Figure 52 displays the key to the virtual simulation map.

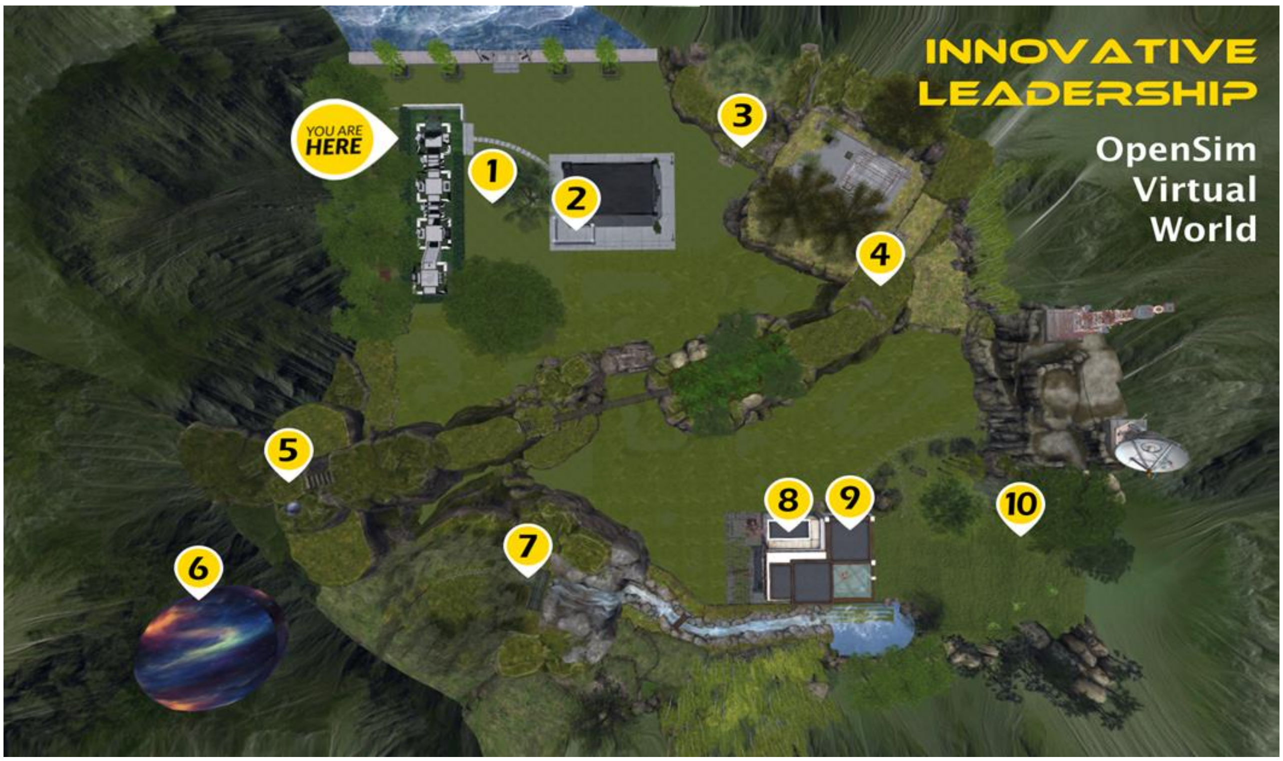


Figure 51: Top view of the virtual simulation area

Figure 52: Key to the virtual simulation area map

This region is a complete virtual world running on a single process. This includes a user registry, user inventory, assets, and messaging, as well as simulating the 3D spaces of this virtual world. It is like any other existing virtual world where users can travel to other OpenSim grids using hypergrid capabilities. The process has 1,024 MB memory, which allows almost 48,000 prims. This mini-grid is hosted as a fully managed service (software-as-a-service) on a high-performance, dedicated, multi-core server that is optimized for OpenSim software.

This virtual region is integrated into Dreamland Metaverse service management platform that provides the following features:

5. The service platform also provides additional features, like the web-based control panel, that allows for controlling multiple aspects of the OpenSim services.

6. The service uses a high-speed internet connection, a considerable amount of

memory, and high-performance processors to ensure that the server is never near to performance limits to allow nearly real-time responses. This is important for a lag-free in-world experience.

7. All user viewers communicate with a single OpenSim process that offers all services and interfaces needed for mini-grid.
8. 3-D Mesh can be uploaded by using the Colada format and use them as objects or avatars
9. User Groups are mainly used to distribute information to certain teams to control permissions for parcels of land or of objects. Groups have great advantages for privacy where closed Groups do not allow other users to add themselves in the group.
10. HyperGrid: This technology allows teleporting between different OpenSim grids and standalone regions.
11. OpenSim regions support in-world scripting using the XEngine script engine and the LSL scripting language.
12. Backup and storage: There are daily database backup to reduce the risk of data loss to minimal level using redundant data storage (RAID)
13. Offline Messages are fully supported. Instant messages to offline users are stored along with the user login and the message delivered to allow engineering leadership trainees always to be connected during the experiment.
14. To allow teams and their leaders to discuss any issues related either to the engineering virtual leadership project or to the team issues using the web, OpenSim provides a feature called media on web content inside the virtual

world. In this feature, they access any website to be displayed in the virtual world for further team discussions.

6.5 Experiment Settings

A total of twenty (20) undergraduate engineering students were randomly invited into the experimental group. All 20 students responded to participate in this project and randomly placed into five (5) groups with demographics, as shown in Table 16. In this experiment, the five (5) groups will be given the same experiment. The experimental group will be subjected to the experimental treatment, which is an immersive 3D virtual leadership simulation. As shown in Figure 53, the experimental group was subjected to Virtual World Innovative Leadership simulation environments to assess the potential changes in leadership skills.

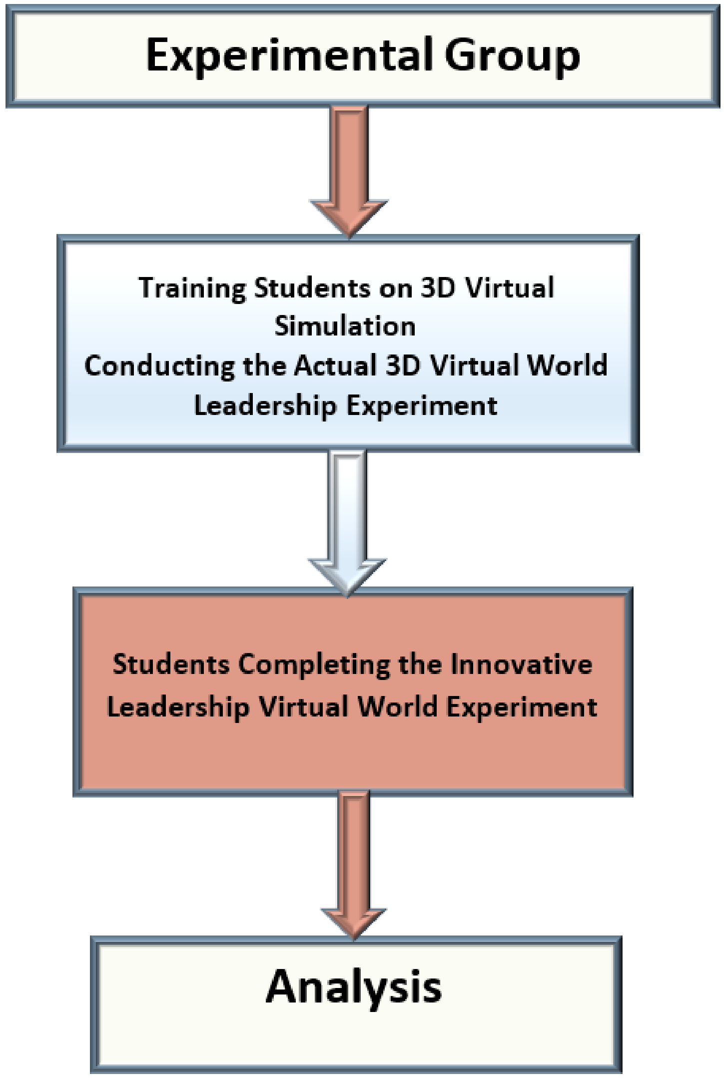


Figure 53: Experimental group activities

Table 16: Demographics of the Research Groups

Characteristics	Total (n=20)	Experimental (n=20)
Number of Teams	5	5
○ Team Members Mean	4	4
○ Team Members (SD)	1	1
Age		
○ Mean	28	28
○ SD	7	7
Gender		
○ Male	17	17
○ Female	3	3
Ethnicity		
○ Hispanic	5	5
○ White	13	13
○ African American	0	0
○ Asian	2	2
○ Prefer Not To mention	0	0
Credit hours Completed		
○ Mean	118	
○ SD	-	
Years of Experience		
○ No Work Experience	2	2
○ Less than a year	2	2
○ 1-2 Year	10	10
○ 2-4 Year	2	2
○ More than 4	5	5

6.6 3D Virtual World Simulation Training

Students were not expected to have any knowledge of either virtual Simulation or the virtual viewer software, Firestorm Viewer. The training started immediately after the Virtual World environment was completed. The training duration was two weeks. In the first week, students completed an orientation training on how to work in the 3D virtual environment of OpenSim with their avatars using the Firestorm viewer. Also, students were given instructions as homework assignments to familiarize themselves with the 3D virtual world and viewer controls. During the second week, each student spent a minimum of three hours in a dedicated virtual world environment in conjunction with Zoom to complete orientation exercises in the virtual simulated training environment, using their avatars within the 3D virtual world. As shown in Figure 54, all students' avatars were customized based on skin color and physical appearance.

Figure 54: Avatar selection and customization based on gender and skin color

After customizing their avatars, students wore shirts that were based on the color assigned to their respective teams. Next, students learned to use the virtual simulation to know how to communicate and move around in the virtual environment. A virtual workshop was dedicated to training students to use this software. As depicted in Figures 55, 56, and 57, all the steps were presented in a logical sequence to allow students to repeat them until they mastered them.

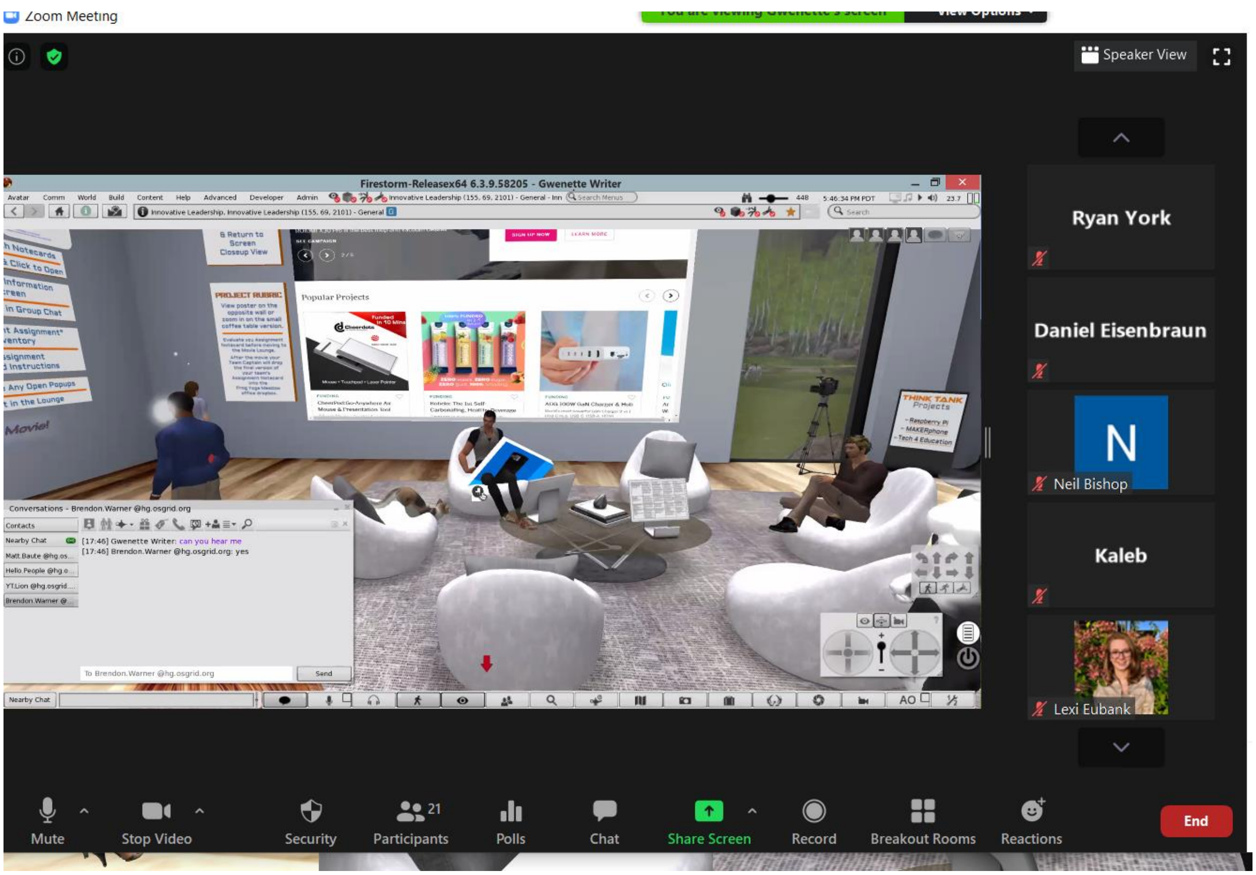


Figure 55: Virtual World Zoom tutorial and training

In this training activity, students learned how to communicate with teammates, how to interact with virtual objects, how to access objects in their inventories, and how to arrange objects in the simulated environment and other features of the 3D virtual world. During the orientation training period, students also completed mock exercises in how to conduct the actual virtual leadership training activities in teams. Each team member was given a username and password for extra training in his/her own time.

Figure 56: Virtual World Zoom tutorial and training

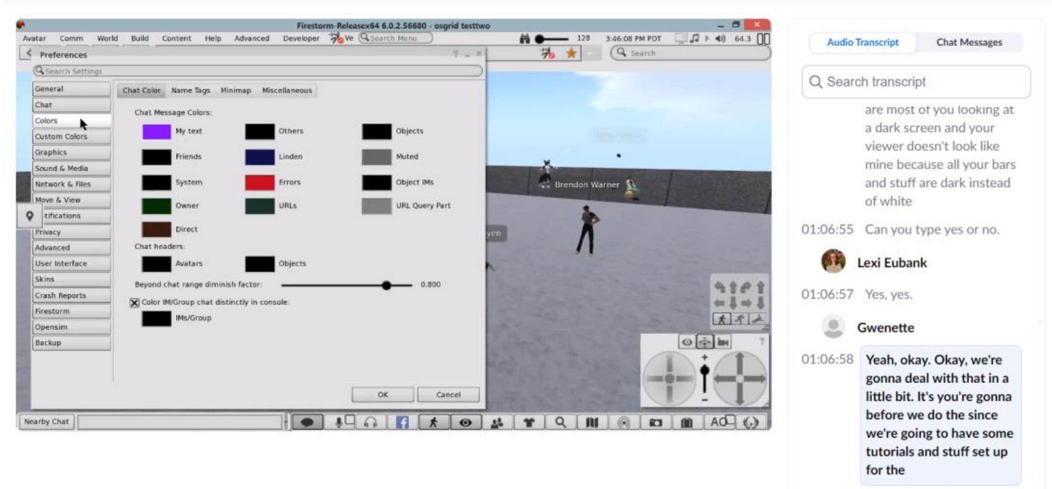


Figure 57: : Virtual World Zoom tutorial and training

6.7 The Virtual Leadership Activity

Figure 58: Sample of tasks used in the virtual simulation activity

Figure 59: Sample of groups watching Steve Jobs video in the Think Tank

If all members cannot agree on the project, it is rejected; and the next one is considered. Because this experiment is time sensitive, once there is unanimous agreement on the brainstorming goal of their project, it is adopted. Figure 58 presents a visual of the process used to select the task for their project in Virtual World. The utilization of videos from Steve Jobs (See Figure 59) to motivate students using the development of a device well known by them: the iPhone.

After successfully negotiating and choosing their project, the team will go to the Meditation Sphere, as shown in Figure 60, 61, 62, and 63 contain graphics depicting the avatar inside of the meditation room.

Figure 60: Avatar making his/her way to the meditation room 2.

Figure 61: Avatar making his/her way to the meditation room 1.

Figure 62: Avatar inside of the meditation room 1.

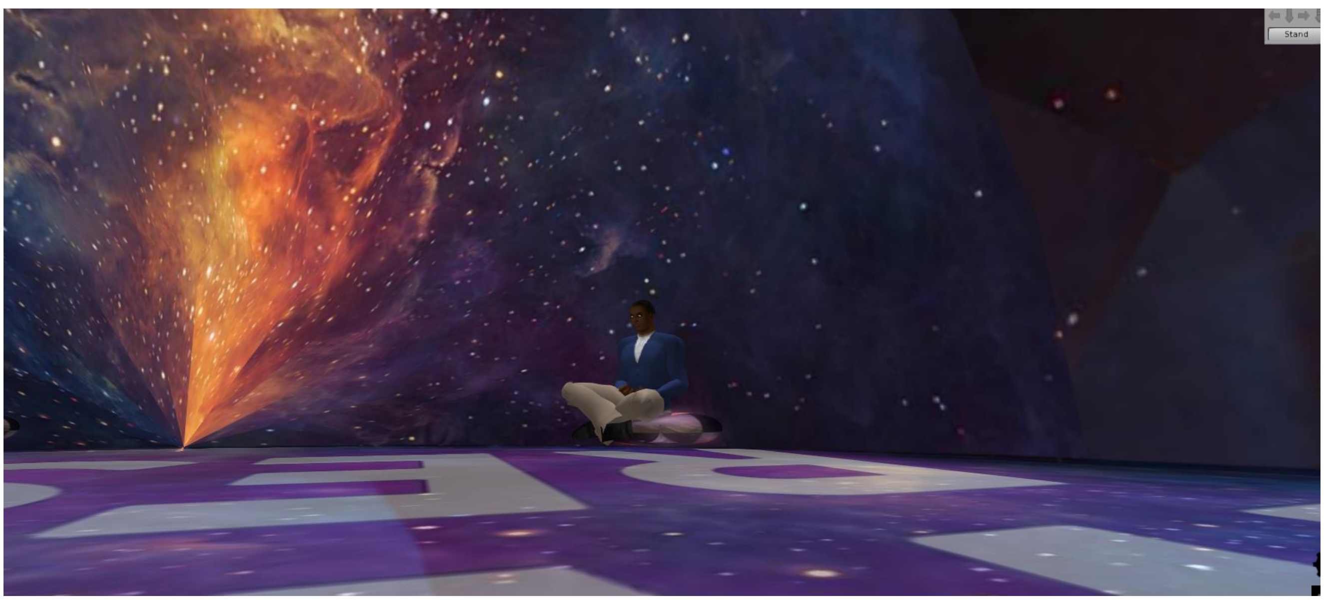


Figure 63: Avatar inside of the meditation room 2.

After the avatars experience in the meditation sphere and finding their creativity and inspiration for innovation thinking about the projects and ideas from within, the students will head to the Leadership Think Tank to commence brainstorming about the project they select, as shown in Figures 64, 65, and 66.

Figure 64: Creativity and Innovation in Leadership Think Tank

Figure 65: Creativity and Innovation in Leadership in Think Tank

Figure 66: Creativity and Innovation in Leadership in Think Tank Groups brainstorming science fair projects in the Think Tank Room

Figure 67: Submitting Surveys and Notecards at the Dropbox office

After selecting the project based on their engineering background and assumptions, all team members will choose the optimum innovative strategy that will complete the development of the project. These decisions are designed to make team members consider future customers' demands and exercise their engineering skills in the selection process to be able to use their engineering knowledge and engineering leadership to design innovative projects to attract future customers. After brainstorming, collaboration, and making final responses to their selected science fair project, the groups will execute their final task by submitting notecards in the dropbox office. This is displayed in Figure 67. The students will also, at this time, send their surveys based on their virtual world experience in the dropbox office.

6.8 Results and Findings: Leadership Skills

Engineering Management, Communications, and Ethics is a course for the Electrical Computer Engineering Technology bachelor's degree at Valencia College. We tried to expedite changes. However, no changes occurred. This was done in one (1) term due to the COVID-19 pandemic.

Before the simulation, during the self-assessment, 9 students were orange, 3 students green, 2 yellow, and 4 were blue. These results determined that 45% more students were orange (directing/systematic leadership style) compared to the other leadership styles. (See Figure 68). The simulation indicated that at least six students changed color from the self-assessment (See Figure 69). The degree of freedom is one (df =1), and the level of significance is 0.05. In this experiment, the experimental group was subjected to the experimental treatment, which included 3D virtual leadership simulation. The null hypothesis and the research hypothesis for teams and individuals were applied as follows:

Null Hypothesis: H_0: 95% of the student's leadership style will not change after the Innovative Leadership 3D virtual simulation.

Research Hypothesis: H_1: 5% of the student's leadership style with change after the Innovative Leadership 3D virtual simulation.

The statistical analysis determined by the Chi-Square test is χ^2= 8.0357 and p = 0.0046.

There was significant statistical evidence that the null hypothesis must be rejected for the experiment group because of the p-value (0.0046), which was less than the significance level (.05). It was expected that at least 5% of the students to change color because of the graded simulation versus the self-assessment pretest. These analyses proved that the 3D virtual leadership simulation was not more effective in enhancing technological engineering leadership in individuals, however, the individual group results did reflect minor changes (See Figures 71 and 72).

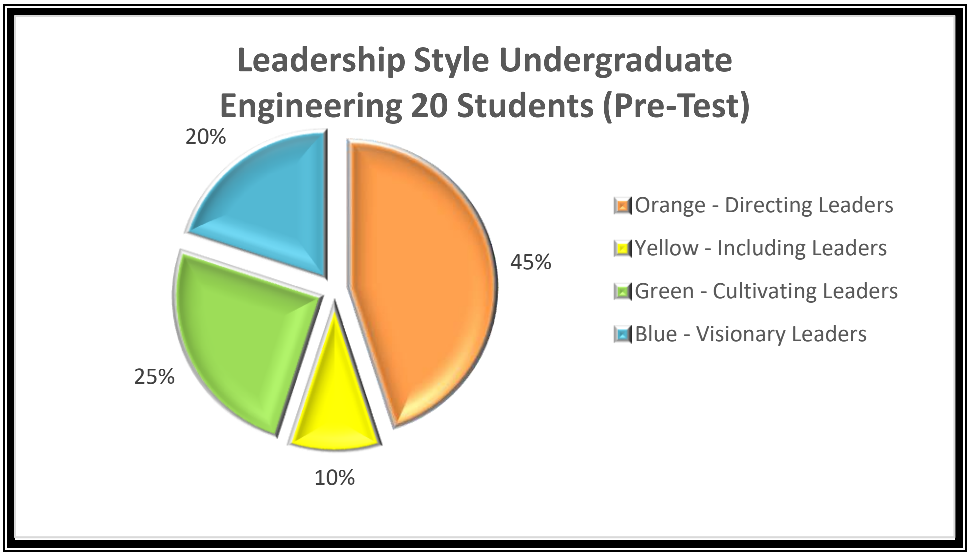


Figure 68: Pre-test Self-Assessment

Table 17. Results of 4-D Leadership Surveys (Pretest and Post-test)

	PreTest		Posttest			2 sample t-test	
	Mean	St Dev	Mean	St Dev			
Emotional	4.8	1.48	4.4	0.98		p= .32	t= 1.01
Logical	4.4	1.04	3.9	0.88		p= .11	t= 1.64
Intuited	4.4	0.76	4.4	0.55		p= 1.00	t= 0.00
Sensed	4.25	0.63	4.9	1.08		p= .23	t= -2.32

Table 17 indicates the results for the teams. There was not a significant difference in the scores for the Emotional Decider pretest (M = 4.8, SD = 1.48) and post-test (M = 4.4, SD = .98) conditions; t (20) = 1.01, p = 0.32. There was not a significant difference in the scores for Logical Decider pre-test (M = 4.4, SD = 1.04) and post-test (M = 3.9, SD = 0.88) conditions; t (20) = 1.64, p = 0.11. There was not a significant difference in the scores for Intuited Information pre-test (M = 4.4, SD = .76) and post-test (M = 4.4, SD = .55) conditions; t (20) = 0, p = 1.00. There was a significant difference in the scores for Sensed Information pre-test (M = 4.25, SD = .63) and post-test (M = 4.9, SD = 1.08) conditions; t (20) = -2.32, p = 0.23. Therefore, orange leadership is the dominant one.

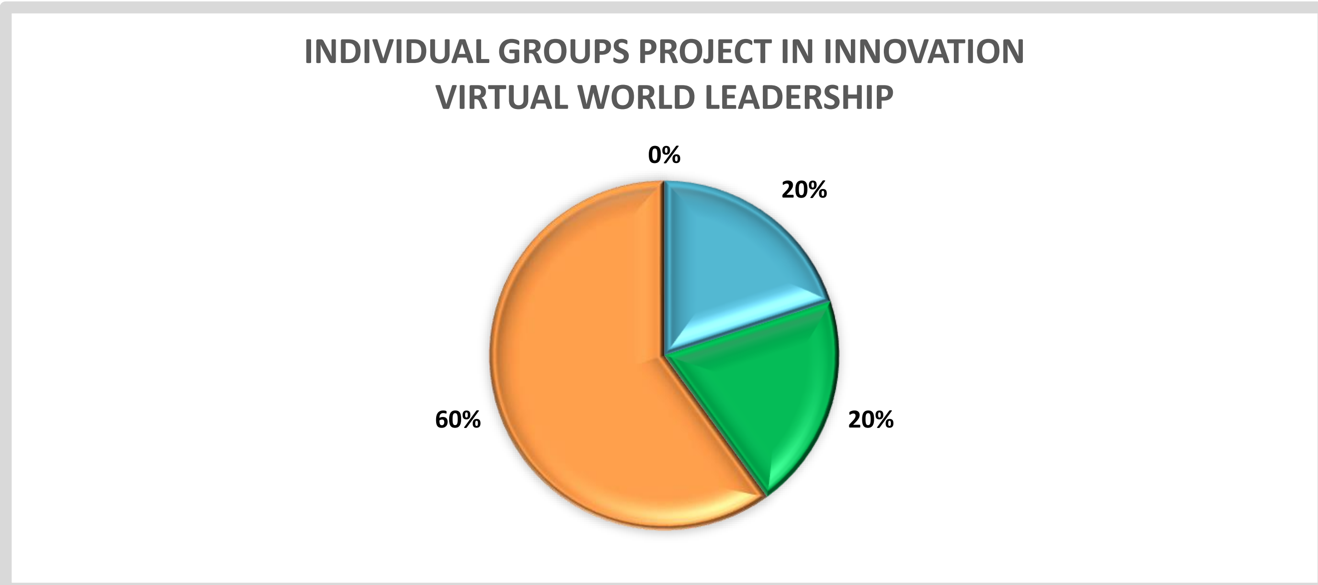


Figure 69: Assessment of Individual Groups Project/Innovation Leadership

Based on the results of the individual group's project in Innovation Virtual World Leadership, 60% of the individual groups were determined to be orange (directing/systematic leadership). In contrast, the other groups, 20% each, respectively, were committed to being cultivating and visionary leadership styles (See Figure 70). The Virtual World resulted in an excellent way to master more the leadership style of directing/systematic. The original hypothesis was that meditation was going to change some of the behaviors and make it a more visionary style (Ho, 2011).

Figure 70: Assessment of Groups Task(s) in Innovation Virtual World

In addition, we performed an analysis of the different tasks accomplished by the different groups. The group projects were assessed based on project experience and the functions in the Innovation Virtual World. The results of these task(s) based on the rubric were proficient in research overview, organize preparation, and design creativity and originality. Teamwork Problem solving was determined to be distinguished based on the project task(s). The selection of these tasks, as mentioned before, was a result of the discussions with the MSEs (See Figure 71). The task with the lower project experience was the one related to design creativity and originality. Therefore, that justifies that the blue (visionary) was not the dominant one (or balanced to the others).

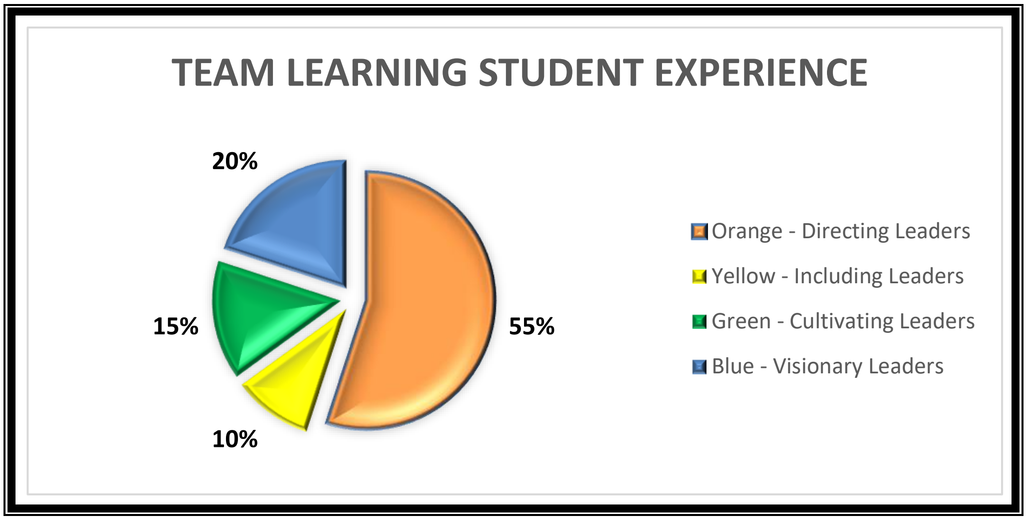


Figure 71: Assessment of Team Learning Student Experience in Innovation Virtual World

The individual results are fascinating. Based on the individual averages of the team learning student experience, 11 of the students were orange (directing/systematic leadership), 4 blue (visionary leadership), 3 green (cultivating leadership), and 2 yellow (including leadership) (See Figure 71). Therefore, as mentioned before, the Virtual Simulator experience had more opportunities for directing/systematic leadership.

6.8.3 Conclusion

In this chapter, the implementation of the experiment using science fair projects in a virtual world simulation was described. The experimental design steps have been presented, followed by the results and assessments that were obtained. Finally, the effects of the 3D virtual world simulation on various relevant leadership skills were reported based on the 4-D leadership responses from students' pre-leadership tests. The results indicate that this investigation is a potential method for enhancing engineering leadership development in teams and on an individual basis of the following:

- There is a statistical affirmation that the administration of the virtual world simulation incorporating a science fair project has the potential to enhance engineering teams' leadership.
- There was a discernible enhancement in groups' engineering leadership because of administering the virtual world simulation from the directing/systematic viewpoint.
- Detailed analysis of participants' responses revealed that the investigation, using virtual world simulation and incorporating a science fair project, may have a more significant impact on achieving effective engineering leadership than did traditional engineering leadership development. However, experiential mechanisms are still the best options.

CHAPTER 7: CONCLUSIONS, LIMITATIONS, CONTRIBUTIONS TO BODY OF KNOWLEDGE AND FUTURE RESEARCH

7.1 Introduction

Based on several results of the investigation related to leadership styles on the decision-making strategy, there is a demand for engineering leadership development. Organizations can not accomplish their optimum objectives without having productive leadership (Caceres, 2018; Schell et al., 2020). Researchers have confirmed that engineering programs are insufficient in the pedagogy of their students in leadership and management competencies (Dunwoody et al., 2018). Also, many experts have advocated that engineering curricula must be modified to create leaders who can possess powerful leadership skills. The absence of experiential learning in engineering programs will develop gaps in engineering leadership progress and may impact the success of undergraduate engineering college students. This investigation consolidating virtual world simulation based on the guidelines and specifications from SME's (systems engineering and psychologist), the fruition of the science fair projects for undergraduate engineering student teams were possible to test a solution for this existing engineering leadership oversight. For future engineers to possess the qualities of being leaders, for a current traditional engineering leadership to be successful, it must encompass a comprehensive engineering leadership perspective. In this dissertation, the researcher established an imaginative investigation of leadership development based totally on the whole and properly proven leadership classification scheme incorporated into the virtual world simulation utilizing innovative leadership science fair projects.

An investigation for effective engineering leadership development discovered that there are leadership gaps in the current traditional curriculum that it was essential to develop leaders in engineering.

Based on the investigation, it was evident that the following components are required:

1. A technological and engineering leadership classification strategy appropriate for engineering to provide assessments and help in the development of education/training materials; thus, the 4-D Leadership System was selected.
2. Based on results that have been produced from the utilization of simulation in education and training, simulation was chosen to furnish students with hands-on experience through real-life innovative leadership scenarios. Simulation can imitate the real environment and provide the participants with the opportunity to practice, engage, and obtain feedback in real-time (Bhide, 2015). The science fair projects were incorporated with the 3D virtual world environment to facilitate leadership development for undergraduate engineering students.
3. The investigation steps were used in designing the 3D virtual world leadership simulation to derive maximum benefits for undergraduate engineering students in their leadership development training.

7.2 Conclusion

Engineers have a vital role as leaders of teams and technical personnel tasked who may be tasked with creating, designing, and implementing engineering projects sufficiently and adequately. The focus of this research is to investigate ways to enhance the quality of engineering leadership development programs for undergraduate engineering students to prepare them better as they assume their responsibilities in the profession. In this study, the researcher proposed an engineering leadership development investigation using a science fair project approach that assimilated in 3D virtual world simulation.

The 3D virtual world environment was carefully designed using the guidance of psychologist and systems engineering, based on unique planning processes that incorporate science fair projects and an engineering leadership classification strategy. Noteworthy awareness about engineering leadership development obtained from the literature review and the gaps identified in the literature were applicable in deriving essential components of the investigation. Several classification strategies have been utilized to comprehend and measure leadership styles and recognize inherent leadership and personality traits.

The researcher concentrated on technological and engineering leadership classification strategies that may best serve undergraduate engineers in their preparation for leadership positions. The 4-D Leadership System was selected for use in this research sufficient to the advantages in recognizing engineering and technical teams' behaviors and phases of projects, assessing engineering leadership, and development of pedagogy/training materials. Also investigated in this research were using 3D virtual world simulation advantages in education and training. 3D virtual world simulation supports communication, collaboration, team brainstorming discussion, and negotiations and bridges the gap between experiential learning and traditional methods of face-to-face education and training. Engaging the users of 3D provides them with a sense of being present in an environment; encourages taking risks and exploring while learning modern ideas, skills, and techniques. Due to these advantages and others, 3D virtual world simulation was utilized to design the virtual engineering leadership activity based on selected innovative leadership science fair projects allowing students the opportunity to gain the utmost benefits from their leadership training. The leadership development investigation was validated by subject matter experts (SME's) to ensure the effectiveness and ability of such an inquiry to enhance the leadership development of undergraduate students.

A randomized post-test experimental group design examined this investigation. A Chi-square test showed no significant statistical change in the average individual. However, from the perspective of the group, there are changes. The detailed analysis of participants' responses, it can be concluded that this investigation, using virtual world simulation, has the potential with further research and more experiments to have a positive impact on engineering leadership development.

The research has resulted in an insight that should be useful in assisting engineering programs to complement engineering leadership development. Fostering 3D virtual leadership and incorporating science fair projects in the curricula of undergraduate engineering students has excellent potential in further developing undergraduate engineering students' leadership skills. It can enhance their communication, collaboration, engagement, brainstorming, team building, and business skills using practical scenarios and provide a viable alternative to more costly experiential real-world preparation.

7.3 Limitations

COVID-19 has not just altered our everyday life (the year 2020), but it is also upending research. As universities and colleges throughout the country have gone virtual, as the investigator of the study and scrambling to protect human participants, the research was impacted due to campus closures. Although this initially felt like it would be a challenge and sometimes frustrating knowing that on-campus labs and face-to-face meetings would not be an option, the researcher persevered through the pandemic.

Other constraints that impacted the study was obtaining a substantial number of human subjects to participate in the Virtual World Simulation environment due to the COVID-19 limitations. We initially had more than 100 undergraduate students aligned for the research in March 2020. We had to cancel the plans and re-assess the situation to start with a smaller group of 20 students by Mid May 2020. The actual training of OpenSim was completed in a virtual environment where the human subjects via Zoom with the researcher and facilitators (originally, this was planned to be face to face in Mid March 2020). The experiment was conducted in a virtual environment as well, with the researcher observing the participants while completing the simulation.

7.4 Contributions to the Body of Knowledge (BOK)

In this study, the main objective was to contribute innovative ways to address the existing leadership deficiencies within the field of engineering leadership development. The researcher attempted to identify and test innovative techniques to assist engineering programs in enhancing leadership development for undergraduate engineering students. The contribution of this dissertation is as follows:

The investigation empowered the inception of innovative team leadership improvement for undergraduate engineering students that targeted the team as a constituent rather than individual team members using Virtual Simulation. This was accomplished by educating individuals while they were carrying out their assigned responsibilities as team members. In addition, virtual worlds were capable of providing challenges that are very hard to offer in the real world.

7.5 Future Research

The investigation suggests several important topics for future research.

- **Extending the period of the experiment:** There was a detectable reduction in the mean score of posttest results, but there was no statistical significance in the individual case. This reduction indicated that the leadership of students on an individual basis was becoming well- rounded along the same lines as the average team leadership skills. One realizable explanation is that the duration of the 3D virtual leadership simulation was not enough to reflect the enhancement of the individual as it does in the team case. In the future, a researcher might duplicate the study over a more extended period to further explore the effects of meditation on the leadership development on individuals.

- **Extending the research to other STEM Disciplines**: This study was designed, using the 3D virtual world leadership simulation activity based on a science fair project(s) that targeted multi-engineering disciplines. It would be appropriate to explore more specialized science fair projects further, focusing on specific engineering majors such as Civil, Industrial, Mechanical, Environmental, and Electrical Engineering. Those who participated in the study were undergraduate engineering students. Future research may focus on graduate students and even scientists (Noordern 2018) to discover their leadership preparation requirements and determine whether similar simulation activities might be advantageous to them.

- **Adding qualitative instruments to validate the research:** This study was quantitative and did not contemplate the apprehension of the participants regarding the simulation experience. Qualitative research utilizing interview procedures would be a logical follow-up to this study to determine the program participants' identification of their strengths or weaknesses. It is paramount to develop a methodology using system engineering principles and the expertise of psychologists to select and organize the science fair projects in a simulated environment. The objective would be to have many science fair projects to create a better virtual simulation environment for leadership in STEM to test subjects and see the potential changes in leadership skills.

APPENDIX
IRB APPROVAL

University of Central Florida Institutional Review Board
Office of Research & Commercialization
12201 Research Parkway, Suite 501
Orlando, Florida 32826-3246
Telephone: 407-823-2901 or 407-882-2276
www.research.ucf.edu/compliance/irb.html

Approval of Exempt Human Research

From: **UCF Institutional Review Board #1**
FWA00000351, IRB00001138

To: **Charles W. Davis**

Date: **July 28, 2017**

Dear Researcher:

On 07/28/2017, the IRB approved the following activity as human participant research that is exempt from regulation:

Type of Review:	Exempt Determination
Project Title:	Using Systems Engineering and Virtual Simulation to Develop Engineering Leadership Skills.
Investigator:	Charles W. Davis
IRB Number:	SBE-17-12853
Funding Agency:	
Grant Title:	
Research ID:	N/A

This determination applies only to the activities described in the IRB submission and does not apply should any changes be made. If changes are made and there are questions about whether these changes affect the exempt status of the human research, please contact the IRB. When you have completed your research, please submit a Study Closure request in iRIS so that IRB records will be accurate.

In the conduct of this research, you are responsible to follow the requirements of the Investigator Manual.

On behalf of Sophia Dziegielewski, Ph.D., L.C.S.W., UCF IRB Chair, this letter is signed by:

Signature applied by Renea C Carver on 07/28/2017 08:34:14 AM EDT

IRB Coordinator

REFERENCES

Academy of Program/Project and Engineering Leadership (APPEL). (2009). NASA's Systems Engineering Competencies. Washington, DC. US National Aeronautics and Space Association.

Accreditation Board for Engineering and Technology. Criteria for Accrediting Engineering Programs. 2020 - 2021. https://www.abet.org/accreditation/accreditation-criteria/criteria-for-accrediting-engineering-programs-2020-2021/

Aldridge, D., (1994). "Professional practice: A topic for engineering research and instruction." J. Engineering Education, 83(3), p. 231-236.

Alrayes. A., & Sutcliffe, A. (2011). Students' attitudes in a virtual environment (secondlife). *Journal of Virtual Worlds Research,* 4(1), p. 4-17.

Babuscia, A., Craig, J. L., & Connor, J. A. (2012). Teaching practical leadership in MIT satellite development class: CASTOR and Exoplanet projects. *Acta Astronaut,* 77, p. 138-148.

Backer, P. R. (2005). A shift in Teaching Methodology. From Instructor Led to Student Driven Multimedia Instruction, 2005 ASEE Annual Conference, p. 1275-1272.

Bamoudu, O., & Ye, X. M. (2013). Virtual reality and virtual reality system components. *Advanced Materials Research,* 765(1), 1169.

Bass, B. M. (1998). Transformational Leadership: Industry, Military, and Educational Impact. Hillsdale, NJ: Lawrence Erlbaum.

Bayless, D. J. (2010). *Leadership education for engineering students.* Paper presented at the 40th ASEE/IEEE Frontiers in Education Conference, Washington, DC.

Bhide, S. Rabelo, L., Pastrana, J., Katsarsky, A., & Ford, C., (2015). *Development of Virtual Reality Environment for Safety Training.* IISE Annual Conference Proceedings 2302-2312 Retrieved from https://search.proquest.com/docview/1792029019?accountid=10003

Briggs-Myers, I., McCaulley, M. H., Quenk, N. L., & Hammer, A. L., *Manual: A guide to the development and use of the Myers-Briggs Type Indicator* [measurement instrument]. Palo Alto, CA: Consulting Psychologists Press.

Bradley, J. H., & Hebert, F. J. (1997). The effect of personality type on team performance. *Journal of Management Development,* 16(5), p. 337-353.

Brashears, A., Meadows, A., Ondrejka, C., & Soo, D. (2003). Linden scripting language guide. San Francisco, CA: Linden Language Lab. Retrieved from http://static-secondlife-com.s3.amazonaws.com/downloads/textures/guides/LSLGuide.pdf

Brown, F. W., & Reilly, M. D. (2009). *The Myers-Briggs Type Indicator* [measurement instrument] and transformational leadership. *Journal of Management Development,* 28(10), p. 916-932.

Bryan, B., Goodman, M., & Schaveling, J. (2006) Systeemdenken. Academic Service.

Caceres, D. (2018, August 15). Why engineers can struggle to lead. LSE. https://blogs.lse.ac.uk/management/2018/08/15/why-engineers-can-struggle-to-lead/ Dunwoody, A., Teslenko, T., Reilly, J., Cramond, J., & Nesbit, S. (2018).

Callaghan, M. J., McCusker, K., Lopez Losada, J., Harkin, J. G., & Wilson, S. (2009). Engineering Education Island: Teaching engineering in virtual worlds. Innovations in Teaching & Learning in Information & Computer Sciences, 8(3), p. 2-18.

Caza, A., & Rosch, D. M. (2014). An exploratory examination of students' pre-existing beliefs about leadership. *Studies in Higher Education,* 39(9), p. 1586-1598.

Cianfrani, C.A., Tsiakals, J. J., & West, J. E. (2002). *The ASQ ISO 9000: 2000 handbook.* Milwaukee, WI: ASQ Quality Press.

Chorafas, D. N., & Steinmann, H. (1995). *Virtual Reality: Practical applications in business and industry.* Englewood Cliffs, NJ: Prentice Hall.

Clinebell, S., & Stecher, M. (2003). Teaching teams to be teams: An exercise using the Myer-Briggs type indicator and the five-factor personality traits. Journal of Management Education, 27(3), p. 363-383.

Collins, J. C., (2001). Good to Great: *Why some companies make the leap and other do not*, (1st ed.). New York, NY: Harper Collins.

Conine, T. E. (2014). The virtual simulation: A tool for leadership education in global corporations. Global Business & Organizational Excellence, 33(5), p. 17-28.

Cox, M. F. (2012, July 8). Leadership, Change, and Synthesis Survey, Retrieved March 8, 2013 from Pedagogical Evaluation Laboratory at Purdue: http://web.ics.purdue..edu/~bahn/survey2.html

Cox, M. F., Cekic, O., Ahn, B., & Zhu, J. (2012). Engineering Professionals' Expectations of Undergraduate Students. Leadership and Management in Engineering 12(2), p. 60-70.

Crumpton-Young, L., McCauley-Bush, P., Rabelo, L., Meza, K., Ferreras, A., Rodriguez, B. Kelarestani, M. (2010). Engineering leadership development programs: A look at what is needed and what is being done. *Journal of STEM Education: Innovations & Research, 11*(3/4), 10-21.

Cruz-Benito, J., R., García-Peñalvo, F. J., & Pizarro, L. E. (2015). Discovering usage behaviors and engagement in an educational virtual world. *Computers in Human Behavior*, *47*, 18- 25.

Defense Acquisition (2001). Systems Engineering Fundamentals. University Press.

Duliba, K., & Felder, W. (2018). Strengthening Systems Engineering Leadership Curricula Using Competency-Based Assessment. In Disciplinary Convergence in Systems Engineering Research (pp. 1121-1133): Springer.

Dunn, K., (2009). The case for leadership skills courses in engineering curriculum. *Proceedings of the 2009 Midwest section of the American Society of Engineering Education.* Lincoln, NE: Olsson Associates.

Elattar, A. A. (2014). *A holistic framework for transitional management. [Electronic resource]*: Orlando, Fla.: University of Central Florida, 2014.

Engineering Leadership Development Minor, School of Engineering Design, Technology, and Professional Programs, Pennsylvania State University https://www.sedtapp.psu.edu/eld/undergraduate-minor-campuses.aspx

Fairley, R.E., (2009). Managing and Leading Software Projects. Hoboken, NJ, USA: John Wiley & Sons.

Farr, J. V., & Brazil, D. M. (2009). Leadership Skills Development for Engineers. *Engineering Management Journal, 21*(1), 3-8.

Forrester, Jay W. (1969). Urban Dynamics. Waltham, M.A: Pegasus Communications. 285 pp.

Fox, J., Ahn, S. J., Janssen, J. H., Yeykelis, L., Segovia, K. Y., & Bailenson, J. N. (2015)

Froh, J. P. (2003). *An exploratory study on visionary leadership development in an electrical engineering program at the undergraduate level.* (Doctoral dissertation). Capella University, Ann Arbor. Retrieved from https://login.ezproxy.net.ucf.edu/login?url=http://search.proquest.com/docview/305212734?accountid=10003

Fundamental Competencies for the 21st-Century Engineer, 2nd ed. Oxford University Press, 2018.

General Education, Mission Statement, Clemson University, http://www.registrar.clemson.edu/publicat/prevcats/0001/sections/gen_ed/gened.htm, last access 02/11/2010.

Girvan, C. (2013). *What is a virtual world? Definition and classification*. Retrieved from http://sfx.fcla.edu/ucf?url_ver=Z39.88-2004&rft_val_fmt=info:ofi/fmt:kev:mtx:dissertation&genre=dissertations+%26+theses&sid=ProQ:ABI%2FINFORM+Global&atitle=&title=An+exploratory+study+on+visionary+leadership+development+in+an+electrical+engineering+program+at+the+undergraduate+level&issn=&date=2003-01-01&volume=&issue=&spage=&au=Froh%2C+James+P&isbn=&jtitle=&btitle=&rft_id=info: Eric/&rft.id=info:doi/ ABI/INFORM Complete; ProQuest Dissertations & Theses A&I; ProQuest Dissertations & Theses Global database

Gordon, B.M – MIT Engineering Leadership Program, (2011). Capabilities of Effective

Engineering Leaders. Retrieved March 5, 2013, from web.mit.edu/gordonelp/leadershipcapabilities.pdf

Graham, R., (2009). Engineering leadership education: a snapshot review of international good practices. *Bernard M. Gordon MIT Engineering Leadership Program [online].* Available from http://web.mit.edu/gordonelp/elewhitepaper.pdf [Accessed 9 March 2011].

Green Report. (1994). *Engineering Education for a Changing World,* American Society for Engineering Education (ASEE), 2010.

Griffin, M.D., (2007). Engineering Leadership Education: A snapshot review of international good practices. *Bernard M. Gordon MIT Engineering Leadership Program [online].* Available from http://web.mit.edu/gordonelp/elewhitepaper.pdf [Accessed 9 March 2011]

Grinter Report, (1994). Repriated from Journal of Engineering Education, September 1955, p. 25-60.

Gurdjjan, P., Halbeisen, T., & Lane, K. (2004). Why leadership-development programs fail. *McKinsey Quarterly*, 121.

Hegarty, M. (2004). Mechanical reasoning as mental simulation. *Trends in Cognitive Sciences*, 8, 280-285.

Hegarty, M., & Just, M. A. (1993). Constructing mental models of machines from text and diagrams. *Journals of Memory and Language*, 32, 717-742.

Hasler, B. S., Tuchman, P., & Friedman, D. (2013). Virtual research assistants: Replacing human interviewers by automated avatars in virtual worlds. Computers in Human Behavior (4), 1608.

Hartmann, B. L., & Jahren, C. T. (2015). Leadership: Industry needs for entry-level engineering positions. *Journal of STEM Education: Innovations and Research*, *16*(3), p. 13-19.

Hebbel Seeger, A., Reiners, T., & Schaffer, D. (Eds.) (2013). *Synthetic worlds: Emerging technologies in education and economics.* London: Springer.

Ho, L. (2011), "Meditation, learning, organizational innovation and performance," Industrial

Management & Data Systems, Vol. 111 No. 1, pp. 113-131. https://doi.org/10.1108/02635571111099758.

Hooi, R., & Cho, H. (2014). Avatar-driven self-disclosure: The virtual me is the actual me. *Computers in Human Behavior, 39*, p. 20-28.

Hingorani, K., Sankar, C. S., & Kramer, S. (1998). Teaching Project Management Through an Information-Technology Based Method. Project Management Journal, 29(1), p. 10-21.

Hollnagel, E., & Woods, D. D. (2005). *Joint cognitive systems: The foundations of cognitive systems engineering.* Tayloor & Francis.

Hudson, K., Taylor, L. A., Kozachik, S. L., Shaefer, S. J., & Wilson, M. L. (2015). Second life simulation as a strategy to enhance decision‐making in diabetes care: A case study. *Journal of Clinical Nursing, 24*(5-6), 797-804.

Ibn-e-Hassan, I., Talib, N., Riaz, A., & Iqbal, M. (2014). Influence of national and engineering culture on team role selection. *International Journal of Technology & Design Education, 24*(1), p. 91-105.

Kahai, S., Jestire, R., & Huang, R. (2013). Effects of transformational and transactional leadership on cognitive effort and outcomes during collaborative learning within a virtual world. *British Journal of Educational Technology, 44*(6), p. 969-985.

Kirsch, I., Braun, H., Yamamoto, K., & Sum, A. (2007*). America's Perfect Storm: Three Forces Changing Our Nation's Future.* Princeton, NJ: Educational Testing Service.

Kotnour, T., Hoekstra, R., Reilly, C., Knight, R., & Selter, J. (2014). Infusing leadership education in the undergraduate engineering experience: *A framework from UCF's eli2*. Journal of Leadership Studies, 4, 48.

Krumm, S., Terwiel, K., & Hertel, G. (2013). Challenges in norm formation and adherence: The knowledge, skills, and ability requirements of virtual and traditional cross-cultural teams. *Journal of Personnel Psychology, 12*(1), p. 33-44.

Kumar, S. (2000), "Industry participation in a capstone design course," Proc., International

Conference on Engineering Education, International Network for Engineering Education and Research, Arlington, Va.

Kumar, S. (2004). "Teaching geotechnical engineering using professional practice." Proc., International Conference Education, International Network for Engineering Education and Research, Arlington, Va.

Laglera, J. L. M., Collado, J.C., & de Oca J. (2013). Effects of leadership on engineers: A structural equation model. *Engineering Management Journal,* 25(4), p. 7-16.

Lemheney, A. J., Bond, W. F., Padon, J. C., LeClair, M. W., Miller, J. N., & Susko, M. T. (2016). Developing virtual reality simulations for office-based medical emergencies. *Journal of Virtual Worlds Research, 9*(1), p. 1-18.

Lepsinger, R. (2012). The virtual challenge: It is more than cultural differences. *People & Strategy, 35*(1), p. 10-11.

Lesko, C. J., & Hollingsworth, Y. A. (2013). Architecting scalable academic virtual world grids: A case utilizing Opensimulator. *Journal of Virtual Worlds Research, 6*(1), p. 2-16.

Lockheed Martin Engineering Leadership Program. https://www.lockheedmartinjobs.com/leadership-development

Life, M. A., Narborough-Hall, C. S., Hamilton, W. I. (1990). *Simulation and the user interface*. London: Taylor & Francis.

Lin, H., & Wang, H. (2014). Avatar creation in virtual worlds: Behaviors and motivations. *Computers in Human Behavior, 34,* p. 213-218.

Little, P., (2001), Use of Studio Methods in the Introductory Engineering Design Curriculum, Journal of Engineering Educations, July.

Luecke, R., (2004). *Harvard business series: Manager Toolkit: The 13 skills managers need to succeed.* Boston, M.A.; Harvard Business School Press.

Maxwell, J. R., Gilberti, A. F., & Mupinga, D. M. (2006). *Use of Case Study Methods in Human Resource Management, Development and Training.* Terre Haute, IN: Indiana State

University.

Mihajlović, N., & Apostolovska, M. (2018). Engineering leadership in successful business organization. Serbian Journal of Engineering Management, 3(1), 30-34.

Morgeson, F. P., DeRue, D. S., & Karam, E. P. (2010). Leadership in teams: A functional approach to understanding leadership structures and processes. *Journal of Management*, *36*(1), 5-39.

Nanjundeswaraswamy, T. S. (2014). Leadership styles. Advances In Management, p. 57-62.

National Academy of Engineering. (2004). *The engineer of 2020: Visions of engineering in the new century*. Washington, DC: National Academies Press, p 50.

Nikolic, V. (2002). A Hands-On Approach to Teaching Freshmen Design, 2002 North Midwest Section Annual Conference of ASEE, Madison, WI.

Norman, D. (1983). Some observations on mental models. In D. Gentner & A. Stevens (Eds.), *Mental models* (pp. 7-14). Hillsdale, NJ: Lawrence Erlbaum Associates.

Nordern, R. (2018). Some hard numbers on science's leadership problems. Nature. News Feature, 16 May 2018.

Ohio State University (2011). Material Science Engineering and Welding Engineering ABET Self-Study.

Olude-Afolabi, O. (2011). *A systems-based approach to assessing leadership styles in engineers.* (71), ProQuest Information & Learning, US. Retrieved from https://login.ezproxy.net.ucf.edu/login?auth=shibb&url=http://search.ebscohost.com/login.aspx?direct=true&db=psyh&AN=2011-99020-408&site=eds-live&scope=site Available from EBSCOhost psyh database.

OpenSimulator. (2014). Retrieved from http://opensimulator.org/wiki/Main_Page

Overfield, D. V. (2016). A comprehensive and integrated framework for developing leadership teams. *Consulting Psychology Journal: Practice and Research*, 68(1), p. 1-20.

Özgen, S., Sánchez-Galofré, O., Alabart, J. R., Medir, M., & Giralt, F. (2013). Assessment of engineering students' leadership competencies. *Leadership & Management in Engineering, 13*(2), p. 65-75.

Pappo, H. A. (1998). *Simulations for skills training.* Englewood Cliffs, NJ: Educational Technology.

Pellerin, C. J., (2009). *How NASA builds teams: Mission critical soft skills for scientist, engineers, and project teams.* Hoboken, NJ: John Wiley & Sons.

Problem Based Learning, Victoria University, Melbourne, Australia. https://www.vu.edu.au/learning-teaching/learning-teaching-at-vu/learning-teaching-approaches/active-and-inquiry-based-learning

Putman, P. G. (2013). *Virtual simulation in leadership development training: The impact of learning styles and conflict management tactics on adult learner performance.* (73), ProQuest Information & Learning. Retrieved from https://login.ezproxy.net.ucf.edu/login?auth=shibb&url=http://search.ebscohost.com/login.aspx?direct=true&db=psyh&AN=2013-99111-269&site=eds-live&scope=site Available from EBSCOhost psyh database.

Quenk, N. L., (2002). *Essentials of Myers-Briggs Type Indicator* (measurement instrument] assessment. New York: John Wiley & Sons.

Reeve, D., Evans, G., Simpson, A., Sacks, R., Olivia-Fisher, E., Rottman, C., & Sheridan, P. (2015). Curricular and co-curricular leadership learning for engineering students. *Collected Essays on Learning and Teaching*, 8, p. 1-16.

Richard, B. W., Holton, E. F., & Katsioloudes, V. (2014). The use of discrete computer simulation modeling to estimate return on leadership development investment. *The Leadership Quarterly*, 5, 1054.

Rodríguez Montequín, V., Mesa Fernández, J. M., Balsera, J. V., & García Nieto, A. (2013). Using MBTI for the success assessment of engineering teams in project-based learning. *International Journal of Technology and Design Education*, *23*(4), p. 1127-1146.

Rosch, D. (2015). Effects of classroom-based team experiences on undergraduate student leadership development: When practice does not make perfect. *Journal of Leadership Education, 14*(3), p. 104-118.

Rumelhart, D. E. Smolensky, P., McClelland, J.L., & Hinton, G.E. (1986). Schemata and sequential thought processes in PDP models. In J. L., McClelland, D. E. Rumelhart (Ed.) & The PDP Research Group (Eds.), Parallel distributed processing. Explorations in the microstructure of cognition. Psychological and biological models (Vol. 2, pp. 7-57). Cambridge, MA: The MIT Press.

Santhanam, R., Sasidharan, S., & Webster, J. (2008). Using Self-Regulatory Learning to Enhance E-Learning-Based Information Technology Training. *Information Systems Research*, 19(1), p. 26-47.

Schell, W., Hughes, B., & Tallman, B. (2018). Understanding the Perceived Impact of Engineers' Leadership Experiences in College. Paper presented at the ASEE annual conference & exposition.

Schell, W., Hughes, B., Donald, J., Goldfinch, T., Kadi, A., Moore, E., & Sheridan, P. (2020). Leadership Transcending Borders: Building bridges to Integrate technical and Professional Knowledge. Proceedings of the Canadian Engineering Education Association (CEEA).

Schuhmann, R. J. (2010). Engineering Leadership Education – the search for definition and a curricular approach. *Journal of STEM Education: Innovations & Research,* 11(3/4), p. 61-69.

Schwartz, D. L., & Black, J. B. (1996). Analog imagery in mental model reasoning: Depictive models. Cognitive Psychology, 30, 154-219.

Sequeira, L., & Morgado, L. (2013a). Mechanisms of three-dimensional content transfer between the OpenSimulator and the Second Life Grid® platforms. *Journal of Gaming & Virtual*

Worlds, 5(1), 41-57. doi:10.1386/jgvw.5.1.41_1

Sequeira, L. M., & Morgado, L. (2013b). Virtual Archaeology in Second Life and OpenSimulator. *Journal of Virtual Worlds Research,* 6(1), p. 2-16.

Sheppard, S. D., K. Mucatangay, A. Colby, W. M. Sullivan, Education Engineers: Designing for the Future of the Field, Indianapolis: Jossey-Bass, 2008.

Showanasai, P., Lu, J., & Hallinger, P. (2013). Developing tools for research on school leadership development: An illustrative case of a computer simulation. *Journal of Educational Administration,* 51(1), p. 72-91.

Sidor, S. M. (2007). *The impact of computer-based simulation training on leadership development*. (Doctoral dissertation). University of Central Florida, Orlando, FL.

Siewiorek, A., Saarinen, E., Lainema, T., & Lehtinen, E. (2012). Learning leadership skills in a simulated business environment. *Computers & Education, 58*(1), 121-135.

Siewiorek, A., Gegenfurtner, A., Lainema, T., Saarinen, E., & Lehtinen, E. (2013). The effects of computer-simulation game training on participants' opinions on leadership styles. *British Journal of Educational Technology, 44*(6), p. 1012-1035.

Sillitto, H. (2011). Panel on "People or Process, which is More Important." Presented at the 21st Annual International Council on Systems Engineering (INCOSE) International Symposium. 20-23 June 2011. Denver, CO, USA.

Strang, S. E., & Kuhnert, K. W. (2009). Personality and leadership development levels as predictors of leader performance. *The Leadership Quarterly*, 20(3), p. 421-433.

Summers, M., Davis, B., and Tomovic, C. (2004). "When engineering and technology skills are not enough; Engineering leaders out of their element." Proc., CEIC Conference, Biloxi, Miss, ASEE, Washington, D.C.

Thottam, J. (2011). "The little car that couldn't." Time Magazine, Business p. 1-4.

Tolga K. Capin, I., Magnenat-Thalmann, N., Thalmann, D. (1999). *Avatars in networked virtual environments*. Totonto: John Wiley & Sons.

von der Pütten, A.M., Krämer, N. C., Gratch, J., & Kang, S.-H., (2010). 'It doesn't matter what you are!' Explaining social effects of agents and avatars. *Computers in Human Behavior*, 26(6): p. 1641-1650.

Varvel, T., Adams, S. G., Pridie, S. J., & Ruiz Ulloa, B. C. (2004). Team effectiveness and individual Myers-Briggs personality dimensions. *Journal of Management in Engineering, 20*(4), p. 141-146.

Williams-Bell, F. Kapralos, B., Hogue, A., Murphy, B., & Weckman, E. (2015). Using serious games and virtual simulation for training in the fire service: A Review. *Fire Technology, 51*(3), p. 553-584.

Wysocki, R. K. (2002). *Building effective project teams.* New York: John Wiley & Sons

Xanthopoulous, P., Pardalos, P., & Trafalis, T. B. (2012). *Robust data mining.* Springer Science and Business Media.

Yuki, G. (2013). *Leadership in Organization,* 8th ed. Upper Saddle River, NJ, USA, Pearson.