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THE GAMIFICATION FRAMEWORK OF MILITARY FLIGHT SIMULATOR FOR EFFECTIVE LEARNING AND TRAINING ENVIRONMENT

by

DAEHO NOH
B.E. Republic of Korea Airforce Academy, 2007

A thesis submitted in partial fulfillment of the requirements
for the degree of Master of Science
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at the University of Central Florida
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Major Professor: Gene Lee

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ABSTRACT

The purpose of this thesis is to develop a framework for the gamification of flight simulators to provide an active learning and training environment for military jet pilots. Currently, with the development of visual displays and computer processing capabilities, the modern simulator has made great progress in visual and auditory terms that is incomparable to the past. In addition, functions that were previously implemented through supercomputers and complex hardware devices are now available through desktop computers at an affordable cost. Despite these advances, the simulators so far are thought to have been negligent in building an active learning and training environment for users, focusing only on such things as sound and visual immersion and training requirements. On top of that, misbelief in the effectiveness of pilots' flight simulators, old paradigms failing to keep up with computer technology, and lack of instructor manpower have not led to the progress of simulator training programs. Meanwhile, studies show that the gamified system, which has become an increasingly hot topic in business, health care, and education over the past decade, has made users more motivated and actively engaged in the use of specific platforms. And the resulting effect was also positive. This Research aimed: (1) to examine a research-based Gamification Framework to understand the concept of a gamified system, (2) to identify pilots' flight training needs and motivations, (3) and finally to suggest evaluation tool with example. The Gamification Framework of Flight Simulator(GFFS) was designed on the basis of research and a survey conducted for Korean Air Force fighter pilots for detailed Gamified Flight Simulator(GFS) evaluation tool. GFFS was modified and applied from Kim's gamification framework and the Octalysis framework was used to identify and compare pilots' needs and motivation factors.

Keywords: Gamification, Gamified Flight Simulator, Military Training, Computer-based learning, Motivation, Octalysis Framework, Gamification Framework, Usability

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CHAPTER 1: INTRODUCTION

1.1 Research Motivation

More than 50 years have passed since the introduction of the first supersonic fighter jet, the F-5 in South Korea. So far, F-4s, F-16s and F-15s have been introduced one after the other, and now the F-35, one of the most powerful stealth fighter on the planet have been introduced in South Korea. And it is still in South Korea where all of these types of fighter jets are operating. When operating F-4s and F-5s, which have only the most basic navigation systems and are mostly manual, the ability to control aircraft close to acrobatics was an important indicator of pilots' ability. Pilots flying the current 3rd, 4th and 5th generations of fighter jets needed far more multitasking, information processing and situational awareness. And the process of acquiring the knowledge necessary to deal with it has also become very important, as pilots deal with much more kinds of armament and sensors. And also the ability to handle complex systems has become more important than just to control aircraft, as the system becomes more complex(Radar, Datalink, TGP, Advanced missiles and bombs).

In the early days of flight simulators, it was impossible to simulate actual flight training or most exercises in real operations due to limitations in the visual field of view, limited computer capability, and limited communication with other computers and players, but continued development of computers and displays, and advances in peripheral devices such as VR(Virtual Reality), AR(Augmented Reality) and MR(Mixed reality) enabled realistic visualization (Eugenijus Kurilovas 2016) and interaction with other agents. Because these technologies are further reinforcing the effectiveness of flight simulators for pilots dealing with complex systems, the use of flight simulators has become more reliable than in the past. If these

advanced flight simulator capabilities are used more effectively and systematically, it is also expected to be possible to partially replace live flight time.

1.2 Problem Statement

However, the attitude of pilots to deal with flight simulators and the frequency of the simulator sorties have not changed much since the simulator was first introduced. All training courses are done in accordance with the syllabus and the portion of the flight simulator is rather small for the adaptation concept prior to the live flight. Other than that, it is mainly composed of training for handling emergency situations in the event of an aircraft malfunction or evaluation of pre-flight qualification. However, live flight training is often limited by fixed sorties, weather or other duties. And, even if they feel they are less skilled than other pilots, they cannot personally perform more live training than other pilots. Although training using simulators falls short of live flight training in terms of performance, there are some advantages only in simulator training. For example, complex battlefield situations or explosion effects that cannot be experienced in live training, such as viewing or responding to real-world enemy aircraft. It also has the advantage of increased retention and accuracy through repetitive practice, and continuous training is possible even in the weather or in the event of inevitably not being able to fly live. Despite many analyses and studies that simulators are effective, simulator training does not account for much throughout flight training. (De Ponti et al., 2011; Hays, Jacobs, Prince, & Salas, 1992).

Flight simulators account for less than 20 hours, compared with 180 hours of required annual flight time for South Korean fighter pilots. Also, just few pilots are spending their

personal time to do simulator training. This problem can be explained in terms of satisfaction, motivation and environment.

Satisfaction

- There is no built-in curriculum covering a series of live flight training courses and missions.
- When training in a simulator, there are insufficient instructors to check the pilots' training.
- Simulator training has limitations in achieving operational training effects.

Motivation

- There is no element within the flight training curriculum or simulator training system that can motivate pilots to train.
- There is no objective feedback.
- There is no personalized database where pilots can check their flight skill improvement or their simulator flight time.

Environment

- The squadron is not equipped with enough simulators to train all pilots for flight simulators at any time.
- Current simulators have limited time available due to complex equipment, frequent maintenance, and maintenance personnel's operation hour.
- It is not an environment where theoretical knowledge is transferred directly to simulator training.

That is, once the causes for the above problems are resolved, the proportion of simulator training could be increased, resulting in increased quality of live flight training, a decrease in live flight sorties, and a decrease in the time it takes to produce advanced pilots, a decrease in the overall budget for training pilots and an increase in quality pilots.

On the commercial side, with the highly developing industry related to learning and training, the method of learning and training applied with gamification has become a hot topic, with some showing that its effectiveness is significant. Accordingly, it is essential to find a way to overcome the above problems by applying gamification elements to military flight simulators.

1.3 Research Objective

The purpose of this thesis is to develop a framework for the gamification of flight simulators to provide an active learning and training environment for military jet pilots. The framework will be verified by exploring current gamification theories, listening to opinions from pilots through survey, and finally providing tool to evaluate the specialized characteristics of a gamified flight simulator. This created GFFS will make it possible to give developers requirements and recommendations for a gamified flight simulator.

The main goal of the GFS(Gamified Flight Simulator) is to ensure that the pilot enjoys and is satisfied with the flight simulator training and is motivated to be engaged to training consistently. This is based on the assumption that the more time pilot spends on flight-related theoretical knowledge and simulator training, the faster growth will be possible and higher levels of flight qualification will be achieved in less live flight time.

It is assumed that the main factors of time that pilots invest in theoretical knowledge and simulator training are satisfaction based on usability and motivation. Usability refers to the user's functional satisfaction with the software's design. Therefore, the research will be done to seek various usability models to create a model specific to gamification. While there is a lot of study on motivation, The Octalysis framework (Chou, 2019) of gamification is mainly applied. This is because this framework represents the areas in which people are immersed and motivated by games or something that is game-like. It is assumed that this Octalysis framework will give us insight into creating a framework and an assessment tool for a gamified flight simulator and be effective in analyzing and designing pilots' motivational elements.

1.4 Contribution

The main contributions include the following.

- It gives the Air Force leadership an understanding of gamification and show them the advantages of various gamification techniques.
- It can provide how much the motivational factors and satisfaction with the simulators of the Republic of Korea pilots can affect their training satisfaction through surveys.
- The requirements and recommendations of research-based gamification using GFS evaluation tool can be communicated to the developer of the gamified flight simulator.

1.5 Thesis Overview

This thesis consists of a Literature review and The Design Methodology for GFS, and Survey results and analysis, GFS assessment tool, Discussion and future research.

- Literature Review: This thesis discovers the features of the flight simulator and the devices that can be applied, along with the current gamification theory and motivation theory and learning theory that affect it through the literature review.
- Gamification Framework: The initial gamification framework will be developed for flight simulators and discovered examples that may be applied. And the survey method and analysis method will be explained.
- Survey results and analysis: The Survey for pilots will be done and then analyzed to identify the needs and motivation factors for the flight simulator to prioritize the elements of framework.
- GFS(Gamified Flight Simulator) Evaluation tool and applied cases: It is developed the evaluation form according to weights developed by survey and application to current simulators and commercial games
- Discussion and future research: Finally, The limitations of the study and the direction of future research will be discussed.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

This chapter analyzes the expected effects of adding gamification to the Flight Simulator while exploring various definition of game and gamification as well as training simulator. Second, the theory for gamification in learning and training is looked at and analyzed for some advantages and disadvantages. Thirdly, the applicable gamification elements of the flight simulator are analyzed, taking a look at the gamification framework.

2.2 Flight Training Simulator

It will be necessary to look at the definition of the simulator before seeing the effect of integrating the gamification elements in the flight simulator. Next, the elements of simulator training and what kind of simulator can be applied to gamification will be analyzed.

2.2.1 Training simulator

The definition of a simulation is “The imitative representation of the functioning of one system or process by means of the functioning of another” ("Simulation" 2019). From a computer-engineering perspective, simulation is a model that mimics a situation or a particular process. In a complex real world, when it is very difficult to provide accurate information simply by using mathematical methods, simulation can be used to numerically evaluate a model and to obtain data to estimate expected true characteristics of the model (Law & Kelton, 2000). Simulation can be used in three main areas: Live, Virtual, and Construction where virtual refers to simulations that involve real people operating simulated systems and this is what is mainly

called a simulator. These simulators are a type of HITL(Human-in-the-Loop) model that requires human interaction during runtime. Therefore, human intervention can lead to changes in the outcome of an event or process ("Human-in-the-Loop (HTL)," 2019). These simulators can be used for a variety of purposes, such as games, statistics, and behavioral analysis, but the scope of my research is limited to those designed for training and, more specifically, practice tasks.

Skills that can be trained on virtual include motor control skills for flying aircraft, driving car, or sailing boat, decision skills for emergency control or fire control in command center and, communication skills for members of a C4I team or air traffic control respectively (Elliott, Edmondson, Scrudder, Igarza, & Smith, 2009; Verstegen, 2004). Although motor control skills were the main training areas in terms of flying an aircraft, various scenarios, interoperability between simulators, and advances in constructive have also made it possible to train decision skills and communication skills through flight simulators.

Farmer, Van Rooij, Riemersma, and Jorna (2017) mentioned that a simulator consists of realistic replication of the operational environment and the system, including the displays and controls available to the operator. In particular, simulators of the kind that perform operations on certain mobile devices, such as automobiles, tanks, and airplanes, can give a much greater sense of immersion to other types of simulators when the elements of vision, hearing and motion are properly combined. In addition, a training-purpose simulator can have a tremendous effect on the operator by enabling repeatable mastery or experience with specific scenarios that are physically impossible in the real world or subject to constraints in time and space.

2.2.2 Types of Flight Simulators

Flight simulators vary depending on their purpose, their use, and their field. It can be divided into civil and military sectors as higher categories. It is important to know how to distinguish between these types of flight simulators in order to explore how the new simulator interface can be implanted.

2.2.2.1 FAA Standards

(*14 CFR Part 60 - Flight Simulation Training Device Initial And Continuing Qualification And Use*, 2019; *14 CFR part 61-136B - FAA Approval of Aviation Training Devices and Their Use for Training and Experience*, 2018)

Globally, there are FAA(USA – Federal Aviation Administration), EASA(Europe – European Aviation Safety Agency), CASA(Australia – Civil Aviation Safety Authority), CAA(New Zealand – Civil Aviation Authority), etc., but since the criteria are similar and do not deviate significantly from the framework of FAA, It can be explained by the criteria based on the standards of FAA. Flight simulators as defined by the FAA are largely divided into FFS(Full Flight Simulators) and FTD(Flight Training Device) and are divided into BATD(Basic Aviation Training Device) and AATD(Advanced Aviation Training Device) that replace levels 1, 2 and 3 of FTD. The FFS is a high-fidelity full-size replica of the Flight Deck that can simulate aircraft on ground and flight operations. The biggest difference that distinguishes FFS from other categories is that it has at least 3 axis or higher motion systems. The FAA defines FTD as a replica of aircraft instruments, equipment, panels, and controls in an open flight deck area or an enclosed aircraft flight deck replica. Level 1-3 of FTD has been replaced by newly defined

BATDs and AATDs with devices corresponding to this level, and Level 1-3 are no longer applicable to new devices except devices previously licensed. The biggest feature of the FTD is that it is equipped with all hardware and software for procedural and operational training. BATDs and AATDs, which are defined by ATDs other than FFS and FTDs, typically include aircraft instruments, equipment, panels, and controls in the open flight deck area or enclosed aircraft cockpits. The big difference between BATD and AATD lies within the scope of pilot certificates through training using this device. Details are given in the following table.

Table 1 Simplified FAA standards for Flight Simulator Levels

Category	Sub-Cat (Level)		Description
FFS		A	3 axis motion / night visuals
		B	3 axis motion / night visuals / ground handling simulation
		C	6 axis motion / night & dusk visuals / dynamic control loading / higher fidelity
		D	6 axis motion / night, dusk & day visuals / dynamic control loading / highest fidelity
FTD	1	BATD	Provides an adequate training platform for Private Pilot Certificate and instrument rating
	2		
		AATD	Provides an adequate training platform for Private Pilot Certificate, instrument rating, Commercial Pilot Certificate, and Airline Transport Pilot (ATP) Certificate, and Flight Instructor Certificate
	3		
		4	Basic cockpit procedural trainer / often a touch screen procedural trainer
		5	Specific class of aircraft / meets a specific FTD design criteria
		6	High fidelity / aircraft specific / specific aerodynamic modelling
		7	Helicopters only / all controls & systems modeled / vibration system / visual system

2.2.2.2 Military Flight Simulators

In fact, military flight simulators have no general standards for types or levels. Military flight simulators can be divided into FMS(Full Mission Simulator) and FTDs, much like

commercial ones, by looking at product introductions by operators providing simulator devices. However, the level of detail is not distinct because procurement of military flight simulators is subject to individual specific standards under the ROC(Required Operational Capability) and varies according to training goal and purpose.

Chatham (2009) divided the types of training into part tasks and whole tasks and divided the whole tasks into simplified, realistic, and mission. Military flight simulators can be divided into part task and FMS / FTDs and analyze them with a focus on the possibility of procedural and operational training in terms of performing the entire mission.

A part task simulator can be defined as a type of simulator for a single-purpose or for only procedural training. Part-task simulator include spatial disorientation trainer(4 axis motion), High G trainer, Night Vision trainer and CPT(Cockpit Procedures Trainer) as well as Ejection trainer that can only perform ejection seat operation procedure. General aviation may also fall into the category of part task simulators in that it provides basic flight environments, controllers, and visual elements, but it is not possible to carry out procedures and operational training that can be performed through a particular aircraft. Unlike the FFS of a civil flight simulator, even military part task simulators have some DOF(Degree of Freedom) in motion for a particular purpose. The following table is the results of the types of Part Task military flight simulator obtained by investigating the products of military flight simulators companies ("Aerospace Industries SP. Z O. O.," 2019; "Aircrew Training systems," 2019; "AMST," 2019).

Table 2 Types of Part Task military flight simulator

Types	Characteristics	Training availability	
		Procedural	Operational
Spatial Disorientation Trainer	4 axis in motion	X	X
High G Trainer	3 axis in motion	X	X
Night Vision Trainer	Provide visual environment with night and NVG aided	Partially	X
Ejection Trainer	Physical motion of ejection seats	X	X
General Aviation Trainer	Typical IFR and VFR flight procedures and operational skills training	Partially	X
Cockpit Procedures Trainer	Replica of specific aircraft but do not provide audiovisual environment	O	X

As shown in the Table 2 above, partial mission simulators with specific purposes have no operational capability and only some partial procedural ability.

In the Overview of MAR-FSTD Military Aviation Requirements Flight Simulation Training Devices, which is the only paper to study the level of military flight simulators, Jansen and Koolstra (2011) created levels of flight simulators according to visual FOVs, details of various visual flight environments and various sensors. However, the details of sensor and environmental realistic visualization can be viewed as the basic components of the ROC and divide the types of full mission flight simulators according to how much visual FOV, interaction with other players and tactile capability can influence procedural and operational training.

With searching the websites of companies that produce military flight simulators to investigate what kind of flight simulator solutions they offer ("CAE," 2019; "Collins Aerospace," 2019; "Elbit Systems," 2019; "Elite Simulation Solutions," 2019; "FlightSafety Internatioal," 2019; "Frasca Flight Simulation," 2019; "Haelsan Inc.," 2019; "L3harris," 2019; "L3Harris Link

Training & Simulation," 2019; "Lockheed Martin Corporation," 2019; "Thales Group," 2019; "TRU Simulation + Training, A Textron Company," 2019).

Visual capabilities affecting procedural and operational training can be divided according to the FOV and visual coverage. Devices that present visual elements can be largely divided into MR, Dome, and Monitor. MR(Mixed Reality; Continuum of Virtual Reality) (Milgram & Kishino, 1994) is a visual device that encompasses AR and VR devices and currently has the widest range of coverage, but so far, FOV does not cover all of human's eye sights. Dome-type devices used to be mounted on full mission simulators prior to the advance of MR and have relatively wide viewing angles, but have the disadvantages of poor down- and rear-view visibility. Monitor-type devices can extend visual coverage by connecting multiple monitors, but they are still forward-looking.

Interaction is divided into whether cooperative play is possible. While past simulators could only be single mode focused on single maneuvering and performing procedures, recent simulators have evolved into a trend that enables multi-play by interplaying simulators in one base. Here, as LVC technology evolves, it is possible to create different types of scenarios as well as play between networks. (Hodson, 2017)

The tactile component can be an important part of a simulator's operational or procedural capability. Most military flight simulators are composed of FMSs with all tactile conditions, but in some cases, touch screens are introduced for training pilots who are already operational to reduce costs. Some simulators have only a very small number of basic flight controls, and in the case of on-the-market flight simulation games, most of which have only these functions, and procedures such as switching or pushing are performed using a mouse or keyboard.

Table 3 The Elements that affects the procedures and operational training.

Area	Element	Description	Capability
Visual	MR	Provide view through head mount display	No visible area restrictions, limited FOV
	Dome	Provide view through beam projectors	FOV is limited by the angle of the area visible, mainly it has rear view limit.
	Monitor	Single or a couple of monitors for visible area	Limited visible area, limited FOV
Interaction	Network Play	Connects to other bases over the network	Almost any kind of operation is possible
	Local net Play	Interact only devices connected to the local line	Ability to train tactics in a formation
	Single mode only	Individual unit training	Unable to cooperate with other pilots
Tactile	Full Flight Control	BFC + full replica of Cockpit	Capable of all kinds of procedures for the sensor control and input
	Intermediate Flight Control	BFC + Touch screen	Provide a similar experience to FFC but no tactile experience
	Basic Flight Control	Throttle, Stick, Rudder + Mouse, Keyboard	Procedure can be carried out, but there can be a gap between the procedure and the delay of the procedure execution on the actual aircraft.

It may be pointless to divide the level of FMS / FTDs because simulator types are divided according to how the components in the table above are combined and each has its own pros and cons. However, if MR is used for the visual component and network play is enabled, then tactile procedural and operational performance can be achieved through even the most basic flight control system, while it has differences in quality.

2.3 Gamification

Education is as important as training and doctrine in post-modern warfare. This education needs to focus on the developments of mind and vision, understanding, wisdom and good judgment (Kiszely (2009). Military organizations rely on education and training to prepare individuals and groups to perform extremely difficult tasks with very high levels of expertise under stressful conditions.((Fletcher (2009)). Education helps military personnel decide when and how to apply knowledge and skills at all levels.

Acquisition of vast knowledge and training is necessary to become an Air Force fighter pilot. Furthermore, it is imperative for the skilled pilots to improve their knowledge and skills associated with flying, they need to learn and train themselves consistently. It takes approximately seven years to have a pilot capable of carrying out all tasks. During that period, a tremendous amount of knowledge such as Technical specification of aircraft, Aerodynamics, Rules of engagement, Tactics, Normal/Emergency procedures must be acquired and following skills through continuous training. It also requires continuous learning and training to maintain knowledge and skills even after becoming a skilled pilot. However, novice pilots often don't know what direction they should study and prepare for flight, and improved pilots find themselves somewhat skilled and are likely to fall into a mannerism that they no longer have the will to improve.

2.3.1 Research Activity of gamification

For the last 10 years, studies for the gamification have been going very fast in the academic and in the military field. Figure *1* gives an overview of the increase in writing on the

topic in google scholar search. With the topic of research on the Gamification rising steeply, It shows the similar rise in the military sector in applying gamification. Hamari, Koivisto, and Sarsa (2014) attributed the rise in research topics on gamification to the positive effects of increased user activity, social interaction and intrinsic motivation.

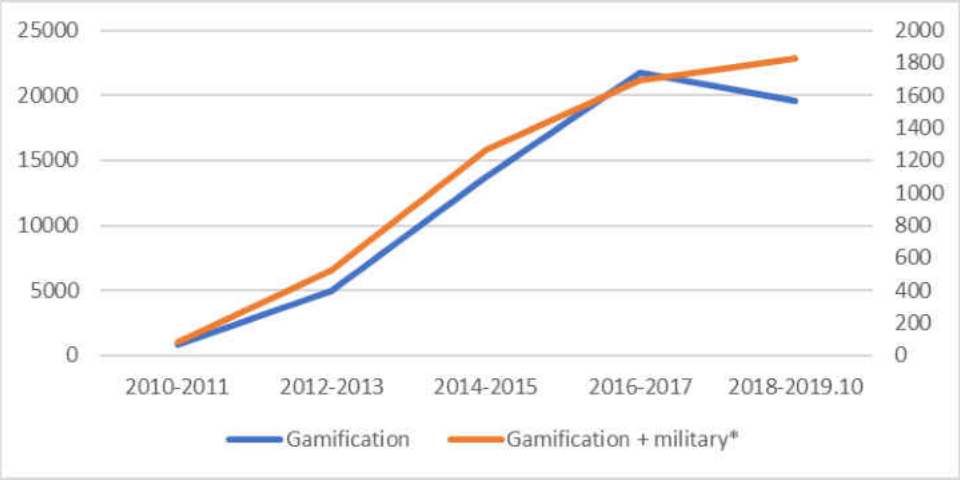

Figure 1 Search hits for "Gamification", "with military"

* Uses the right axis

When searched by each forces in the military area, Figure *2* shows that there has been a steady increase in research on gamification since 2010. As the growth rate appears to be slowing down but not decreasing since 2014, interest in gamification is seen as continuing. While the Air Force and Navy's research on gamification appears to be quite small in terms of quantity compared to the Army, it is believed that this is because the amount of content for application to gamification is relatively small compared to that of the Army.

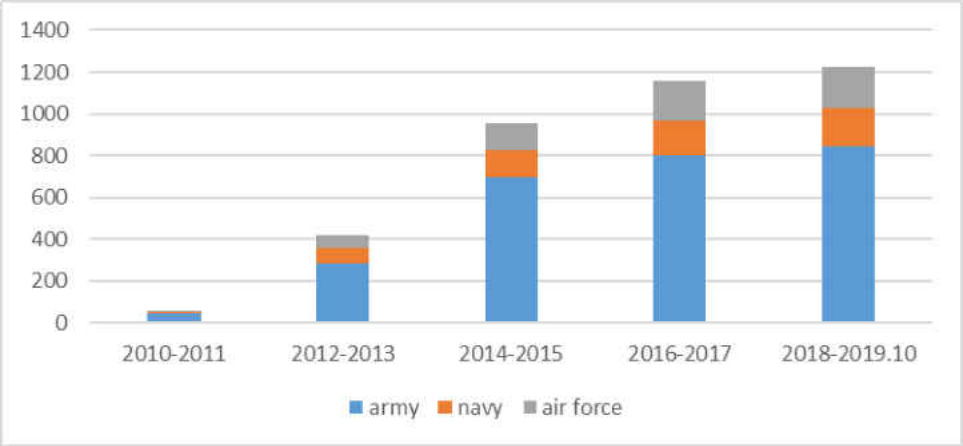

Figure 2 Search hits for each forces

Figure *3* shows that research that has been mentioned in both gamification and simulators also shows a steady increase, but has slowed down to the start of 2016. And studies related to flight simulators and flight simulators + military sectors also show a decline since 2016. However, the data for 2018-2019 is considered more consistent than reduced because the data for 2010-2019 are not fully aggregated, meaning the activity of the related study has reached its peak.

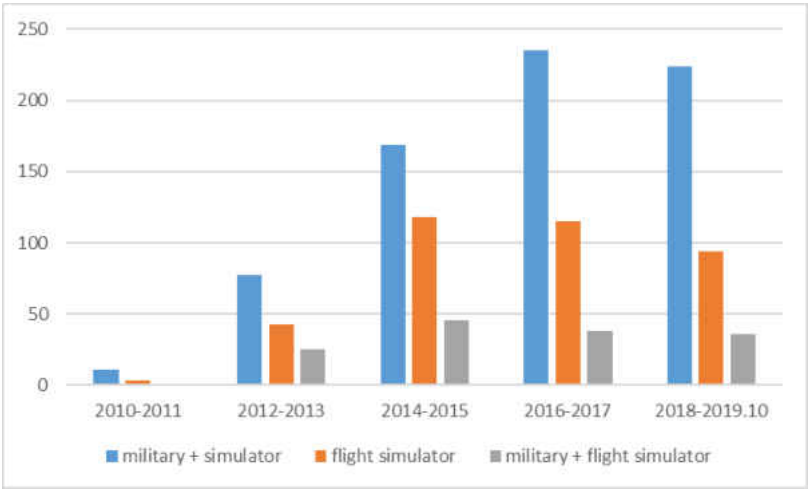

Figure 3 Studies on the Gamification in Relation to the Simulator

Research on the application of independent gamified elements related to flight simulators is being found somewhat, but no paper on the overall application of gamified elements of flight simulators for pilot training could be found. Therefore, a study on the overall concept of how to apply gamified elements to flight simulators will be significant.

2.3.2 Definition of Game

It is necessary to look at the various definitions related to the game first before defining the gamification. As the video game industry develops along with the development of computer technology, People are often reminded of video games when they hear the word "game". This is because the way they play with digital games is in line with the definition of a game.

2.3.2.1 Game

Suits (1967) defined a game as "an activity directed toward bringing about a specific state of affairs, using only means permitted by specific rules, where the means permitted by the rules are more limited in scope than they would be in the absence of the rules, and where the sole reason for accepting such limitation is to make possible such activity". This definition indicates that it is significant to set rules and to engage in certain activities within them. More to relate to digital games, Sid Meyer said a game is a series of interesting and meaningful choices made by the player in pursuit of a clear and compelling goal. However, not everyone agrees with this definition. Bateman (2008) said not all games require choice or decision. In some cases, the players perform repetitive motions such as playing a game that deals with musical instruments to strengthen certain related skills or get scores to compete. Both are necessary factors for the

characteristics of the gamification of flight simulator. In the book 'Art of Game Design', Schell (2019) listed the following characteristics of the game: games are entered willfully, interactive and have goals, conflict, rules, win/lose, challenges and create their own internal value. Among them, goals, rules, and interactions are common to most games (Kim, Song, Lockee, & Burton, 2018). Charsky (2010) mentioned training always has goals and requires appropriate levels to successfully carry out a particular mission. In terms of the flight simulator, it's not just a few training sessions, but gradually it becomes more difficult, starting with the most basic aerodynamics and understanding of aircraft systems and basic flight skills. In addition, successful missions require interaction with various agents and other flight elements, understanding the rules required for flight and combat, and performing missions within them. This series of processes is similar to the characteristics of the game. But these features are just a way to play. The reason people get hooked and become immersed in the game is that it gives players a desire for competence, autonomy, and relatedness in the SDT theory (Rogers, 2017).

2.3.2.2 Serious Game

A serious game is a game developed for a purpose other than entertainment (Ulrich & Helms, 2017). Zyda (2005) said that the consequences of applying games and simulations technology to the non-entertainment sector are serious games. What separates serious games from common games or education/learning is the addition of value through educational components within the value of entertainment (Ritterfeld, Cody, & Vorderer, 2009). In other words, a game can be classified as a serious game if they are given any other purpose than entertainment, such as education, training, information transfer, or public relations. (Lim & Jung,

2013; Michael & Chen, 2005). However, since the realm of game itself focuses on playing based on entertainment, even if the main purpose is something other than entertainment, the term "game" will not be able to be used without this component. Because to achieve certain goals more effectively, a game is used to capitalize on the main positive features of the game which is called motivation and immersion. Meanwhile, learning in the serious games can be called game-based learning. Military often uses commercial military games for their various purposes. Even in the U.S. military, commercial off-the-shelf games such as America's Army, Delta Force, Steel Beasts, VBS, and Falcon 4.0 have been used for general, familiarization or tactical training (Korteling, Helsdingen, & Sluimer, 2017; Mead, 2013). Therefore, it is necessary to understand and apply game characteristics even if serious games are used for other purposes.

2.3.3 Gamification

Deterding, Dixon, Khaled, and Nacke (2011) defined the Gamification as *"the use of game design elements in non-game contexts."*.

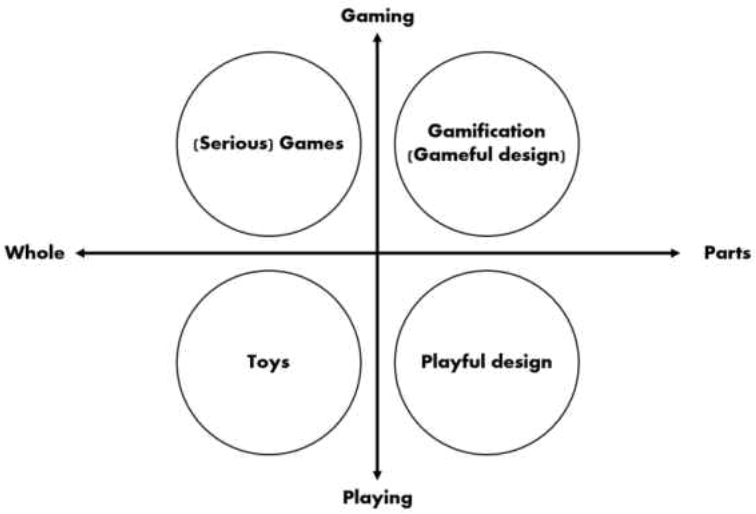

Figure 4 Gamification between game and play, whole and parts (Deterding et al. 2011)

In Figure *4*, each definition was distinguished by the use of gaming or playing, and by whether each feature is used entirely or partially. It is undeniable that the serious game itself is within the framework of the game, even though the distinguishing feature of the serious game is for other purposes than entertainment. Instead, the term "gamification" can be understood as a concept of accepting key positive features of games in line with its main objectives and goals rather than seeking other purposes in the game. As this definition suggests, they associated gamification with game itself, not play, and emphasized game design elements rather than playfulness. While playing is as a free form, it can be said that freedom is high because it consists of different combination of behaviors, gaming focuses on specific playing structured by rules to achieve its goals (Barr, 2008). In other words, a gamified system design is to exclude a playfulness that can exist in a variety of forms and focus on one extreme play so that it can elicit certain effects.

Kim et al. (2018) defined the Gamification in learning and education as the activities and processes of solving problems related to learning and education by applying or using the characteristics of the game mechanics. Unlike Deterding et al.(2011), he saw serious games can be included in broad definition of gamification. And the purpose of the gamification is to create a real world environment that supports learning.

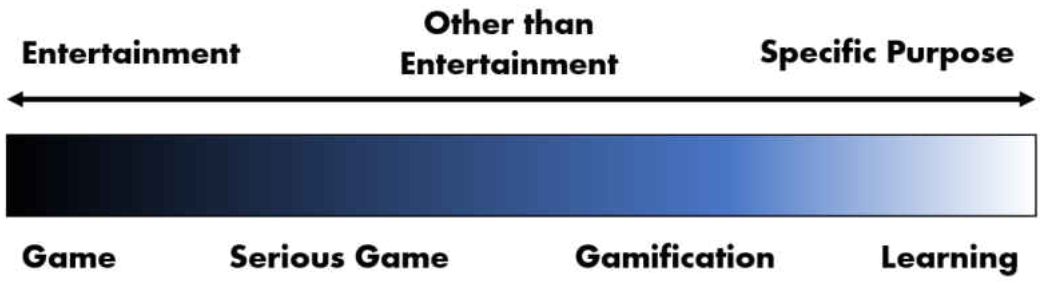

Figure 5 Continuum of Gamified Learning and Education

However, The Gamification can be seen as present in the continuum of entertainment and certain purposes. This is because if there are any game elements in military simulation, war games, and simulator training, all of them can be classified as serious games mistakenly even though they are originally made for only training or simulating. Because of that, when distinguishing between serious games and gamification, it is appropriate to divide the definitions by finding the purpose of learning in a game or integrating gamified elements for the purpose of learning.

2.3.4 Theories for Gamification in learning and education

Kim et al. (2018) suggested that the following things can be expected when gamification is applied to learning and education.

- Increase student engagement and motivation.
- Enhance learning performance and academic achievement.
- Improve recall and retention.
- Provide instant feedback on students' progress and activity.
- Catalyze behavioral changes.
- Allow students to check their progress.
- Promote collaboration skills.

Individuals can gain the benefits of motivation and feedback, the retention of knowledge, and the changing behavior of individuals through gamification. It also enhances team-level collaboration skills as well as just improving individual performance. In fact, for a variety of

studies and research for gamification is being undertaken, Mayo (2009) compared the learning outcomes of several games for specific learning to lectures on the same subject, showing that they had significantly greater effects in algebra, geography, and biology etc. Yunyongying (2014) stated that more than 20 % increases in confidence for military trainee compared to traditional methods, increase of 14 % of procedural knowledge, 11 percent increase in knowledge recall, and 9 percent greater retention of knowledge. Therefore, It needs to be looked at the theories behind these gamification.

2.3.4.1 Motivation Theory

Motivation is one of the factors that has the greatest impact on the success of gamification. This is because the purpose of the gamification itself is to promote learning and education through motivation. Motivation can be divided into two types: intrinsic and extrinsic motivation.

Intrinsic motivation can be aroused by an individual's pleasure, curiosity, or interest. (Deci & Ryan, 2010). They define intrinsic motivation as "the doing of an activity for its inherent satisfactions rather than for some separable consequence". An internally motivated individual has an active motivation because he or she feels satisfied with any action or effort, regardless of the outcome or rewards.

Extrinsic motivation is caused by environmental and external factors, such as pressure, punishment, or rewards. Deci and Ryan (2010) define extrinsic motivation as "a construct that pertains whenever an activity is done in order to attain some separable outcome". If an individual can be given external stimulation, such as compensation or punishment, he or she has a passive

motivation because they act to get the reward or avoid punishment. Extrinsic motivation needs to be approached carefully because it is essentially done by external stimuli, so that when external factors disappear, the motivation can be eliminated or internal motivation can be reduced by this external stimulus (Warneken & Tomasello, 2008).

One analogy here is that intrinsic motivation in which person already has may be weakened by external factors, but a person who does not have it may be exposed to certain circumstances by doing something by external motivation, resulting in the acquisition of a positive intrinsic motivation. For example, if a parent promises to give a child a dollar for each book he reads, the child would read to get that dollar. However, being fascinated by the stories and information that the book conveys while reading, reading books may become a habit for him/her without external stimuli.

2.3.4.2 Self-Determination Theory(SDT)

Self-determination theory is a macro theory of motivation based on the assumption that people's volition and motivation can be influenced by their environment, including social and cultural factors. It makes the above concepts of extrinsic and intrinsic motivation clearer. According to the theory of self-determination, individuals tend to grow by their innate psychological needs, such as autonomy, competency and relatedness (Deci & Ryan, 2008).

To encourage autonomy in pilot training, it would be more effective to give pilots the opportunity to make decisions on their own by providing available useful resources with a variety of possibilities in mind, rather than giving fixed direction and training mission. By

developing various types of scenarios and contents that can be actively trained in training, pilot autonomy will be able to maximized (Niemiec & Ryan, 2009).

Competence is also linked to motivation. When individuals believe they can do something well, they can be more motivated. However, if a given task is too easy, they may not have the opportunity to reveal their skills and thus may not be motivated. So to be motivated by competency, an appropriate level of challenge may be required to match the abilities of individuals at present (İHSAN, Ekici, Soyer, & Eskiler, 2015). When applied to pilot training, scenarios and curricula need to be created depending on pilots' skill level and training on increasingly difficult missions should be carried out as pilot skills develop.

Relatedness is a sense of belonging, and people tend to accept and internalize their own values and training when they experience the feeling that they belong to something and somewhere (Niemiec & Ryan, 2009). During simulator training, It is possible to make groups like battalions or squadron, such as guilds or clans in online games, to make them feel a sense of belonging. And also it can be contributed to enhancing the training effect by creating various kinds of devices that take into account the traditions, environment, and culture of each group.

As you can see in Figure *6*, motivation is largely divided into amotivation that represents lack of motivation, and extrinsic / intrinsic motivation. Deci and Ryan (2010) subdivided external motivation into four levels of regulation level. Starting with the most basic controlled motivations, individuals could have more autonomous motivation by absorbing the regulations into the environment, social, and cultural contexts and internalizing values and goals within them. The process of internalizing motivation and regulations depends on the environment and

individual characteristics, but these concepts will help pilots engage in training more actively and set goals.

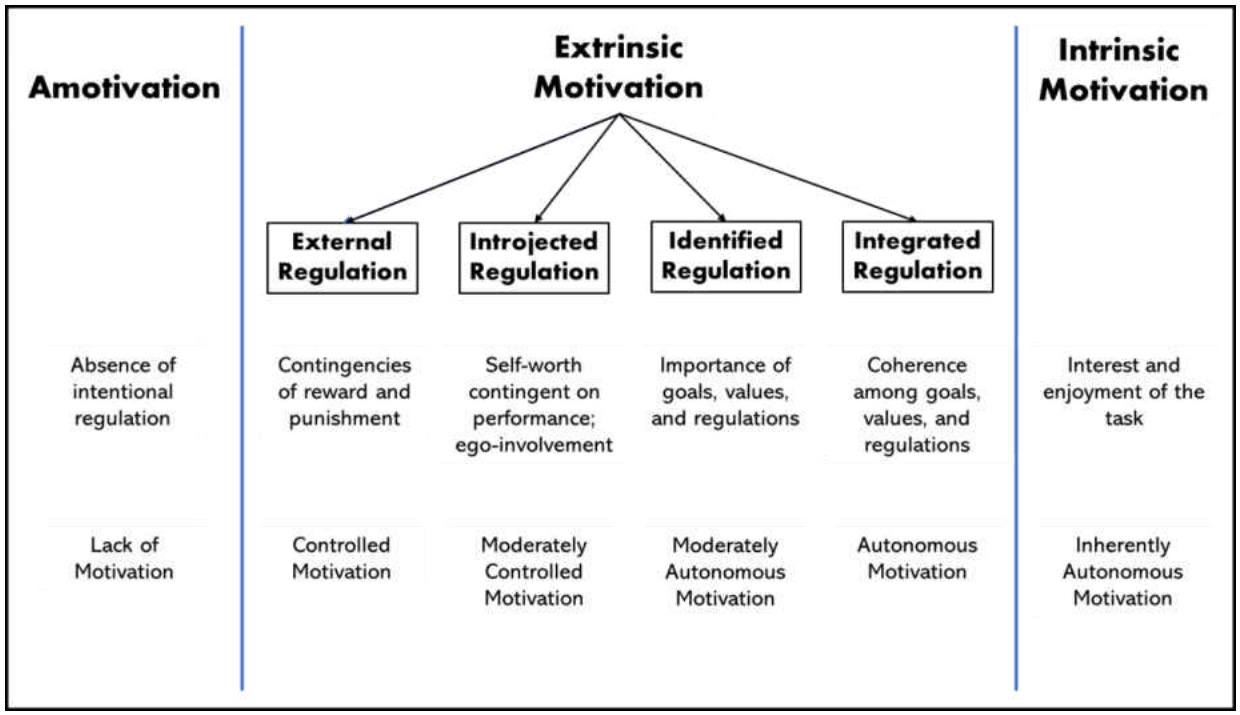

Figure 6 The self-determination continuum (Deci & Ryan, 2010)

2.3.4.3 Achievement Goal Theory

The achievement goal theory is the theory that individuals can be motivated to achieve a individual's goal, which is closely related to motivation . (Barkoukis, Ntoumanis, & Nikitaras, 2007). Dweck and Leggett (1988); Nicholls (1989) distinguished the two independent achievement goals; a task and ego goal orientation. A person with a high task goal orientation determines their ability within themselves as to achieve his or her own personal improvement and mastery, while a person with a high ego orientation conducts activities to achieve his superiority and outperform through comparison with others. Along with his criticism of these dichotomous thinking, Elliot (1997) proposed a trichotomous goal approach that consisted of a

masterly goal and two performance objectives. While the ego goal is to show superiority to others, Elliot suggested that it is also aimed at avoiding showing incompetence to others by dividing it into performance approach goal and performance avoidance goal. This theory has been widely used to understand the motivation of youth sports and physical education, which could also be used for pilot training. For example, an internally motivated pilot will approach achieving his goal by continuously upgrading his skills through simulator training with sufficient training content. On the other hand, a device can be mounted on the simulator interface to indicate a leaderboard or ranking for pilots who are not fully equipped with an intrinsic motivation but do not want to show that they are lacking skills compared to other pilots or pilots who want to demonstrate superiority to others.

2.3.4.4 Feedback

Feedback is sort of information provided by an agent regarding aspects of an individual's performance or understanding (Hattie & Timperley, 2007). Feedback is therefore a result of performance and the agent is the medium that delivers it. It is necessary to set a more cautious approach because feedback affects motivation a lot depending on how it is conveyed.

Feedback can be divided into positive and negative feedback depending on the feelings of the information provided about an individual's performance. Burgers, Eden, Van Engelenburg, and Buningh (2015) found in a study on how feedback promotes motivation that negative feedback reduces feelings of a player's competency and autonomy needs, while increasing immediate game play. They believe that positive feedback satisfies the need for competence and autonomy, thereby promoting intrinsic motivation.

Feedback types can also be divided into descriptive, comparative, and evaluative types. Descriptive feedback is a sum of an individual's attitude or behavior based on observational data or player's own input. Comparative feedback is to provide social comparison information by comparing an individual's performance with those of others. Evaluative feedback is the addition of judgement to an individual's performance (Hawkins, Kreuter, Resnicow, Fishbein, & Dijkstra, 2008). Each type of feedback can have a different effect depending on the feedback balance. However, evaluative feedback is seen as more persuasive than descriptive feedback when clearly specifying both the evaluations and evaluated behaviors (Johnson, 2013).

The Table *4* below shows an example of the type of feedback that can be applied to the flight simulator. How the pilot can give feedback according to the time it takes to start the engine of the flight simulator is divided by type. The situation in the example is divided by type how feedback can be given to the pilot, depending on the time it takes for the flight simulator to start the engine. Descriptive only provides simple facts, and comparative compare to the average performance of other pilots, and evaluation types determine and make directions according to specific criteria.

Table 4 Example of types of feedback applied for flight simulator

Type of feedback	Positive feedback	Negative feedback
Descriptive	You completed the procedure in 5min. You passed the test.	You completed the procedure in 8min. You failed the test.
Comparative	You completed the procedure in 5min. You are faster than average.	You completed the procedure in 8min. You are slower than average.
Evaluative	You completed the procedure rather quickly. You did good. Keep it up.	You completed the procedure rather slowly. Try to be faster next time.

When it comes to feedback timing, it can be divided into delayed and immediate feedback. Delayed feedback facilitates the retention of information learned during the performance, but only if the content includes meaningful matter usually encountered during the performance. Instead, immediate feedback was seen as more effective when it was difficult to acquire knowledge or to fully understand its contents (Kulhavy, 1977). However, excessive use of immediate feedback can cut and disrupt the flow of individual's performance (Scheeler, Ruhl, & McAfee, 2004). Therefore, it is more effective to use immediate feedback for correction when an error occurs and not to provide feedback when the performance is normal (Gilman, 1969). Cohen (1985) stated that descriptive(informational) feedback had the best effect after an inaccurate response assuming that sufficient information is provided for individuals to take the correct action. Therefore, it can have the best effect by providing immediate descriptive feedback to individuals' inaccurate actions.

2.3.4.5 Experiential Learning

Keeton and Tate (1978) define experiential learning as learning in which the learner is directly in touch with the realities being studied. Lewin (1951) presented a model for experiential learning. An immediate concrete experience is the basis of observation and reflection. This observation is fused with the theory as a new implication in which actions can be drawn. This implication serves as a guide to action to create a new experience.

He emphasizes the 'here and now' experience to make the abstract concept valid. An immediate personal experience is the center of learning. It also provides a concrete, public-shared reference point to test the validity and implication of ideas created during the learning

process. He also emphasizes the feedback process. Many individuals and organizations are said to be ineffective due to the lack of adequate feedback processes. Information feedback provides the basis for the continuous process of goal-oriented action and the evaluation of the results of that action.

From the pilot's point of view, the process of applying the knowledge gained from text or illustrations to actual flight training can be described as experiential learning., the objectives and the goal of missions can be tested in one's own training after understanding and generalizing the concept of training by identifying technical guide books, lectures, simulators, and video clips that have been recorded in actual/training battlefields. Their experiences become new experiences and knowledge.

Figure *7* shows the experiential learning model for pilots.

Figure 7 The Experiential Learning Model for Pilots

Harris, Heneghan, and McKay (2003) concluded that when knowledge gained is not directly relevant or applicable to clinical contexts, it is lost rather quickly. In this experiential

learning model, the process of solidifying the knowledge gained from education or learning is very important and has great training effects when it can be experienced right away without a time delay. This is why an integrated flight simulator with gamification is considered an essential requirement in order to successfully transition the training experiences to manage the actual combat environment. This new knowledge and experience allows the pilot to have a more complex level of decision-making and situational awareness. On top of that, as Lewin suggests, an important part of this is feedback. Objective feedback must be provided for the knowledge they have trained and accumulated to be positive experience and knowledge. Therefore, it is necessary to study how the feedback can be provided and positively affect the trainees.

2.3.4.6 Knowledge Retention

Friedrich Nietzsche said that "Man will desire oblivion rather than not desire at all." Unfortunately, oblivion is obstacle for pilots who need to know countless tactics, rules and procedures and are constantly training to maintain their flight skills. Therefore, further training investment is required to maintain these skills as well as the cost of bringing pilots to operational proficiency levels in initial training (Prophet, 1976). Pilots who constantly maintain and enhance flying skills in their squadron are relatively free to retain knowledge and skills, but as officers, pilots are not only able to fly, but also they are often given various kinds of education, work in command, and work far from the flight environment. For these pilots, it is not easy to maintain the skills that can be immediately put into battle. However, not all skills and knowledge quickly degenerate. Arthur Jr, Bennett Jr, Stanush, and McNelly (1998) have found evidence that performance on physical, natural and speed-based tasks is less susceptible to decay than

performance on cognitive, artificial and accuracy-based tasks. It's like riding a bike again after a long time after learning how to ride it doesn't get very rusty. Similarly, a task that is artificial, like computer coding, and cannot be naturally associated with it in its head, can be considered to be decayed over time. This is in line with what Svensson, Angelborg-Thanderz, Borgvall, and Castor (2013) said was the skills on aircraft handling or maneuvering retained longer than dealing with radar control or weapons systems. Now, as compared to the past, the kind of skills that pilots deal with today is a cognitive oriented skills such as sensor / radar handling, complex decision making, and weapon system handling. Desktop computer-based flight simulator can be an alternative for training in the form of enhancing cognitive abilities. Because they can experience and repeat different types of scenarios on their own, and actively learn about situational awareness and battlefield management methods that vary depending on each scenario. Other training for aircraft control, maneuvering, and instinctive senses will be available through fully equipped simulators or live training that are better equipped for vision, touch and hearing.

Like repetitive procedural mastery and training, the acquisition of military-related knowledge , and the retention of that knowledge, the pilot requires constant learning and training throughout his/her flight life. It would be good if all pilots actively do their best to boost their flight skills and military knowledge, but there are times when they neglect training for their respective reasons. Among them, concern about work-efficiency is one of the ideas people feel. Many people often feel bored and useless about repetitive and simple tasks. People are especially more resistant to overlapping duties or excessive administrative work. In that sense, pilots are not much different. Memorizing procedures and mastering them over and over again is a very dull and tedious task. In addition, due to the unintegrated training system, in addition to receiving

pre-planned academic training related to military knowledge and emergency procedures, other similar kinds of training may take place as directed by the superiors, or extra workshops or lectures may be held. However, performing procedures instinctively through repetitive memorization is also a skill the pilot needs.

2.3.4.7 Conclusion of Theories for Gamification

As Kim et al. (2018) mentioned, gamification is closely related to motivation. In order for the gamification to be integrated into the flight simulator and to have the intended effect, it will need a device that can boost intrinsic and extrinsic motivation. Furthermore, proper scenarios and interface designs should be created to show pilots' competence while ensuring autonomy according to SDT theory. Similarly, relatedness is an important element of SDT, so a device that can feel a sense of belonging to specific group in the design of the simulator interface is needed. The achievement goal theory, closely related to SDT, can be combined with feedback theory, such as masterly goal related to intrinsic motivation and comparable performance with others, and organic and objective feedback should be designed according to experiential learning model and knowledge retention theory.

2.3.5 Gamification Characteristic

Gamification design is very different from game design. The biggest reason is that while gamification is used to increase participation in various environments, games are used for pure entertainment purposes. Therefore, not all game design elements can be applied to the

gamification design. However, to see what can be applied to a gamification, it is necessary to checkout a lot factors that make the game plausible.

Reeves and Read (2009) suggested 10 elements to create a successful game design. Each component is as follows; self-representations, three-dimensional environments, narrative, feedback, reputations, ranks and levels, marketplaces and economies, competition under rules, teams, communication and time pressure. Da Rocha Seixas, Gomes, and De Melo Filho (2016) created an indicator called the energy indicator, which are as follows; autonomy, execution, social, delivery, participation, collaboration, cooperation, questioning, organization of the environment, fun.

Meanwhile, Korhonen, Montola, and Arrasvuori (2009) presented a framework called PLEX(Playful Experience) that can be found in games. They categorized the playful experience into 20 types; captivation, challenge, competition, completion, control, discovery, eroticism, exploration, expression, fantasy, fellowship, nurture, relaxation, sadism, sensation, simulation, subversion, suffering, sympathy, and thrill. This PLEX framework comes from analyzing different kinds of games and can be considered to include almost any kind of experience. And it includes all sorts of emotions that people can experience in the real world as well as in the games. Charsky (2010) viewed the game's intrinsic purpose as being motivated and entertaining, and defined the game's characteristics of the game as follows; competition, goal, rules, choices, challenges, fantasy.

While the elements and characteristics of the game vary depending on the viewing angle or the purpose, it cannot be denied that these factors motivate the player and enable sustained play. Here are the summary of game characteristics that make individuals motivate and play.

- Considerable feedback leads to ongoing challenges with a given purpose and rule
- Feedback type of comparison that could lead the competition.
- Social interaction as a group system that leads to cooperation
- Induce various emotions within the story
- Choice to Drive Autonomy
- A device that affording them a sense of immersion

2.3.6 Gamification Framework

2.3.6.1 MDA framework

A framework is needed to view the various features of game and gamification in a systematic way. The most widely known of the various frameworks on gamification is the MDA framework proposed by Hunicke, LeBlanc, and Zubek (2004). The MDA framework consists of mechanics, dynamics, and aesthetics, each representing rules, system and fun.

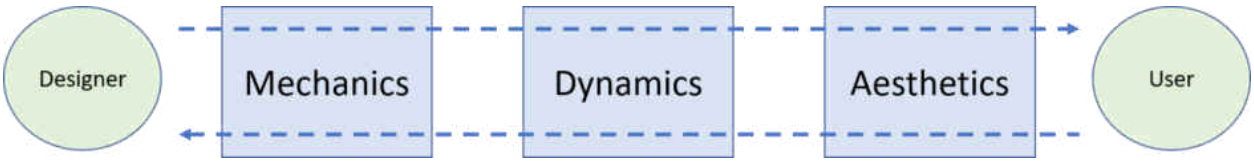

Figure 8 MDA framework (Hunicke et al, 2004)

The mechanics defines the actions or rules allowed to the player within the game by depicting specific elements of the game at the data representation and algorithm level.

The dynamics is real-time behavior of mechanics according to the expression of the players' input and other's output, which refers to the results of the player's choices and actions on the game over time.

The aesthetics is a desirable emotional response that can occur in players as they interact with the game system. It is a device that can elicit emotions such as cooperation, competition, along with personal desire for achievement in the framework created by mechanics and dynamics.

Each element is closely related to each other. From the designer's point of view, the mechanics influences the dynamic system behavior, which leads to a particular aesthetic experience. From the user's point of view, the user sees something aesthetics through the designer-generated dynamics, which in turn comes from a operable mechanics. Hunicke et al. (2004) emphasized that the interaction between designers and users, as seen in Figure *8*, should provide experience to users, and that minor changes in each element could come as a big difference for users.

2.3.6.2 Integrated Gamification framework

Kim et al. (2018) presented an integrated gamification framework in the form of a pyramid, combining various kinds of other gamification frameworks and terms. He arranged each element according to the experience that users could grasp directly from the actual play.

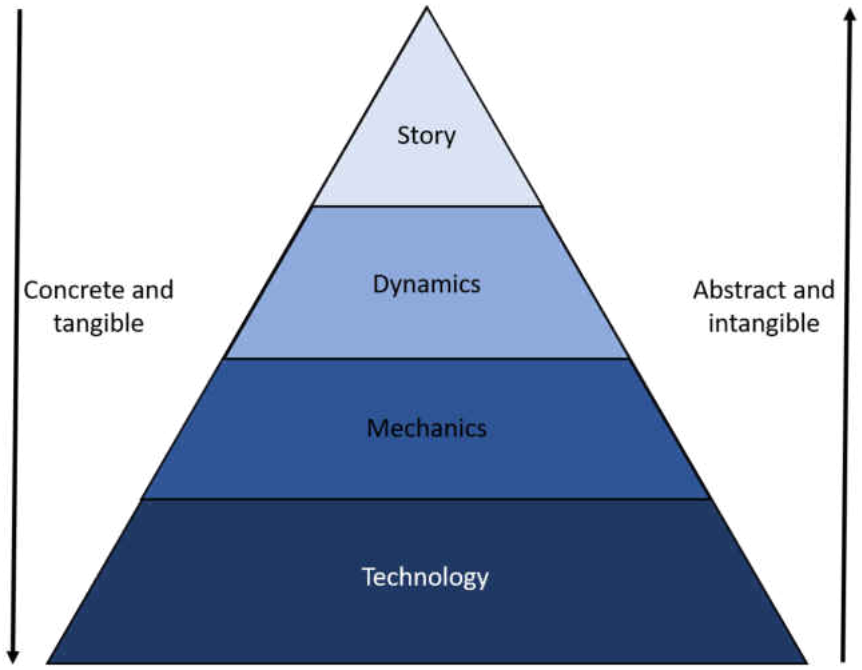

Figure 9 Integrated gamification framework (Kim et al. 2018)

In gamification, Story offers an important process in leading education and training programs. Through a series of stories, users can go through a phased challenge with a variety of fun. Bopp (2008) suggested the term virtual extrinsic motivation. The external motivational process of storytelling involves a single operator who is immersed in a fictional interactive world that can acquire and learn the necessary knowledge as it participates in the story and performs certain tasks in the face of various situations.

Dynamics combines the 20 PLEX elements presented by Korhonen et al. (2009), and motivates users to engage in learning through the fun derived from the Story. The definitions of each component are as follows.

- Captivation: Experience of forgetting one's surroundings
- Challenge: Experience of having to develop and exercise skills in a challenging situation

- Competition: Experience of victory-oriented competition against oneself, opponent, or system
- Completion: Experience of completion, finishing, and closure, in relation to an earlier task or tension
- Control: Experience power, mastery, control, or virtuosity
- Discovery: Experience of discovering a new solution, place, or property
- Eroticism: Experience of sexual pleasure or arousal
- Exploration: Experience of exploring or investigating a world, affordance, puzzle, or situation
- Expression: Experience of creating something or expressing oneself in a creative fashion
- Fantasy: Experience of make-believe involving fantastical narratives, worlds, or characters
- Fellowship: Experience of friendship, fellowship, communality, or intimacy
- Nurture: Experience of nurturing, grooming, or caretaking
- Relaxation: Experience of unwinding, relaxation or stress relief, calmness during play
- Sadism: Experience of destruction and exerting power over others
- Sensation: Meaningful sensory experience
- Simulation: Experience of perceiving a representation of everyday life
- Subversion: Experience of breaking social roles, rules, and norms
- Suffering: Experience of frustration, anger, boredom, and disappointment typical to playing
- Sympathy: Experience of sharing emotional feelings
- Thrill: Experience of thrill derived from an actual or perceived danger or risk.

This is a kind of story-making component. When these components melt into a story, they can motivate users and make them play.

Mechanics is the implement of Dynamics at the data and algorithm level. Users receive feedback and rewards through Mechanics elements. Kim et al. (2018) presented the Mechanics elements based on research from Duggan and Shoup (2013); Kapp (2012); Kumar (2013); Schell (2014); Zichermann (2013). Table *5* shows each categories and mechanics.

Table 5 Mechanics elements (Kim et al. 2018)

Categories	**Mechanics**
Rewards	Point, level, progression, badge, authority, virtual good, physical good, discontinuation, gifting, free lunch, and virtual currency
Rewards Schedules	Fixed interval reward schedule, fixed ratio reward schedule, variable interval reward schedule, and variable ratio reward schedule
Avoidance	Discouragement and leaky bucket
Leaderboard	Macro leaderboard, micro leaderboard, indirect competition, and direct competition
Status	Avatar and social network
Quest	Unlocking content, countdown, lottery, communal discovery, and scaffolding

The Table *6* shows rearranged Mechanics categories according to motivation and feedback type. The Mechanics consist of elements that properly stimulate intrinsic motivation and extrinsic motivation through positive and negative feedback enabling players to check their level and status to challenge themselves as well as making them continuous and phased challenges for the rewards.

Table 6 Classification of Mechanics Elements by Motivation and Feedback

	Positive (Encourage)	**Negative (Avoid)**
Intrinsic (Challenge)	Progression, indirect competition, Avatar and social network, Unlocking content, communal discovery, and scaffolding.	Discouragement, Macro leaderboard, micro leaderboard, direct competition, countdown, leaky bucket
Extrinsic (Rewards)	Point, Level, Badge, Virtual good, Physical good, Free lunch, Gifting, Virtual currency, lottery, variable interval reward schedule, and variable ratio reward schedule	Fixed interval reward schedule, Fixed ratio reward schedule, Discontinuation

The Mechanics of encouraging a particular action or mission can be put into "Positive" and the Mechanics of being wary of avoiding or falling behind can be put into “Negative”. Intrinsic motivation basically applied mechanics to stimulate individual’s own will to challenge and competitive spirit, and extrinsic motivations applied mechanics through virtual, physical and psychological rewards.

Technology is an overall gamified system that allows Mechanics to be seen and touched by users, including hardware, software, networks and other objects. In the case of a flight simulator, for example, hardware refers to the flight simulator equipment itself including VR, AR devices, monitors, and beam projectors, and software is a program that allows players to perform a mission or training in it. The network is intended to be internally connected with pilots and other flight-related personnel other than pilots so that they can operate and influence each other, while other objects refer to the various facilities and maintenance personnel required for training.

2.3.6.3 The Octalysis Gamification Framework

Chou (2019), who has studied and worked on games, serious games, and gamification for more than a decade, created the Octalysis Gamification Framework with eight main categories by bringing a myriads of game techniques(mechanics). While most systems in society focus on functional aspects, this framework presents human-focused designs. Motivation forces the user to use the system in one or multiple system. Even if it's what they want or is forced to do by others, it can be divided into some sort of positive / negative motivation and extrinsic / intrinsic motivation. The eight core drives are more detailed motivational methods that allow users to take

desired action. The author says it can include all phenomena in society and factors that cause human expected behavior. Figure *10* shows each core drive within the Octalysis framework and the various techniques associated with it. The 8 core drives are as follows:

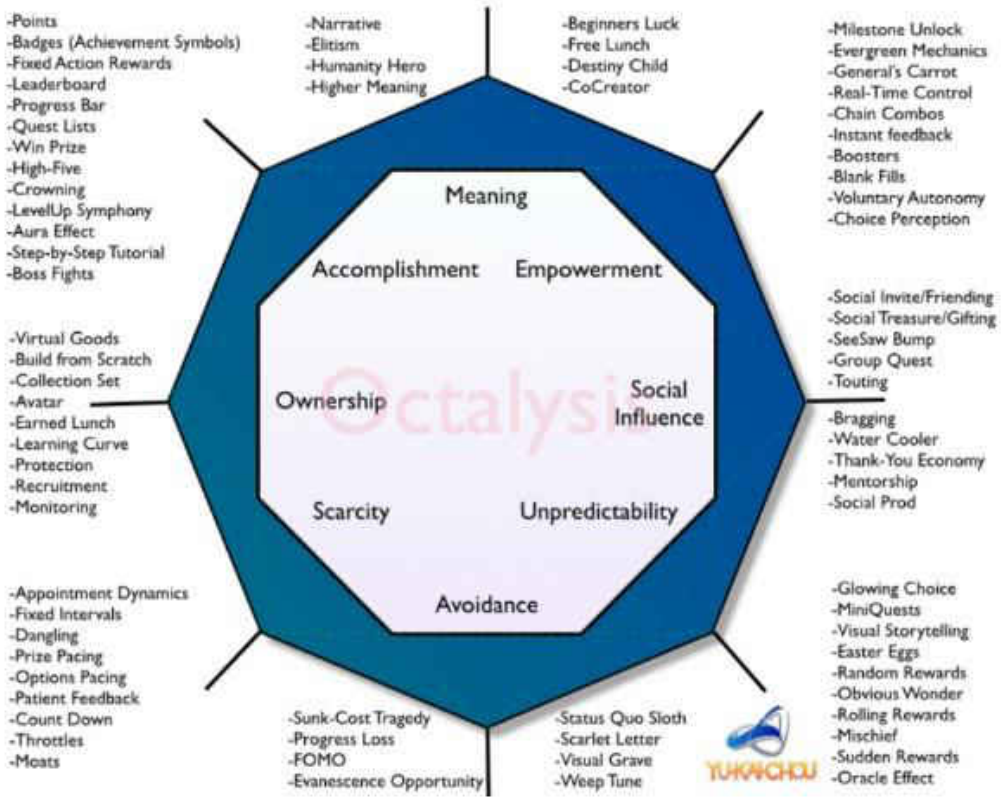

Figure 10 The Octalysis Gamification Framework (Chou, 2019)

1. Epic Meaning & Calling: To believe that one person in a play is doing something great or that he or she is chosen to take certain actions
2. Development & Accomplishment: Internal drive for making progress, developing skills, achieving mastery, and eventually overcoming challenges.

3. Empowerment of Creativity & Feedback: To engage in a creative process in which one can discover new things and make various combinations. And not only do they need ways to express their creativity, but to want feedback soon as a result of their creativity.
4. Ownership & Possession: That a person can be motivated when they feel they own or control something.
5. Social Influence & Relatedness: This drive incorporates all the social elements that motivate people including mentorship, social acceptance, social feedback, companionship, and competition and envy.
6. Scarcity & Impatience: Simply wanting something because it is very rare, exclusive, or it cannot immediately be obtained.
7. Unpredictability & Curiosity: Continuous immersion because people don't know what will happen next
8. Avoidance & Loss: avoiding something negative happening

Chou (2019) also divided it into the 'left and right brain' for conceptual understanding and explained the extrinsic and intrinsic motivations according to the nature of the motivation. Drives with respect to achievement, ownership and scarcity in the left brain realm are those that stimulate extrinsic motivation. One individual may be motivated to get something that is a goal, an object/good, or something that is not easily obtainable. On the other hand, creativity and feedback, social influence and unpredictability in the right brain realm stimulate intrinsic motivation. people enjoy essentially creating things, and at the same time are social animals and are attracted to certain things that cannot be expected.

In addition, Chou (2019) divided each drive top and bottom and named it White Hat and Black Hat Gamification. The White Hat is considered a positive motivational realm and the Black Hat is considered a negative motivational realm. When an individual is involved in something, if it allows them to express their creativity and gives them a sense of meaning or a feeling of great achievement through skill mastery, it will make them feel very good and powerful. On the other hand, if an individual continues to have fear that he or she will lose something, that he or she don't know what will happen next or that something will not be easily gained when doing something, it will be a negative experience, even if he or she is constantly motivated to take the actions. Figure *11* and Figure *12* show how external motivations and internal motivations are divided from left to right, and positive motivations and negative motivations are divided from top to bottom.

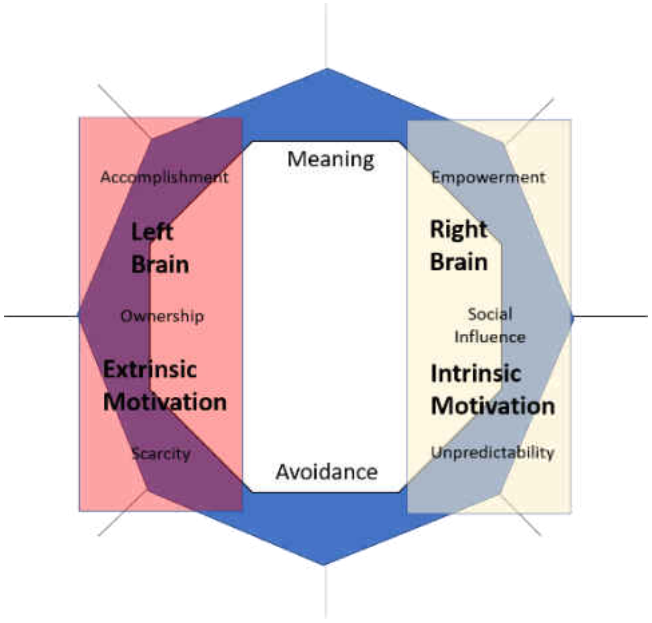

Figure 11 Left and Right Brain realm

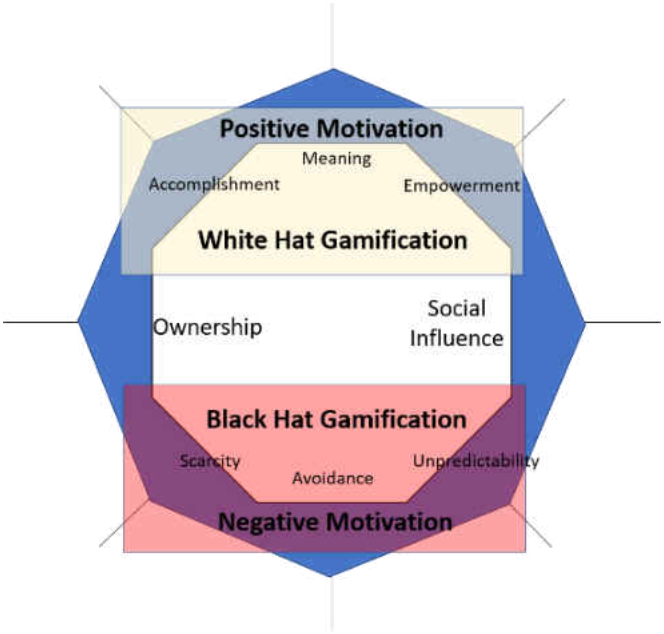

Figure 12 White and Black Hat Realm

One interesting thing is that this Octalysis framework can explain most of the different theories about behavioral economics, motivational psychology, neurobiology and feedback.

Through academic experiments and surveys, controlled variables and limited comparisons, the following various theories have been presented, and each theory can be applied to the core drives in the Octalysis Framework. The widely known Self-Determination theory (Deci & Ryan, 2008) is that from a long-term perspective, it is more motivated to do anything or activities that can satisfy something internally than simply external rewards and punishments. Competence, Relatedness and autonomy in this theory are in accordance with core drives that represent the Accomplishment, Social Relatedness and Creativity of the Octalysis framework.. Flow theory (Nakamura & Csikszentmihalyi, 2009) shows the flow of skill level to challenge rather than dividing type, but it can also be explained by the definition of core drives 2 through 8.

Fogg (2009), which presented a model that divides all behavior into three factors; motivation, ability, and a trigger, with details relating to motivation in line with core drive 2, 4, 5, 7, 8. In addition, interpretations of other behavioral and gamification models can be included in this Octalysis framework.

The most important thing in gamification is how to motivate individuals to use the system, but it is also necessary to pay attention to sustainability. , Chou (2019) distinguished the user's experience through four phase. These phases are:

- Discovery: Why people wound even want to try out the experience
- Onboarding: Where users learn the rules and tools to play the game
- Scaffolding: The regular journey of repeated actions towards a goal
- Endgame: How do you retain your veterans

2.3.7 A variety of Game Techniques into Octalysis Framework

Chou (2019) has already deployed many kinds of game techniques to each of the core drives within his own Octalysis framework. In addition to that, the Table *7* is a compilation of various kinds of game techniques that have already been defined in gamification theory or are considered similar. The framework of Kim et al. (2018) described above, the story, the dynamic and the mechanics, can all be aggregated into game techniques to classify as each core drive as well as data from Tondello et al. (2016) that studied applicable game elements according to user type,. The story itself gives meaning to the game, and 20 FLEX dynamics (Korhonen et al., 2009) is also a kind of technology that powers the story.

Table 7 Game techniques based on core drive

Core Drives	***Game Techniques***
Meaning	*Story, Narrative, Elitism, Humanity Hero, Higher meaning, Beginners luck, Free lunch, Destiny child, Cocreator, Fantasy,*
Achievement	*Point, Badges, Fixed Action Rewards, Leaderboard, Progress bar, Quest Lists, Win Prize, High-Five, Crowning, Level-up Symphony, Aura Effect, Step-by-step tutorial, Boss Fights, administrative roles, Learning, Certificates, Rank, Grades, Challenge, subversion,*
Creativity	*Milestone unlock, Evergreen Mechanics, General's carrot, Real-time control, Chain combos, Instant feedback, boosters, blank fills, voluntary autonomy, choice perception, development tools, mission/scenario creator, Discovery, Eroticism, Expression, Exploration, Sensation, simulation, Exploratory tasks, Nonlinear gameplay, Creativity tools, Customization, Innovation platforms*
Ownership	*Virtual Goods, Virtual Currency Physical good, Build from Scratch, Collection set, Avatar, Earned Lunch, Learning Curve, Protection, Recruitment, Monitoring, Control*
Social Relatedness	*Social Invite, Gifting, Seesaw bump, group Quest, touting, bragging, water cooler, Thank-you Economy, Mentorship, Social Prod, Competition, Q&A session, Knowledge sharing, Guilds or teams, voting mechanisms, Fellowship, Nurture, sympathy, Voting,*
Scarcity	*Appointment Dynamics, Fixed Intervals, Dangling, Options Pacing, Prize Pacing, Patient Feedback, Count Down, Throttles, Moats, Unlockable contents, rare contents, time-constraints contents,*
Unpredictability	*Glowing Choice, Mini Quests, Visual storytelling, Easter Eggs, Random Rewards, Obvious Wonder, Rolling Rewards, Mischief, Sudden Rewards, Oracle Effect, Thrill, Easter eggs, Lotteries, Games of chance*

2.4 Summary

The characteristics and types of simulators, various motivation theories and learning theories, and different gamification frameworks to develop the Gamification Framework of flight simulators have been identified so far. Developing a gamification framework with a specific purpose requires consideration of all of this and then systemized needs to be done through user analysis of how to design other details.

CHAPTER 3: : GAMIFICATION FRAMEWORK OF FLIGHT SIMULATOR

3.1 Introduction

The purpose of this chapter is to provide an Gamification Framework of Flight Simulator (GFFS) to enable developers to make a Gamified Flight Simulator (GFS) for effective and efficient learning and training environment. This framework will provide a foundation for creating a GFS specialized for pilot training and will help to change the paradigm of future training methods and patterns.

3.2 Development of Gamification Framework of Flight Simulator

Although flight simulators can be used to develop a new aircraft or research aircraft characteristics, it is assumed that the main purpose for flight simulator is pilot training. In addition, the purpose of this thesis is to effectively apply the various game techniques used in gamification theory to motivate pilots to engage much more time on the simulators and present a framework to establish a systematic training system at the same time.

Figure *13* is a diagram of a gamification framework that shows the basic configuration of a gamified simulator. This diagram shows subcategories for gamification under the objective of each education and training part. The reason why gamification are largely divided into education and training is that military training consists mainly of education of theoretical knowledge and training for its transfer. Learning and training are connected by a strong link because the transfer of learning to its application occurs whenever previously learned knowledge and skills affect the way in which new knowledge and skills are learned and performed (Simons, 1999). Since current

simulators are made up only for training, apart from theoretical knowledge, the gamification of education and training on both sides should be carried out simultaneously in terms of transferring theoretical knowledge in order to increase effectiveness and efficiency. What sets the flight simulator apart from those of the general education and business line is that it should transfer theoretical knowledge to technical learning through training, not just for knowledge transfer and it needs a specific device for achieving its goal. The purpose of flight simulators is to help improve the skills of live flight by practicing acquired knowledge through the simulator, or to develop other skills that are necessary in real operation but not practicable in live training. Thus, GFFS can be represented as a basic proposition to acquire flight skills associated with the theoretical knowledge needed to perform live operations, addressing three sub-category to achieve the desired objectives in the educational and training areas.

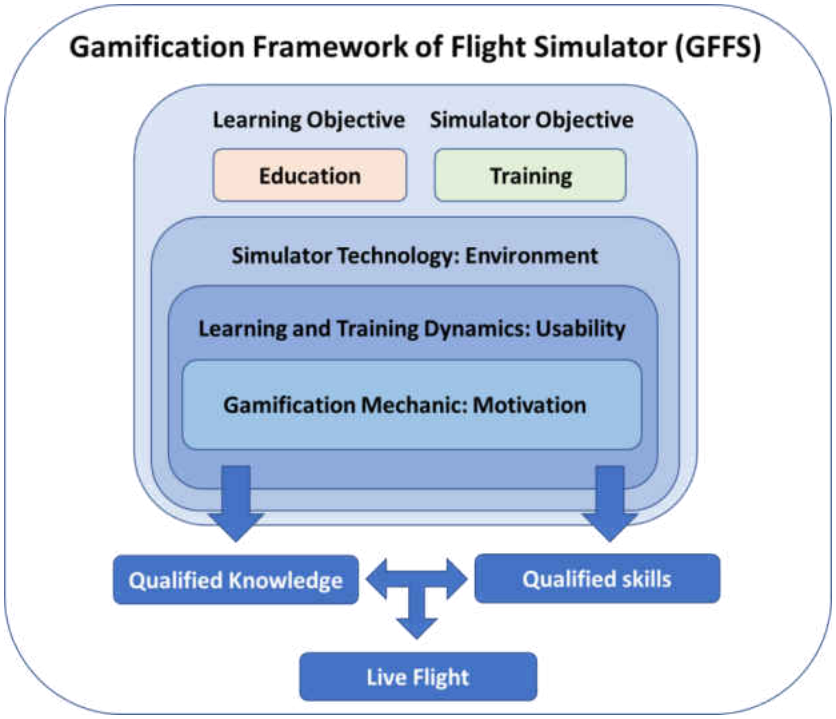

Figure 13 Gamification Framework of Flight Simulator

Next, The technology is needed to support this gamification, i.e. environment. The technology is about whether the education and training program themselves meet the requirements along with the technical capability of software and hardware to express gamification. This also concerns the capacity to accommodate users. Technology can also be seen as the reliability of existing validated simulators or learning programs themselves.

The sub-category is a Dynamic of learning and training, which can be expressed by user and stakeholder's satisfaction as Usability. This represents the subjective satisfaction of the use of this system from the perspective of users and can be a factor that allows users to continue to use the system in a way that differs from gamification from the motivational perspective.

Gamification Mechanics form the basis of this gamification framework, which can be said to be an motivational factor for users to use the system. Gamification are available in various ways not only in education but also in the business sector and use a variety of different mechanic items to ensure that they work evenly across society, not in a particular target group. However, in order to make a gamification system for a particular target group, It is imperative to identify the motivation factor of those users and apply them to meet their characteristics.

3.2.1 Objective

The purpose of gamification is to actively use simulator training platform, as mentioned in the problem statements. Current simulator training is not used as a tool for active flight skill improvement, although it has many advantages, as shown in the Academic paper (Haque & Srinivasan, 2006; Hays et al., 1992), because it is considered only as an auxiliary means of live training or as a means of procedural practice. As a result, the GFFS's purpose should be able to

address areas that are relevant to the objective of education and training. In other words, the use of Gamified Flight Simulators should be able to achieve educational and training objectives. Learning platforms for educational purposes enable accumulation and evaluation of the theoretical knowledge, and retention of the knowledge through periodic and repetitive learning in educational context. Training platforms, likewise, train specific skills and link theoretical knowledge with empirical knowledge through repetitive and periodic exercises. Training in virtual space through computers has the advantage of being able to make objective assessments based on data related to trainee patterns. However, the training curriculum may not cover all of the essential theoretical knowledge. Therefore, it is necessary to acquire and test theoretical knowledge through education, and to improve and evaluate skills through training.

Various kinds of theoretical knowledge are required to conduct military-purpose flight training, whose platforms are scattered in the form of in-class lectures and video clips, books or e-books. The requirements for maintaining theoretical knowledge are the method in which instructors conduct lectures in line with the essential training needs on a yearly basis, and the assessment of theoretical knowledge depends on the high level of flight qualification and the annual evaluation requirements. Because it is personal responsibility for the pilots to acquire and maintain the theoretical knowledge and to check and test the assessment schedule, an individual must constantly monitor his or her knowledge and test schedule. Therefore, the system will enable pilots to acquire more efficient and effective theoretical knowledge by mounting a Integrated education platform on the GFFS and ensuring that their theoretical knowledge is acquired and knowledge is maintained, and that test schedules can be checked and evaluated in a glance.

On the training side, it should be equipped with a curriculum to achieve the overall technical goals associated with basic skills, high levels of difficulty, complex skills, and team training and theoretical knowledge, and it should be possible to acquire, polish and evaluate skills step by step with the training platform. Figure *14* represents the Objective of GFS. How to integrate training content with educational content is described in more detail in Dynamics Part.

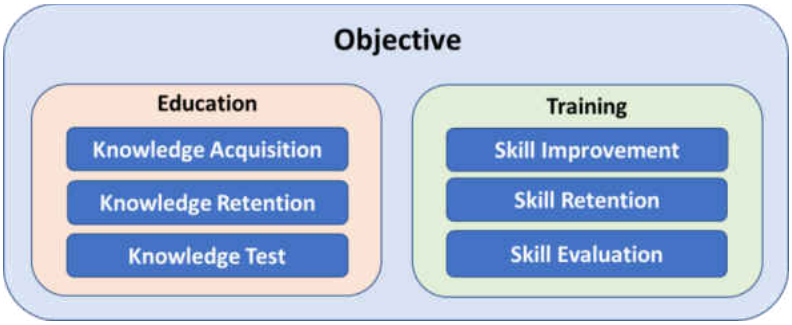

Figure 14 Objective of GFS

3.2.2 Simulator Technology: Environment

Simulator Technology is the flight simulator itself. Flight simulators designed to enable pilots to conduct procedural and operational training satisfying most functional tests that can be performed on live flights. Traditional flight simulators are belong to this area. The pilot will practice specific flight skills before the live flight through flight simulator and will be verified by the simulator evaluation for the live flight. It also helps to maintain certain procedural and operational skills that have not been practiced for a long time by periodically flying the simulator. The technology enables visual, interaction, and tactile capability through hardware and software. The current simulator has focused on the same reproduction of live flights in the simulator space. Thus, there was a limit to the user's active handling of the interface or checking

data. That's why training requires an interface that can check status or setting, other than the play itself, while also requiring devices such as a mouse or keyboard that can control it.

The lack of the number of simulators can affect this framework as a whole because intention of gamified simulator is to spend more time in flight simulators. Installing large simulators, which cost hundreds of thousands of dollars per unit is not effective in terms of politics, economy and cost. Therefore, desktop based simulators could be an alternative and it should be connected to existing flight simulator for tracking user's progress and relevant data. In addition, hardware such as desktop computers and MR equipment, as well as procedural functions such as eyes or laser tracking substitute tactile capability and visualization of inside cockpit are required. It should also be equipped with software that allows the pilot to personally perform learning and training without live instructor intervention. For example, when performing an instrument flight, the pilot must be able to communicate with the virtual ground controllers, receive voice instructions from them, and control the aircraft. In sum, the Simulator Technology attributes for gamified simulator are as follows.

Table 8 Gamification Technology Attributes

Technology	Attributes	Guides
1	The number of simulator platforms	A total of eight computers and peripherals for training four allies and four enemy units by squadron
2	24-hour operation of servers and systems	24/7 operation of servers and systems, Offline availability
3	Interoperability	Works with existing simulators
4	Compatibility	Compatibility with other type of training: Ground controller, Weapons controller
5	Connectivity	Connectivity of visual field of view enhancer, such as AR, VR devices
6	Capability for procedural and operational training	Visualization of inside cockpit for procedural and operational practice, Tracking sensors that enable the execution of procedures without tactile components
7	Network	Network play with other players up to 100 entities

While the above attributes are considered essential for the Capability of desktop-based, gamified flight simulators, the verification of this hardware and software belongs to another area of study, leaving the area used to describe dynamics and technology.

3.2.3 Learning and Training Dynamics: Usability

While there are motivational factors in the benefits of gamification, namely making the system constantly used by users, there are others that make users be satisfied to use the system. The current simulator has focused on the same reproduction of live flights in the simulator space. To carry out the simulator training, the pilot is required to go to the training site according to the schedule prepared by the simulator scheduler and then to carry out the training session in accordance with the instructions by the instructor pilot. After boarding the simulator cockpit, the instructor or maintenance manipulates all settings and functional parts other than the training environment itself. The pilot in the simulator cannot operate any interface or setup other than to operate the actual airplane.

Therefore, a system must be established for pilots to actively utilize the simulator from the user's perspective in order for the gamified flight simulator to function correctly. In other words, the usability of the simulator must be met. .Learning and Training Dynamics are how to construct a system in terms of Usability for effective and efficient training. ISO defines usability as “degree to which a product or system can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use” (ISO/IEC, 2011). Nielsen divided usability into five categories: efficiency, satisfaction, learnability, memorability and errors. Learnability is a concept similar to effectiveness. (Nielsen, 1994). This is associated

with the feelings users sense when using the system in the rest of the area except for the Mechanics associated with motivational aspects. On the other hand, Dawson (2006) focused on holistic usability in a distributed simulation system, dividing the usability framework into six categories: End user needs and goals, End user interface, Programming, Training, Installation, and Documentation. Ardito et al. (2006) divided usability dimension for the application of e-learning into four categories: Presentation, Hypermediality, Application proactivity, and User activity, each of which was determined by effectiveness and efficiency criteria. Therefore, well-constructed Dynamics can give users a satisfying experience in function, aesthetic allowing them to use the system more actively. Dynamics shares much of the usability model. Different types of usability model was analyzed to organize Dynamics to match the gamification aspects. Next, the usability attributes was built so that can be contrasted with existing simulator training programs when adding the characteristics of gamification aspect to this. Usability is divided into four attributes: Learnability, Attractiveness, Interactivity and Productivity The following Table *9* summarizes the terms associated with the usability attributes (Ardito et al., 2006; Dawson, 2006; Harrison, Flood, & Duce, 2013; ISO/IEC, 2011; Nacke, 2009; Rajanen & Rajanen, 2017). Learning and Training Dynamics is an exploration of applicable guidelines derived from the Attributes of Usability.

Table 9 Usability Attributes and Related term

Attributes	Related Term
Learnability	Effectiveness, Engagement, Hypermediality, Media, Text, Video, Presentation, Lecture, Demonstration, Documentation, Understandability, Tutorial, Guide, Evaluation, Assessment, Progress Tracking, Customized training, Personalized data, Level of Difficulty
Attractiveness	Satisfaction, Enjoyment, Experience, Realistic, Intuitive design, Readability, Memorability, Distraction, Custom character setting, Custom interface setting
Interactivity	Satisfaction, User activity, System Status, Communication, Help option, Q&A, Social, Troubleshooting support, Update
Productivity	Efficiency, Easy to control(return, cancel, redo button), Simple dialogs, Shortcut available, Error, Enough information, Cognitive load, Template, Tool, Easy developing, Easy navigation,

3.2.3.1 Learnability

Learnability can be determined whether the system has the capability to meet the objective. What sets gamified simulators apart most from conventional simulators is that trainee can be self-active in learning and training through GFS. To do so, individual progress data must be tracked and contents related to learning and training must be prepared. And as a means of supporting such contents, libraries and archival systems should be mounted, enabling the assessment of individual knowledge and skills.

This learnability allows pilots to learn most of the knowledge and skills directly related to flight when using this system in terms of effectiveness, and to identify and learn from one system, each separately scattered piece of data, in terms of efficiency. One more important thing in this attribute is to have the qualification support system automatically provide various qualification expiration-related tracking through the system, which has so far been considered a personal responsibility. In order for the pilot to want to fly and to be able to perform all the missions, he or she must be able to maintain his or her skills continuously. Thus, to prevent skill

degradation, the expiration of the flight-related qualifications for weapons or equipment has occurred and unless the training is carried out by the expiration date, he must restart according to the training program to obtain that qualification. Therefore, it is necessary in terms of the efficiency and satisfaction of this qualification support system, which automatically recommends or learning knowledge and training missions.

Table *10* shows Dynamics and guidelines for Learnability. Guidelines are examples of how each Dynamics is applicable. These Dynamics enable the acquisition theoretical knowledge and flight skills, and its retention and evaluation which is the objective of GFS.

Table 10 Learnability Dynamics and Guidelines

Learnability	**Dynamics**	**Guidelines**
1	Personal Progress Tracking	Individual ID and Password, Storage of personal status and data
2	Phased Learning Contents	Maintenance knowledge, aircraft technical knowledge, Weapons, normal procedures, emergency procedures, basic flight tactics, advanced flight tactics
3	Phased Training Contents	Normal procedures, emergency procedures, basic flight tactics, advanced flight tactics
4	Non-flight Knowledge and Skills Training	Enemy aircraft identification training, return training, emergency radio operation training, parachute operation training, biochemical attack preparedness training, etc.
5	Library system	A library of documents, books, videos, etc. related to flight and operations, tactics, Etc.
6	Archive system	Save and Replay mission, Sharing experience
7	Assessment system	Evaluation of flight knowledge and skills, Substitution of existing theoretical and simulator flight assessments
8	Custom Difficulty setting	Changeable level of difficulty in a scenario
9	Qualification Support System	Recommendation of learning and training contents for retention of knowledge and skills, Notification of expiration date for flight, weapons and equipment qualification.

3.2.3.2 Attractiveness

Attractiveness is associated with how much immersive the user feels, visual, auditory, and tactile, and how realistic they are. User-friendly designs and photos can make users more familiar with the system. In addition, more immersive training can be possible if realistic explosion effects and the pilot on the team's aircraft playing together were seen. And visualization such as black out and gray out, depending on the G-force that a pilot makes a high-G maneuver can be applied. The use of auditory elements, such as background music and sound effects, is also a factor that causes users to immerse themselves. Pilots can also sense the identity of the system with background music that is continuously heard on the initial interface, and attach meaning to the mission with music that varies according to the mood of the scenario or mission. In addition, the sound effects associated with noise generated in a live fighter jet can be simulated realistically, and the sound effects of AGSM(anti-G straining maneuver) in case of high-G maneuvers can create the immersion of flying an actual fighter jet. On the tactile side, physical switches and buttons simulating real aircraft will have the best effect, but not in desktop-based simulators. Instead, tactile feelings can be replaced in auditory form when a switch or button is operated. Current simulators doesn't have an interface that users directly control or have little. GFS should allow users to adjust interface settings for their preferences. This will give the pilot an attractive feeling similar to live. Each Dynamics can be described as follows. Table *11* shows Dynamics and guidelines for Attractiveness. These Dynamics can provide users with immersion through realistic experiences when using the system, and aesthetic satisfaction from both visual and auditory aspects.

Table 11 Attractiveness Dynamics and Guidelines

Attractiveness	Dynamics	Guidelines
1	Familiar Design	Familiar picture and Icon, text
2	Realistic Visualization	Explosion effects, fellow pilots in a cockpit, blackout at high-G
3	Realistic Sound effects	Breathing sounds and similar noise when pilots are in a cockpit
4	Background music	Attractive music giving immersion
5	Interactive sound effect	Sound effects that are not heard in the real world but help interact with it. Ex) adjusting knob, pushing button
6	Custom Design setting	Visualization device that can influence belonging and immersion ex)Aircraft color, Pilot Avatar, Call sign Patch, Helmet Sticker
7	Custom Interface setting	Sound/Music Volume, Graphic Resolution, Brightness, Font, Voice

3.2.3.3 Interactivity

Interactivity means interaction between users and users, between users and systems, and between users and developers and administrator. This is the attributes that users need to solve or communicate problems themselves without direct intervention from the instructor, the maintenance, and the developer. There should be a plan for trouble shooting because maintenances are not directly interrupt possible error or trouble in the GFS system. the capability to enable the performance of the relevant mission while learning the content to acquire theoretical knowledge, or vice versa, will make experiential learning easier for users. In addition, interactions should be made with other types of users other than pilots, such as Ground controllers and Weapons controllers directly associated with the flight. Until now, multi-play between pilots was possible in part, but communication with other types of users was not possible and there was no system to simulate it. Table *12* shows Dynamics and guidelines for Interactivity. These dynamic helps users interact by providing users with various channels of

communication. Interactivity should be well considered because the lack of effective interaction among different users, system, developer, maintenance can affect efficiency and effectiveness.

Table 12 Interactivity Dynamics and Guidelines

Inter activity	Dynamics	Guidelines
1	User Activity	Forum, Chat, Notification board, Group Communication
2	Troubleshooting support	Q&A menu, Update plan, Help option, Provide System state
3	Organized and Integrated contents	Document and related knowledge available during training
4	Voice Autogenerate	Autogenerated voice of Constructive Ground controllers, Weapons Controllers, Commanders using text-to-speech solution
5	Other type of player connectivity	Interconnectivity with Virtual Ground controllers, Weapons Controllers, Commanders

3.2.3.4 Productivity

Productivity is associated with the time-efficiency during education and training as well as staying in the interface. Having a lot of errors can be said to be very time-efficient because you can't focus on learning and training as much. But from the outset, how to deal with an error should be considered, as creating a system for error-free is not only efficient in terms of time and resources. In addition, from an interface perspective, navigation should be easy to remember, and easy to control and intuitive. Productivity in terms of education and training should facilitate production of various materials to carry out scenarios and missions, and a system should be made to store or share them. The use of templates as a way to save time for users and developers. The built-in scenario development tools and templates will enable developers to develop scenarios faster and easier. Templates of various mission briefing materials, flight procedure materials and flight mission data will also enable pilots to prepare for missions faster and easier. And the sharing of well-made templates will make it possible for pilots with low flight qualifications to

easily become familiar with the system. And the collection of overall engineering data will be necessary for upgrading training programs or updating faults. Table *13* shows Dynamics and guidelines for Productivity. These Dynamics are important because in terms of time efficiency, it can either help users avoid being dissatisfied or give users the perception that they are saving time and using the system conveniently.

Table 13 Productivity Dynamics and Guidelines

Productivity	Dynamics	Guidelines
1	Reaction to Error	Automated Error report, Acceptable error rates, errors that do not cause serious problems with use.
2	Navigation	Intuitive design, Keyword search, Simple dialogs, Shortcut
3	Easy to Control	Easy to Install, Start, Cancel, Return, Redo, and End
4	Devices Connectivity	Plug and Play, Connectivity with peripherals, ease of connection with VR equipment and tracking sensor
5	Easy developing Scenario	Scenario development Tool, Developed Template sharing system
6	Easy developing Mission data	saving personalized mission data, sharing mission data,
7	Automated storage and analysis of engineering data	Data accumulation for updating learning and training programs and for developing tactics and Comparing Performance Between Pilots

The four Usability attributes focusing on gamification are designed to elicit the learning and training effects of already motivated pilots through Gamification Mechanics. No matter how motivated a user is to use a system, the user will no longer want to use it if it is encountered and it is not satisfied in terms of effectiveness or efficiency when used continuously. And in terms of military training, it could be considered an unnecessary task of carrying on another duty. That is why it is ultimately the way for users to use the system for long periods of time by designing each of the Dynamics in detail according to the usability attributes.

3.2.4 Gamification Mechanics: Motivation

Gamification Mechanics are elements that encompass both extrinsic and intrinsic motivations and positive and negative motivations that make users continue to use the system. The Octalysis Framework (Chou, 2019) was used as the basis for Gamification Mechanics and compare the Mechanics that match the possible example with those categories. The Octalysis Framework is divided into eight categories, as described in the literature review: 1) Epic Meaning and Calling, 2) Development and Accomplishment, 3) Empowerment of Creativity and Feedback, 4) Ownership and Possession, 5) Social influence and relatedness, 6) Scarcity and Impatience, 7) Unpredictability and Curiosity, 8) Loss & Avoidance.

3.2.4.1 Epic Meaning and Calling

Meaning literally gives meaning to GFS. Throughout flight training, each pilot attaches significance to his or her own training. The fundamental meaning for each pilot can be different: protecting the country, an unusual job, a desire to fly in the sky, and social position. How to project these things into a flight simulator is possible through the story line. If a story is added to a step-by-step training, the pilot can gradually identify the aspects of his or her progress through the storyline and to what extent he or she has flight skills. The storyline can be used to attach meaning to scenarios in missions. While scenarios simply provide the information necessary to recognize the situation and perform the mission, the story gives the scenario a sense of why it is performed. It can also bring a sense of heroism along with psychological pressure about the impact of success and failure. The fictional story will give the pilot the justification for why they need such flying skills and why they train on such missions. The story may also suggest

solutions to the ethical problems of gamification. The mission of a fighter plane, which destroys buildings or various ground threats in the course of a war and sometimes calls for the killing of human lives, requires a great sense of ethics and moral responsibility of a pilot. Gamification of these training courses can tarnish this ethical significance. In order to prevent various gamification techniques from becoming insensitive to this sense of responsibility and being exposed only to violence, the story line should stimulate sensitivity from ethical, moral and social perspectives. If a character's name is shown or heard through voice on the storyline, this responsibility will increase during mission and the sense of pride will also increase when the mission is successful.

- Main Story: Step by step training, the process of becoming a pilot
- Sub Story: Story for Qualification of Weapons and Equipment
- Narration: Heroism

3.2.4.2 Development and Accomplishment

Accomplishment is an external feedback that can satisfy a desire to challenges and to improve skills. This is the most commonly used drive of gamification in a system that can visually show how much users have achieved through external rewards such as points and badges. This can be further stimulated through the pilot's cultural features. A recognition or coin is used to praise the pilot's achievements. During World War I and II, Ace pilots showed off his skills by marking the number of enemy planes shot down. These features can also be projected in the GFFS, displaying programs such as individual learning time and training time, and praising achievements by awarding recognition, coins, insignias and medals when satisfying certain

conditions. And by granting a promotion certificate upon completion of a specific theoretical training and mission, the validity of one's flight skills can be recognized and this can be used as the basis for actual flight qualification.

- Personal Status for progress record of theoretical education and training time,
- Various records and figures showing personal accomplishment
- Skill trees for flight (qualification system)
- Rank system (Mission points and total training time)

3.2.4.3 Empowerment of Creativity and Feedback

Flight simulators, especially in real time, have essentially a drive with respect to creativity because they have an infinite choice to accomplish one purpose and are guaranteed very high autonomy as it progress in real time. This may stimulate a variety of tactical creativity by including certain factors, such as time and armament limitations, or by increasing the difficulty, including friendly ground troops or civilians close to targets. In other words, it can stimulate creativity by allowing them to carry out difficult operations that are either appropriate or impossible within a mission with a story. And the awarding of recognitions and qualifications to this can also stimulate Accomplishment and Ownership. In addition, to stimulate more creative things, the authority to develop scenarios when certain qualifications are met can be given. Making scenarios with storylines will require a lot of creativity and knowledge and make more experienced pilots continue to use GFFS.

- Missions with a wide selection of options
- Missions with a low probability of success

- Mission and Scenario development tool and sharing system
- White Feedback: Mission success, Heroism, Elitism
- Black Feedback: Mission Failure, Problems Caused by Wrong Decision Making

3.2.4.4 Ownership and Possession

Some types of players prefer to show off or collect some items they have acquired. Individuals can be strongly motivated when they feel they can own or control something. There are a variety of praises mentioned in Accomplishment that relate to the pilot's desire to own. Collecting recognitions, coins, Insignias, medals and certificates through various mission and training is an important part of the pilot culture. The ability to store avatars and aircraft designs associated with creativity, as well as the capability to store what users liked during a play, also meets this Ownership.

- Avatar / Decoration: Helmet design, Camouflage painting design for aircraft
- Collections: Recognitions, Coins, Insignias, Medals, Certificates

3.2.4.5 Social Influence and Relatedness

The military is a kind of small society. Since joining a squadron, the pilots steadily increase their presence and sense of belonging and also demonstrate their value through competition with other squadrons or wings. In the GFFS, pilots can be motivated by enabling a series of activities related to the Social relatedness. Setting up groups and sharing the group's specific designs in the GFFS also boosts the sense of belonging while promoting team play and competition with other squadrons in the simulator. Pilots with player types who want to play

team or exert influence rather than single play can more actively participate in team play or competitive missions. In addition, when sharing one's experiences and knowledge in Q&A sessions and others, it may be possible to gain points based on the number of recommendations or increase social experience points to have a positive impact on one's progress.

- Groups for Squadron and Wing
- Squadron-specific aircraft design and squadron mark / patch for pilot suits
- Competition in squadron and with other squadrons
- Missions that require team or large forces
- Acquiring more points when completing mission as a team
- Comments or Like feature for individuals' play

3.2.4.6 Scarcity and Impatience

Scarcity has to do with the desire to have something when it is so rare and exclusive that it cannot be easily obtained. It is assumed that these features should have a significant relation on the purpose of this system. This is also associated with ownership and accomplishment. A mission that can take part in a particular time or condition may encourage pilots to access the simulator. For example, in weather conditions where live flight training cannot be conducted due to severe weather, an emergency mission can be created by the simulator to perform an instrument flight mission in the presence of strong winds or heavy rain. Performing this mission can also stimulate the desire to possess by granting instrument flight ACE titles or certificates. And it can be emphasized scarcity if players can participate in special competition only by earning more than a certain number of skill points or having a continuous connection for more

than a few days or weeks. And rewards such as certificates, coins and recognitions that can only be received when such a particular mission is completed can enhance this scarcity.

- Pop-up missions that are only capable of participating in a specific time or condition
- Limitations of eligibility to participate in a particular mission
- Rewards that can only be obtained on a specific mission or condition

3.2.4.7 Unpredictability and Curiosity

Unpredictability has to do with continuous immersion because people don't know what will happen in the future. Some people are fascinated by detective stories or mystery novels because they are fascinated by its uncertainty and unpredictability. This is a kind of curiosity and can appear as a Sudden Mission or Random Rewards in GFFS. Random emergency missions are given when connecting to the system, and the mission can also emphasize Meaning, noting that only pilots who are present can perform it. It can also be used to narrate how much important the mission was after the mission was completed without clear explanation.

- Sudden Missions
- Secret Missions
- Random Rewards

3.2.4.8 Loss & Avoidance

Sometimes people continue to do something for fear of losing something. Pilots who have conducted continuous learning and training at the GFS leave a large amount of data and footprints on the system. Even if they haven't used the system for a long time or if they don't

want to use it anymore, they won't want to leave it because of the time and care they've spent. If certain weapons systems or flight qualifications are lost if they do not have access for a certain period of time or fail to meet training time, pilots will have continuous access not to lose them. And displaying a friendly casualty or describing desperate situations when it fails on a mission, shooting down a friendly aircraft or bombing a civilian area, will prompt the pilot to spend on training more.

- The accumulation of visible data over a long period of time.
- Disqualification when not connected for a long time
- Narrate the bad results caused by poor skill or mission failure
- Indication of training requirements for a particular subject, disadvantages when failing to perform

3.2.5 Summary

So far, the GFFS and its applicable elements have been looked. The GFFS consists of hardware Technology and Software dynamics that enable the objectives of improving pilots' theoretical knowledge and flight skills, as well as motivational Gamification Mechanics. Among them, Dynamic and Gamification Mechanics are key elements that make up GFFS as areas that differentiate from conventional simulators. Applying all items to GFFS listed in Gamification Mechanics is ineffective in terms of development costs and time. In addition, certain gamification Mechanics have conflicting or overlapping parts. It should also look at what types of Mechanics are more effective, depending on the pilot's characteristic and experience. And depending on the discovery of applicable gamification Mechanics, Dynamics can also be vary.

To make the Gamification Framework of Flight Simulator more reliable, It is needed to know which core drives can be used more effectively, depending on the pilots' preference and experience.

CHAPTER 4: RESEARCH DESIGN

4.1 Research methodology

The research consists of three phases. The first phase is to identify the specific gravity of each core drive that motivates the pilots in the Octalysis framework and Dynamics preferences through the survey of groups of pilots. The second phase is to develop the Evaluation form of detailed elements of the GFFS according to the identified core drive's priority and Dynamics preference. The last is to test the evaluation form developed in the phase 2.

4.1.1 Research hypothesis

The biggest characteristic of gamification is human focus design and motivation. In other words, it should be understood whether current pilots are satisfied with the Technology, Dynamics of existing simulators or not. Since the motivational area reflects many of the pilots' personal characteristic, it is necessary to identify the motivational tendencies of the pilots. And from a long-term perspective, intrinsic motivation and positive motivation have a greater impact. Extrinsic motivations, on the other hand, will affect the early stages of approaching the system, i.e. beginner pilots. In particular, for GFFS to be effective, the pilot's satisfaction with the current simulator is not high and he / she must be willing to improve it. Therefore, to ensure that GFFS works, It is assumed that the following hypothesis for existing flight simulators:

- Hypothesis 1: Pilots are not satisfied with the current Curriculum for flight simulator training
- Hypothesis 2: Pilots need more diversity of Dynamics in current flight simulator training.

- Hypothesis 3: The Octalysis framework can sufficiently classify the motivational factors of pilots.

4.1.2 Research Questions

The Survey is made to identify the motivational factors, perceptions of simulators for pilots and preference of Dynamics as well as to confirm the hypothesis. The following are the main questions of the Phase 1 survey.

- How does the pilots' perception of games and simulators affect the need of improvement and gamification of simulators?
- What do pilots need directly with regard to improving the gamification and simulator interface?
- What are the priorities of core drives across the pilot population?
- How does the experience or age of pilots relate to the affected core drives? And what's the priority?

Survey analysis in phase 1 classifies pilots' perception of simulators and the types of Dynamics they want to add, and quantifies each affected core drive. Because Dynamics, independent of motivation, represents satisfaction with usability, undesirable Dynamics elements are eliminated. In the phase 2, the priority and score of each attributes of GFFS is given and the essential and non-essential elements are identified. Afterwards, GFS evaluation form are created as a means to evaluate the level of gamification. In the phase3, current simulator that is operating

in south Korea and COTS flight simulator game which has very similar characteristic to real fighter jet are evaluated using GFS evaluation form.

4.1.3 Participants

The phase 1 survey targets pilots of Republic of Korea Air Force fighter jet. The questionnaire was written using an online Survey Tool (Google forms) and links were distributed to each pilots through the operational chief of each squadron. It includes KF-16 and F-15K Tactical Fighter Jet Squadron. The survey was conducted for a total of eight days from Thursday, February 27 to Thursday, March 5, with a total of 96 pilots responding.

4.2 Survey procedures

The phase 1 Survey consists of quantitative and qualitative questions. The questionnaire asked demographics, Awareness and perception of games and simulators, Needs of simulator Usability, and the pattern of motivated core drives. These elements are divided and explained in more detail below. The detailed contents in the questionnaire are included in the APPENDIX A: QUESTIONAIRE OF PILOT'S NEEDS AND MOTIVATION FACTORS.

4.2.1 Demographic information

Demographic information is an indicator of how to distinguish outcomes and can provide meaningful data when divided into subgroups. This demographic information is mostly military specific and includes squadron, age, rank, qualification, flight hours, time spent acquiring theoretical knowledge per week, and time spent training in the flight simulators per week.

Although the last question of the demographics is for asking opinion, it is included to demographics section because it relates to the previous question.

4.2.2 Perception of flight simulator

By understanding the pilot's perception of the existing flight simulator, it can be derived directly or indirectly how the gamification of the flight simulator will affect the pilots' training motivation. The questions in this section ask how positive the pilot's mind is about the simulator, and how satisfied the pilot is with the existing simulator. The questions in this section ask specifically why pilots train simulators and if they are satisfied with the current simulator training. It also can identify how pilots feel gamified simulator. Finally, it asks the pilots' willingness to improve the current simulator training system.

4.2.3 Perception of games

The questions in this section ask if you usually enjoy playing games or have you ever wanted to ride a simulator like a game. These questions are expected to have different trends depending on age and can determine how they feel game-like feature is favorable. Item 13 of the questionnaire refers to Tomcho (2019)'s research, which is recognized as a useful questionnaire because most existing game types are classified and the pilots' motivational characteristics can be indirectly identified according to the checked items.

4.2.4 Gamification of Simulator

This section asks pilots for their opinions on Usability attributes which are closely related to gamification, from several examples presented in Dynamics. This section allows pilots to indirectly know what the gamified features are and judge their own likes.

4.2.5 Motivation

This section has been designed with reference to Chou (2019)'s Octalysis framework model and Tomcho (2019)'s questionnaire set. Tomcho identified the pattern of motivation for the survey respondents by directly asking questions associated with each core drive in the Octalysis framework. The questions consist of a total of 16 quantitative questions, two for each core drive, and a qualitative question that receive additional personal feedback. While there is an advantage that it is not ambiguous when asked directly about "enjoy" to respondents (Tomcho, 2019), Indirect questions were made for some questions because the wording of "enjoy" itself tends to sound rather strong. In addition, the core drives 6,7 and 8 that are considered areas of negative motivation are aimed at emotions that may be somewhat unconscious and visceral, so when asked whether they were simply "enjoying", they are likely to have negative thoughts. So It asked the affecting core drives 6,7,8 whether they have experience, feeling, or tendency.

4.3 Data Analysis

The seven-point Likert scale was used to distinguish the degree of agreement or opinion and for a detailed analysis of priorities. Likert scale used for demographic, Awareness and

perception of games and simulators, is used to separate respondents' responses from the motivation section into subgroups.

The results of the 7-point Likert scale will be mathematically measured. Next, the average value, standard deviations, maximums and minimums will be used to divide the priorities of the Techniques. The average value of each sub-question with respect to the motivational core drive will be shifted to the Octalysis scale from 0 to 10. A negative and neutral response from Likert scale 1-4 can be expressed as zero, because it does not mean that the negative and neutral opinions have a negative effect on the motivational pattern. The following Table *14* shows an expression and an example of changing the Likert scale to the Octalysis scale.

$$Output = Input * \frac{10}{3} + \left(-\frac{40}{3}\right), (If\ Input < 4, Output = 0)$$

Table 14 Likert Scale to Octalysis Scale Conversion

Input(Likert Scale)	**1 - 4**	**5**	**6**	**7**
Output(Octalysis Scale)	0	3.33	6.67	10

CHAPTER 5: SURVEY RESLUTS AND ANALYSIS

In this chapter, the survey results were tested and evaluated for their reliability before analyzing them. The analyzed data could be the basis of GFS Evaluation form design. Survey was distributed via a link through liaison officers of each squadron and allowed each pilot to participate freely for a week. A total of 96 pilots from squadrons participated in the survey. One of them turned out to be an outlier and five of them were excluded from the analysis because more than one quantitative data was missing.

5.1 Participant Demographics

Out of a total of 90 respondents, more than 80 percent of the age groups were 26-35 years old. This is seen as appropriate when comparing the age of the pilot, who is first deployed to the squadron after a period of approximately two years of flight training since he was commissioned, and the age range other than the commander in the squadron. Also, captains and majors accounted for more than 80 percent of the total. This also tended to be similar to the rank structure of the squadron. Qualification is shown to be sufficient for sampling, although the percentage of instructors was relatively high compared to the percentage of qualified persons in the actual squadron, and the percentage of wingmen was relatively low. Pilots' flight time is also consistent with the ratio of rank to flight qualification, with the majority having 301-1000 flight hours.

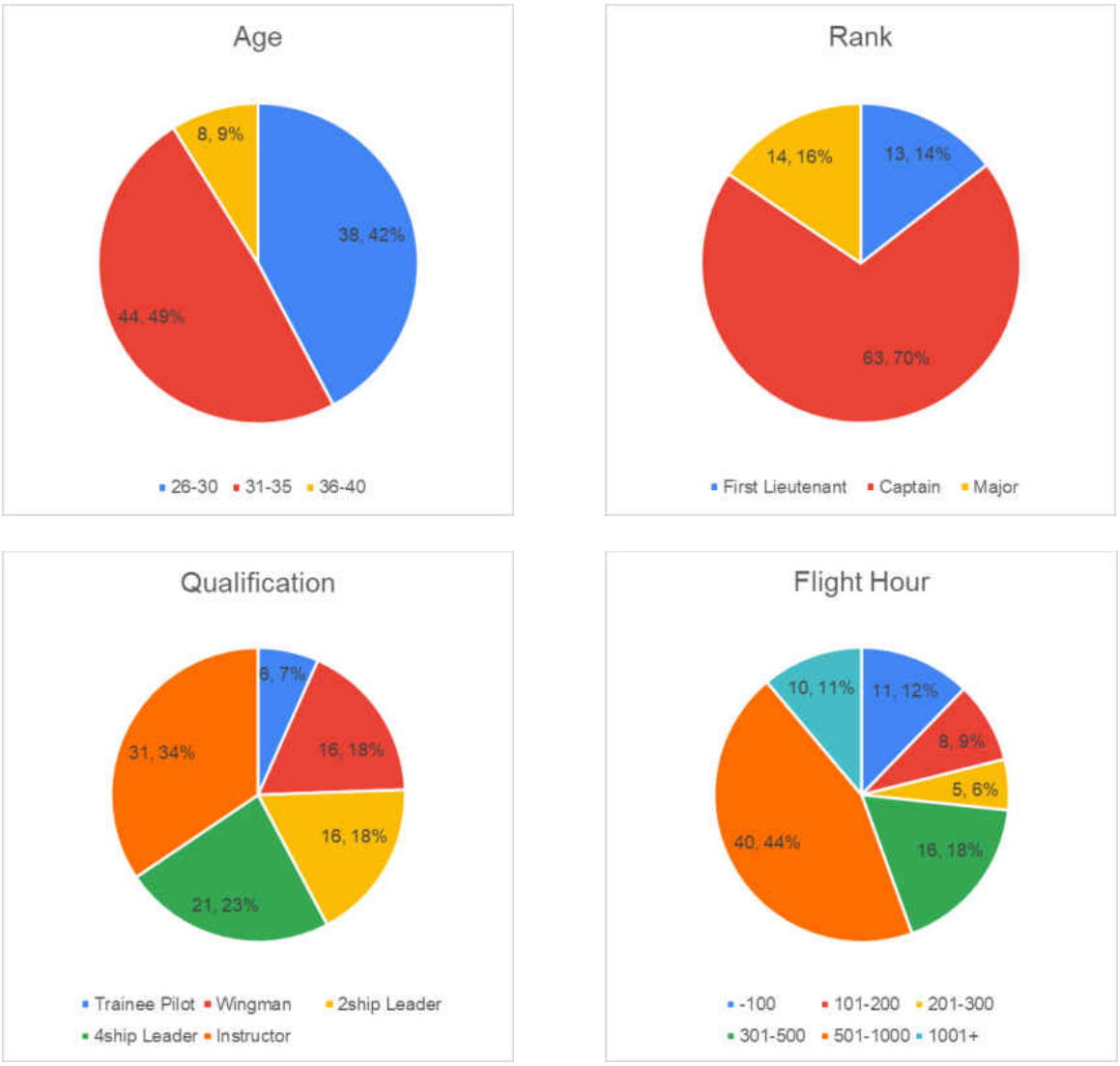

Figure 15 Demographic Information about Survey Participants

5.2 Analysis for survey item

The survey asks about the pilots' perception of games, simulators and the need for improvement, and ultimately identifies the motivational factors to determine how effective existing simulators can be when improved.

Pilots continue to increase their learning time to acquire their expertise. Starting with the 4ship leader, learning times per week are considered to decrease, and since obtaining a high level of flight qualification, motivation for learning is shown to be low. Figure *16* represents the average learning time with flight qualification and indicates that learning time is gradually increasing and then rapidly decreasing after the 4ship leader. The left index of this graph represents a specific time interval rather than the actual time so the difference among the flight qualifications are way bigger.

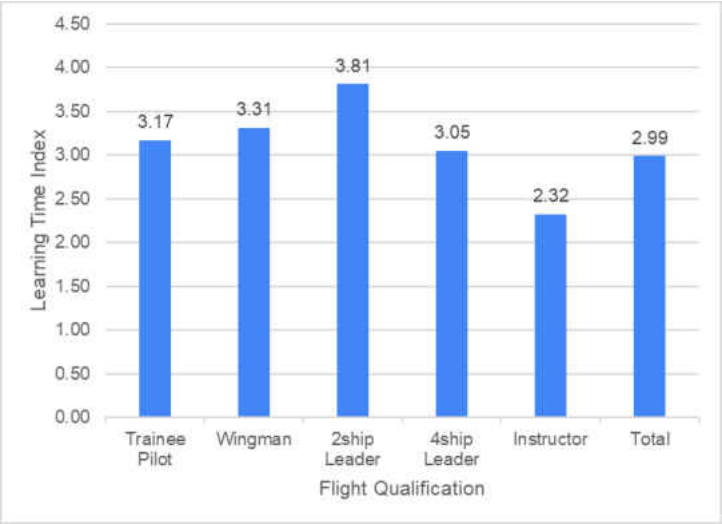

Figure 16 Average Learning Time (1=-2h, 2=2-4h, 3=5-8h, 4=9-12h)

Simulator training time can be seen as a gradual decrease for pilots compared to trainee pilots who have to fly simulator in order to acquire initial flight qualification. When becoming an instructor, simulator time is again increasing. While additional surveys or research may be required as to why simulator time has gone up significantly in instructor, this is seen as because they fly the simulator with trainers and leaders for evaluation and required training sorties.

Figure *17* shows the average simulator time for flight qualification, and the training time decreases as the qualification increases, and then increases again after becoming an instructor.

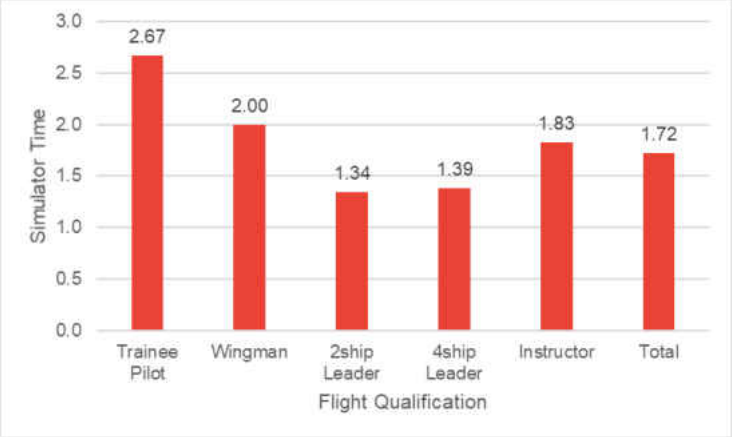

Figure 17 Average Simulator Time

5.2.1 Perception of flight simulator and game

5.2.1.1 Motivation for Current Simulator

The question of why they are flying simulator is a question of fundamental motivation to determine if there is any Intrinsic/Extrinsic and Positive/Negative motivation. The total number of responses to this question exceeds 90 because multiple choices were available. More than half of the pilots respond that they do simulator training because of training requirements, and the next large number of respondents said they were practicing to cope with emergency situations. See Table *15* for the rest.

According to the ratio checked on each of the 90 respondents, 100% is scored on a scale of 10 points and this is translated into the corresponding core drive and applied to the Octalysis Tool. And if core drives overlap, the average value of the combined scores is applied.

Figure *18* shows that the Octalysis graph is focused on the black-hat core drive. This means that the current simulator does not provide motivation for pilots' simulator training from a long-term perspective and can be seen as driven by forcing pilots to fly it.

Table 15 Motivation factor for Simulator Training

Reason	**Number of Responds**	**Ratio**	**Core Drive**
Training Requirement	67	74%	CD8
Practice for an emergency situation that is not known when it will occur	42	47%	CD2, 7
A desire to try something new	23	26%	CD3
A sense of accomplishment in one's skill development	17	19%	CD2
An infrequent opportunity	8	9%	CD6
The pressure of a lack of flight skill	5	6%	CD1
The idea that I want to fly better than other	4	4%	CD5

Figure 18 Octalysis Graph for current Simulator motivation

5.2.1.2 Pilot's Perception of Games and Simulators

As Figure 19 shows, Pilots somewhat agreed that they are satisfied with the current curriculum on average 4.73. On the other hand, with regard to the need for integrated learning and training content, they agreed at 5.43 on average. This can be seen as opposing further action in the current curriculum, but largely agreeing that simulators and learning platforms need to be improved.

When they were asked about enjoying games, the average is 4.5, which is more or less positive. Broken down by age and flight qualification, the younger, the more likely the respondents enjoy it, and the resulting newly recruiting pilots will have a better understanding and enjoying of the game. Questions about having game-like features on current simulators showed a higher average point of agreement than people who enjoy the games. That is, regardless of whether they are currently enjoying the game, they generally want to include game-related features.

Figure *20* shows how agreement varies with age. Current curriculum satisfaction drops with younger age while the need for integrated learning and training contents increases with younger age, and the need for game-related features also tends to increase with younger age. In sum, the younger pilots who are more familiar with the Computer and IT, the more interested in the contents that can be more effective or efficient than the current curriculum. It can be emphasized that changes are needed in current simulators and training programs.

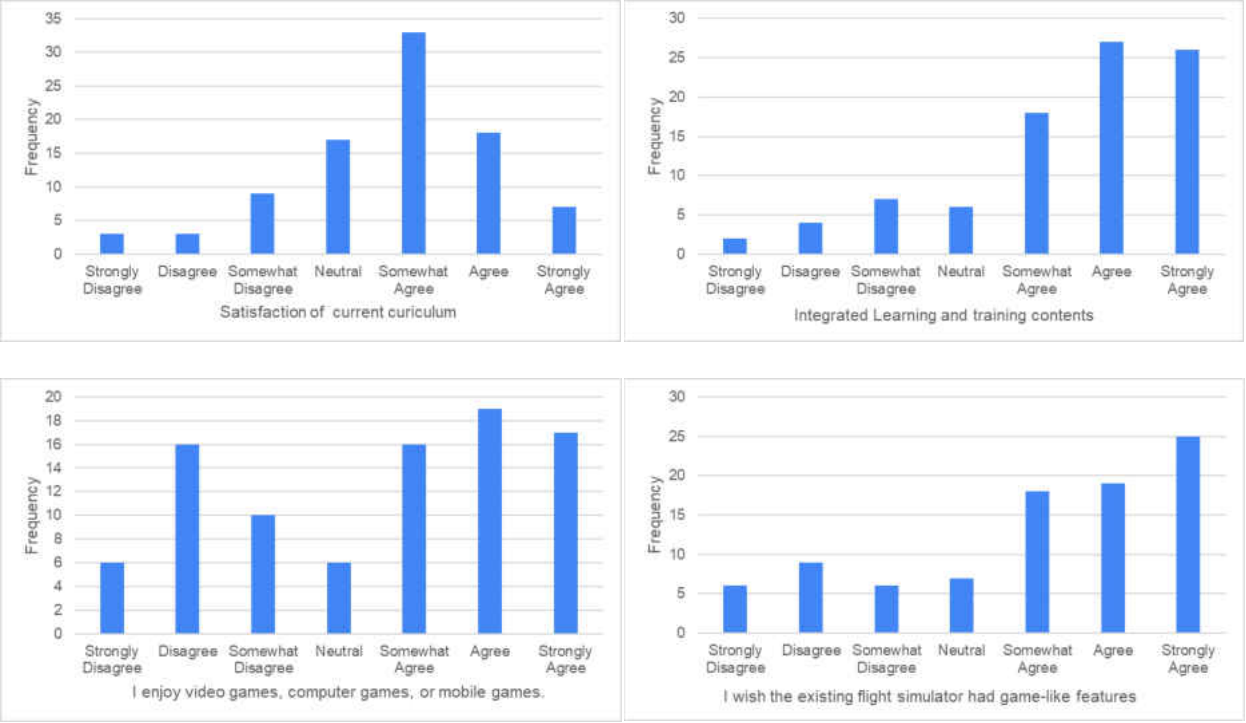

Figure 19 Perception of games and simulator

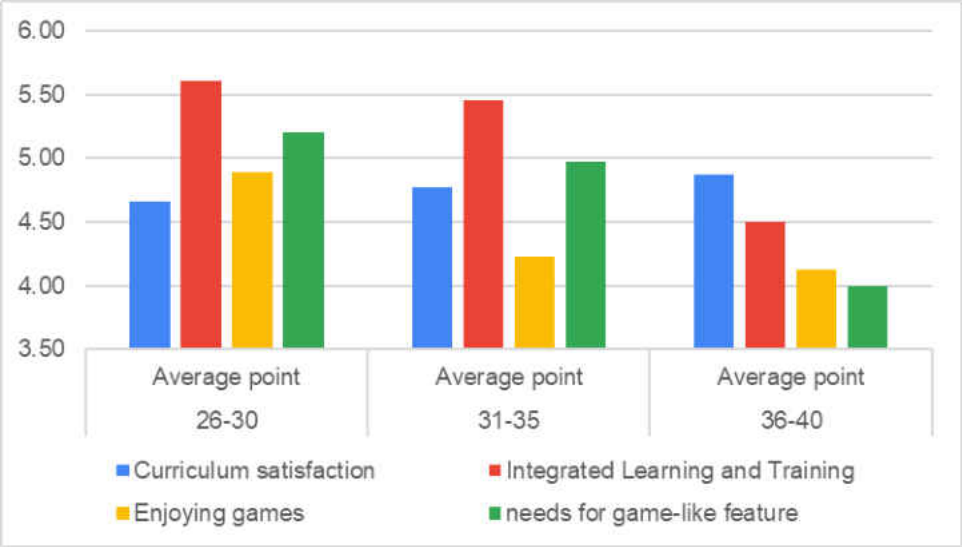

Figure 20 Changes in a degree of agreement with age

5.2.1.3 Learning and Training Dynamics for Gamified Flight Simulator

Pilots were asked several questions, focusing on learning and training content and the computer-based learning platforms to find out what improvements can be made in the current simulator system for pilots. The presented functions are either inefficient or ineffective in conventional simulators, but they are those that can be actively used by users, along with learning content in desktop based simulator. As seen in Table *16*, more than half of the pilots agreed that the ability to save and replay trained images or being played, step-by-step theoretical education and learning contents, and integrated training and evaluation content was needed. Next, 44% of respondents chose the capability to recommend missions or provide notification regarding a variety of Qualification conditions, and 37% of the respondents chose functions of an assessment tool for theoretical knowledge and simulator training, along with an interface to identify the pilot's current training status, and a Q&A menu to share theoretical knowledge and flight skills.

Responds	Percent	Contents	Attributes	Dynamics
56 / 90	62%	Saving and replaying training sortie	Learnability	Archive system
48 / 90	53%	Staged theoretical education and learning content	Learnability	Phased Learning Contents
46 / 90	51%	Integrate multiple training and evaluation content	Learnability	Non-flight Knowledge and Skills training
40 / 90	44%	Recommend missions and notifications regarding various qualification maturities	Learnability	Qualification Support System
33 / 90	37%	Theoretical evaluation and simulator evaluation tools associated with flight knowledge	Learnability	Assessment System
33 / 90	37%	Demonstrate data on pilot learning progress and training patterns	Learnability	Personal Progress Tracking

33 / 90	37%	Q&A Menu for Sharing Flight Knowledge and skills	Interactivity	User Activity

Table 16 Response Percentage for additional features required by the current simulator

When pilots were asked about additional functions other than those found in the selection, the feedback was as follows in Table *17*. Of the total 18, eight were for large-force training. That is the capability of massive multiplayer to simultaneously connect and play. Others suggested that the data base system, i.e. data needed for flight training or actual flight, should be stored or in a template form, so that immediate use can be made during simulator training. There were other opinions about the function of changing view, which can be seen at a glance or at a third person point of view as well as the entire field of battle. Other comments included the ability to display various required qualification procedures or draw maneuvers.

Table 17 Opinions about function that are hoped to improve

Category	Opinion
Support for various play modes, Multi-play Support (Learnability, Interactivity)	Large Force Exercise using VR
	SD experience, Multi-force mission
	Demonstrate multi-player (ex PKG mission) mission
	Training with different type of fighter jet and package training
	Large-scale squadron training through multiple computer connections
	a multiple-jet training
	Large-scale simulator training function under actual C2 support
	multiple-fight jet mission
Easy developing Scenario, Easy developing Mission data (Productivity)	The quality of learning and training will improve if there is a data base for such things as common negligence.
	It would be nice to have some data to prepare for the flight. For example, a flip or a local procedure would help us prepare for the flight
	There's no standard for flying, but I'd like to store and run exemplary missions.
Support for various play modes (Learnability)	Integrated debriefing system (e.g. TA-50 TIME SYNC function) that can be used between flight crew without AIS-POD (e.g. integrated demonstration of the maneuvering patterns)
	Equipment for viewing the location and dimensions of aircraft with 3D

	I think simulation through tactical instruction will help us to conduct tactical research with multiple fighter jets and tactical aircraft mixed into various types through God view as well as from the first person to the third person (like Star craft position.
Qualification Support System, Support for various play modes (Learnability)	Displaying of various required qualification process
	Maneuver drawing function

The following Table *18* is a survey results of preferences mainly regarding Attractiveness among Gamification Dynamics. When compared after converting the 7-point Likert scale to 10pt scale, the Productivity generally showed a higher preference than the attractiveness, with fewer standard deviations associated with it.

Table 18 Gamification Dynamics for attractiveness and other dynamics

Contents	Attributes	Dynamics	10Pt Scale
Changeable Difficulty in a same mission: Increase in enemy aircraft or SAM, Increase in Detection rate from enemy, Complex 3 dimensional maneuver, etc.	Learnability	Custom difficulty setting	7.96
Library system for flight knowledge and skills: document, books, tactics, video	Learnability	Library system	7.59
Interface display using Familiar images and designs	Attractiveness	Familiar design	7.3
Saving Template for mission briefing materials, flight data, and flight mission data stored on aircraft	Productivity	easy developing scenario	7.19
Changeable Interface: Sound Volume, Graphic Resolution, Brightness, Font, Various Voice Choice for Constructive(Ground controller, Weapon Controller), Etc.	Attractiveness	Custom Interface setting, Voice Autogenerate	6.78
Personalized storage of knee board data related to flight procedures and mission data (DTC) that can be loaded onto an aircraft	Productivity	Easy developing mission data	6.7
AGSM sounds and similar noise when pilots are in a cockpit	Attractiveness	Realistic sound effect	6.15
Visualization of Explosion effects, fellow pilots in a cockpit, blackout at high-G	Attractiveness	Realistic visualization	5.96
Sound effect associated with switch and button operation	Attractiveness	Interactive sound effect	5.63

Changeable Character design: Aircraft color, Pilot Avatar, Call sign Patch, Helmet Sticker, etc.	Attractiveness	Custom design setting	5.59
Background music in the starting interface and introduction of mission	Attractiveness	Background music	3.85

When pilots were asked about the preferred features associated with the game, respondents mainly commented on customization and attractiveness. Eight of the 14 opinions were about attractiveness and Learnability. Others suggested that a tool in the form of assessment or scoring was needed. What's interesting here is that, overall, even though the Attractive Attribute received a lower score than the Productivity one, the content about attractiveness took up a majority in the category of personal opinions. There were some other opinion regarding a level of difficulty in learning, and extra knowledge and skills other than flying, as well as the mounting of an assessment system. The following Table *19* is the respondents' subjective comments.

Table 19 Opinions about other Dynamics feature

Category	Opinions
Realistic Visualization, Realistic sound effect, Realistic function (Attractiveness)	Actual communication and simulating jamming
	a realistic sense
	The simulator has Mock cockpit, so it's practical enough, but there are only a few limitations in demonstrating actual operations such as armed effects and aircraft performance.
	High-definition graphical Korean theater that can be implemented with VR.
	"From a first-person perspective, cockpit display and switch operation functions such as realistic view seen in Microsoft Flight Simulator or DCS: WORLD etc. are implemented, When the large forces are exercised simultaneously through "very familiar" methods such as Star craft or Warcraft, how the combat results can be differentiated if it is ordered to do specific action to each flight. When the CAS mission is simulated, how the near ground to air threat react realistically. It is thought that there will be endless possibilities of implementation, such as civilian damage, and it will bring endless interest and academic curiosity to pilots. We also believe that the multi-play capability between simulators will be a very creative response."
Custom Difficulty setting (Learnability)	Various maneuvers of enemy aircraft, practical scenario application training in various weather environments
	I hope that detailed settings for RA and enemy surface-to-air simulations can be established according to the task settings, such as subject or war missions (e.g. RANDOM TGTING and threat simulations within the range of enemy SAM aircraft and modes) (one on board can experience and master the mission in full size).
	I hope that customization is diverse and free. The mission also exists similar to the actual mission (actual package imitations) and if it becomes increasingly difficult like a game (Mission 1 is tr. The last mission is either as a package leader or as a flight as an MC), it will be both tasty and helpful to fly.
Non-flight Knowledge and Skills Training (Learnability)	RWY service (including simulation of procedures required)
	when I trigger ejection seat from the aircraft, I want to train following procedure on the ground before being rescued.
	Practice Data Link Pre-Introduction to VR
Assessment System (Learnability)	The items that go into the actual flight evaluation are scored or deducted. (or kill/deaths or mission success rate in the game) To rank and make a higher score once a month to create a competitive structure.
	Eye tracking Confirmation
Experience (Attractiveness)	I don't want it to be like a current simulator. Like Falcon 4.0, we can entertain simulator software, it would be effective for pilots to experience various battlefield situations in simulators.
Replay (Learnability)	Playback and other point-in-of views
Game-like feature(Attractiveness)	DCS-based software development.

5.2.1.4 Pilots' motivation factor

Motivation is an integral part of the gamification that creates intrinsic and extrinsic usage factors for the user's system, along with the system's usability. This motivational factor is the basis of gamification framework of flight simulator.

The survey on motivation consists of 16 items in total and each two items are grouped together to correspond to each core drive of the Octalysis framework. Data from the Likert Scale from the survey were converted to a 10 point scale and averaged between the same core drives and expressed through a radar graph of Excel program.

There are a total of eight motivators to use a system, each of the following terms: CD1: Epic Meaning and Calling, CD2: Development and Accomplishment, CD3: Empowerment of Creativity and Feedback, CD4: Ownership and Possession, CD5: Social Influence and Relatedness, CD6: Scarcity and Impatience, CD7: Unpredictability and Curiosity, CD8: Avoidance and Loss.

Figure *21* shows the motivating pattern of pilots analyzed in the survey. Pilots appear to be heavily influenced by CD2, CD3, and CD5 and somewhat influenced by CD1, CD6, and CD7 and CD4 and CD8 with little or no motivation. In comparison, the current simulator's motivator is focused on CD8 and CD7 as seen in Figure *22* and meets CD2 and CD3 slightly. Although the pilots' motivational factors and the simulator's motivators are not scored that come from the same measurement method, these figures show that the current simulators do not meet the pilots' motivational factors. The simulator training program sets the training requirements so that the pilots are engaged in the simulator training and the pilots are not able to maintain their pilot

status if they do not meet the training requirements. That is, for reasons other than the training requirement, there is a little or no motivation to do current simulator training.

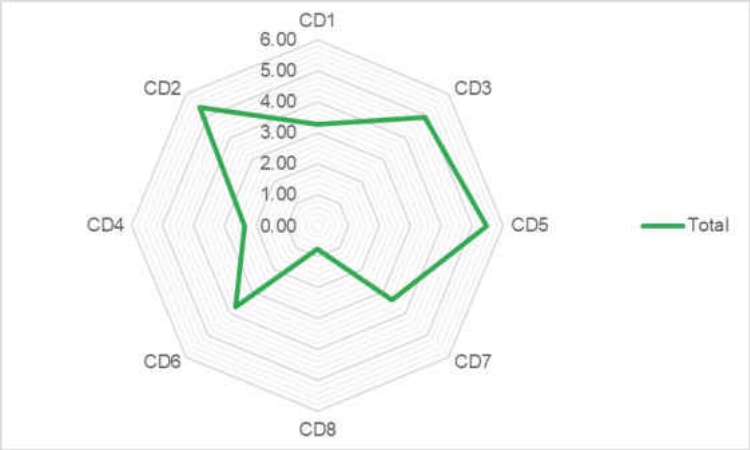

Figure 21 Octalysis Graph of Pilot Motivation

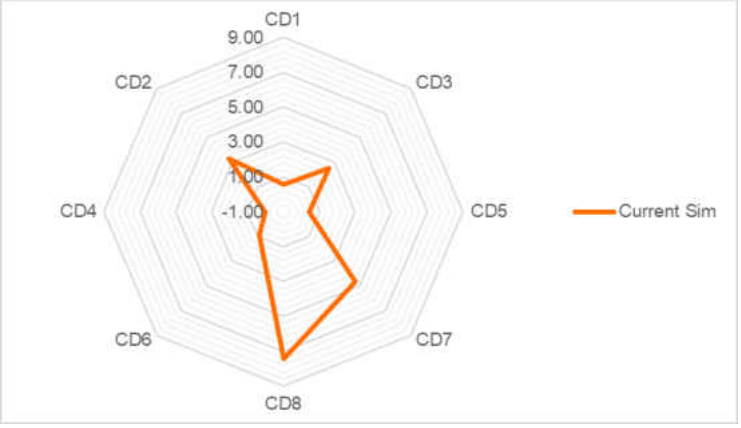

Figure 22 Octalysis Graph of Current Simulator

Table *20* lists the core drives affected by pilots in order of higher points. Pilots largely perceive competition or collaboration with fellow pilots as the main factor of motivation. And they are motivated with achieving goals or accomplishment. they can also be influenced by the mechanics where they are given the opportunity to display their creative thing or get satisfactory

feedback. On the other hand, it appears that they are not motivated to avoid disadvantages or wasteful efforts, but in fact, they are influenced by them, which seems to be the opposite of excessive exposure to CD8 elements. Also, the CD8 is a basic foundation for military training, so it is not necessary to deliberately set up a motivational Mechanic.

Table 20 Priority of Motivated Core Drive

Priority	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Core Drive	CD5	CD2	CD3	CD6	CD7	CD1	CD4	CD8
10pt. scale	5.48	5.39	4.93	3.72	3.39	3.28	2.35	0.76

When analyzed age-specific motivations, the results of Figure *23* came out. CD3 and CD5 which are considered intrinsic motivation core drive show relatively uniform patterns regardless of age, while CD2, CD4, which are considered extrinsic motivation core drive, differ greatly depending on age. The age group after 31 is seen to have little motivating effect in CD8: loss & avoidance areas, while the younger generation, under 30, is seen to have some motivators for CD8, but also as a small portion compared to other areas.

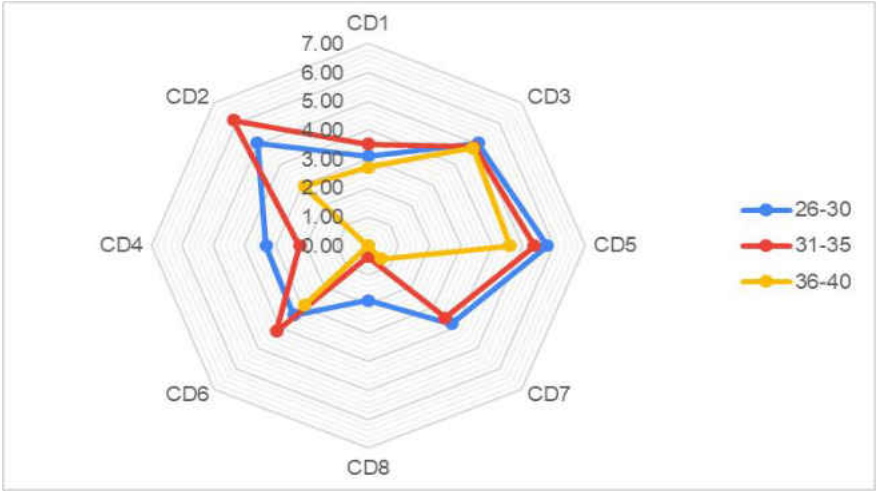

Figure 23 Octalysis graph by age

5.2.1.5 Results Summary

Research assumptions should be met in order for this thesis to have a positive impact on the pilot's needs and motivational patterns. The first assumption appears to have been partially satisfied and the second assumption appears to be satisfied. Pilots generally showed moderate or slight consent to the curriculum associated with flight simulators, but very much agreed on the needs of development of training content. This is seen as meaning that the current training content is not efficient, as well as they do not want to receive additional work load. That is gamified simulators under an integrated educational and training environment can expect positive effects. The Octalysis framework allowed us to recognize the differences in core drives that had an overall impact, and also had distinct characteristics between ages. In the analysis of experience, i.e. differences in flight qualifications, the weight of instructors and advanced qualified pilots is relatively high and often includes pilots with high flight experience but low qualification due to the switching of aircraft types, which seems to be more reliable in the pattern of motivation that varies with age.

Interestingly, regardless of whether they like games and whether they are satisfied with the current curriculum, many pilots agreed that new training platform needs to be developed and wanted simulators with game-like features. It is considered what types of features pilots want in terms of usability and analyzed the age-specific motivating patterns.

CHAPTER 6: GFS EVALUATION FORM AND APPLIED CASES

The gamification framework of flight simulator was developed to create validated evaluation form for gamification index based on what has been analyzed, creating a standard for how efficient and effective way to promote and motivate the users. The main purpose of this gamification is to create an environment that incorporates learning and training and to apply the gamification mechanics to voluntarily engage pilots in learning and training. As a result, the goal is to reduce the training period for developing skillful pilots and increase the portion of training time using simulators in the overall training program. However, as it is another paper's role to evaluate the effectiveness of training and learning with gamification. In this chapter, the focus will be on scoring it according to how well gamification has been done here.

6.1 Development of GFS Attributes weights

The elements for GFS were divided into three main categories. Technology, Usability, and Motivation. Motivation is the element that makes the system used for fun, Usability is the element that makes the system used for satisfaction in terms of learning and training, and Technology means the preparation of a practical environment for using the system.

First of all, Technology is an element that is required to be an environmental condition, and each element in this condition must be equipped to achieve the purpose of GFS. Therefore, Technology is recognized as a prerequisite for GFS. The Table *21* shows the dimensions associated with the gamification Technology. Only when this is basically met will the gamified flight simulator work smoothly.

Table 21 Gamification Technology and dimensions

Gamification Technology	Attributes	Dimensions
1	The number of simulator platforms	Does it provide a sufficient number of simulator platforms?
2	Anytime availability	Is this platform available at any time?
3	Interoperability	Is this platform interoperable with existing simulators?
4	Compatibility	Is this platform capable of training with different kinds of training platforms?
5	Connectivity	Can this platform be connected to a device that provides sufficient visual views for training?
6	Capability for procedural and operational training	Does the platform have a system to carry out procedural and operational training?
7	Network	Is this platform available without delay or error when multiple networks are connected at the same time?

Usability and motivation are inseparable, but it's difficult to divide the portion from the whole score into different areas. It's hard to know which ones let users continue to use the system because these are connected in a complex way. Therefore, usability and motivation have scores individually, and the sum is meaningless.

Usability consists of four Attributes. The basic weights for each attributes are equal to 2. Pilots were asked for the questions mainly about learnability and attractiveness in the survey because learnability and attractiveness are subjective indicators. This does not mean that interactivity and productivity are not important. The default value of 2 was maintained, except for a few questions, because it was difficult for users to judge the value in these. In learnability attributes, a weight of one point was added to items with a response rate of more than 30 percent, and a weight of two points was added to items with a response rate of more than 50 percent. In attractiveness attributes, items with more than 3 points on a 10-point scale added a weight of 1

point, items with more than 5 points added a weight of 2 points, and items with more than 7 points added a weight of 3 points. The default weight was set at 2, and added one extra weight to each items mentioned in the survey's open-ended questions.

The custom difficulty setting in item 8 in the Learnability attribute has been replaced by support for various play modes, including support for multi players that many respondents wanted. This is because it is considered a larger concept to create a system with various modes because setting on difficulty level or the capability of several players to perform missions at the same time are possible through custom play, and multi-user play.

The following Table 22 is a usability attributes with determined weights. Highlighted weights are frequently mentioned in open issues and added weights. Total points are 93 points in total, but the evaluation form translates into 100 points in total to make it easier to see.

Table 22 Usability Attributes Weights

Learnability	Dynamics	Weights
1	Personal Progress Tracking	3
2	Phased Learning Contents	4
3	Phased Training Contents	4
4	Non-flight Knowledge and Skills Training	4
5	Library system	5
6	Archive system	4
7	Assessment system	3
8	Support for various play modes	5
9	Qualification Support System	3
	Learnability Total	**35**
Attractiveness	**Dynamics**	**Weights**
10	Familiar Design	5
11	Realistic Visualization	4
12	Realistic Sound effects	4
13	Background music	3
14	Interactive sound effect	4
15	Custom Design setting	4
16	Custom Interface setting	4
	Attractiveness Total	**28**
Interactivity	**Dynamics**	**Weights**
17	User Activity	3
18	Troubleshooting support	2
19	Organized and Integrated contents	2
20	Voice Autogenerate	2
21	Other type of player connectivity	2
	Interactivity Total	**11**
Productivity	**Dynamics**	**Weights**
22	Reaction to Error	2
23	Navigation	2
24	Easy to Control	2
25	Devices Connectivity	2
26	Easy developing Scenario	5
27	Easy developing Mission data	4
28	Automated storage and analysis of engineering data	2
	Productivity Total	**19**
	Total	**93**

Finally, the motivational factor was determined by rounding each of the motivational core drives converted to 10 points. Applying an effective method of motivation for the highest-weighted core drive is believed to have far greater effect than that for the less-weighted core drive. As shown in Table *23*, the total score is 28 points, and similarly, the total score is converted to 100 points in the evaluation form to make it easier to see. For more information on the evaluation form, see Appendix B.

Table 23 Core drives weights for Motivation

Motivation	Core Drives	Constant Weights
1	CD1: Epic Meaning and Calling	3
2	CD2: Development and Accomplishment	5
3	CD3: Empowerment of Creativity and Feedback	5
4	CD4: Ownership and Possession	2
5	CD5: Social influence and relatedness	5
6	CD6: Scarcity and Impatience	4
7	CD7: Unpredictability and Curiosity	3
8	CD8: Loss & Avoidance	1
	Total	**28**

6.2 Application to current simulator and game

Simulators and games differ in their purpose in terms of training and enjoyment. But there's a game that you enjoy as if you're training, and it's a serious game. It is needed to take a look at how the gamified simulator evaluation form can be used through the comparison between the simulator currently in operation and the serious game. The current simulator and the COTS flight simulator game were analyzed with the developed evaluation form. The simulator used for

the flight training of (K)F-16 pilots has been analyzed as the current simulator (KAI, 2020). The analyzed game was Falcon 4.34 BMS. It is believed to be the most realistic and sophisticated F-16 flight simulator game on the market. This game is a serious game that simulates almost similar avionics, maneuvers, and procedures of actual F-16 fighter jets, and is actually very detailed, unlike other commercial flight simulator games. Players can perform most procedural and operational tasks that are not confidential. The photo of the Figure *24* below is from KAI's website, which has been used for Republic of Korea Air Force F-16 flight training since 2015. Figure *25* on the right is a photo of Falcon 4.34 BMS that has been in operation since the game was first introduced in 1998. I evaluated these two through the evaluation form based on my experience in flight simulator training as a KF-16 pilot for 10years, and the experience in the Falcon BMS game and the attached manual (BMSDOCteam, 2019).

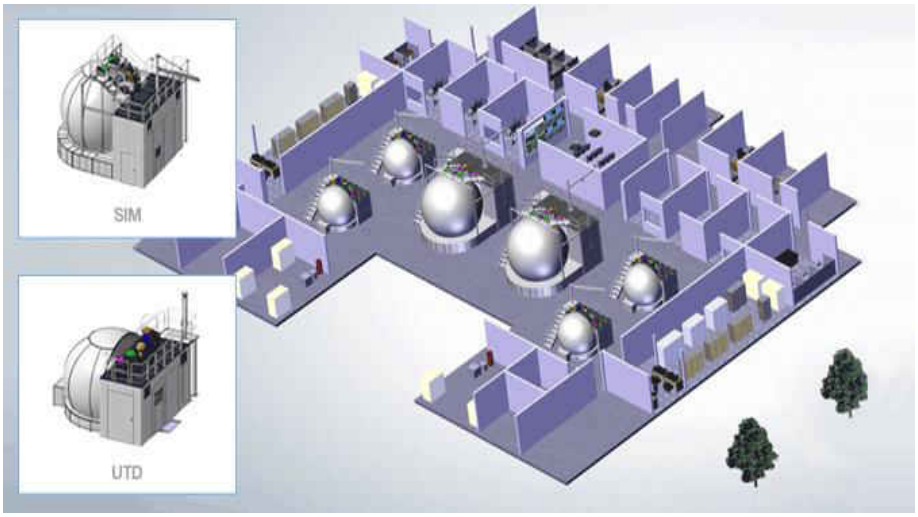

Figure 24 KF-16 simulator bird's eye view

Figure 25 The COTS flight simulator game

The following Table *24* is a form that has been evaluated. Among the evaluation items, gamification technology is not evaluated here because it corresponds to the environment for gamified simulators. the adjusted points are calculated by multiplying the developed weight by the measurement of subjective judgment. To add objectivity to subjective judgments, zero was measured at no relevant dynamics, 0.3 was measured when it has a similar dynamics but it is not equipped with direct system , 0.5 was measured at partial operation but it is somewhat satisfied, 0.7 was measured at full operation but it is not fully satisfied, and 1.0 was measured at full operation and full capability.

Table 24 Evaluated form for current simulator and Falcon BMS game

Gamification Usability			**Current Simulator Program with curriculum, human instructor**		**Falcon BMS, Serious Game**	
Learnability	Dynamics	Weights	Point (0 - 1.0)	Adjusted Point	Point (0 - 1.0)	Adjusted Point
1	Personal Progress Tracking	3	0.3	0.9	1	3
2	Phased Learning Contents	4	0.3	1.2	0	0
3	Phased Training Contents	4	0.3	1.2	0.7	2.8
4	Non-flight Knowledge and Skills Training	4	0.3	1.2	0	0
5	Library system	5	0.3	1.5	0.5	2.5
6	Archive system	4	0.3	1.2	0.5	2
7	Assessment system	3	0.3	0.9	0.5	1.5
8	Support for various play modes	5	0.3	1.5	1	5
9	Qualification Support System	3	0.3	0.9	0	0
		35	10.50	10.50	16.33	16.80
Attractiveness	Dynamics	Weights	Point (0 - 1.0)	Adjusted Point	Point (0 - 1.0)	Adjusted Point
10	Familiar Design	5	0.3	1.5	0.7	3.5
11	Realistic Visualization	4	0.5	2	0.7	2.8
12	Realistic Sound effects	4	0.5	2	0.7	2.8
13	Background music	3	0	0	1	3
14	Interactive sound effect	4	0	0	0.7	2.8
15	Custom Design setting	4	0	0	0.5	2
16	Custom Interface setting	4	0.3	1.2	1	4
		28	6.40	6.70	21.20	20.90
Interactivity	Dynamics	Weights	Point (0 - 1.0)	Adjusted Point	Point (0 - 1.0)	Adjusted Point
17	User Activity	3	0.3	0.9	0.5	1.5
18	Troubleshooting support	2	0.7	1.4	0.5	1
19	Organized and Integrated contents	2	0	0	0.5	1
20	Voice Autogenerate	2	0	0	0.7	1.4

Gamification Usability				Current Simulator Program with curriculum, human instructor		Falcon BMS, Serious Game	
21	Other type of player connectivity		2	0.3	0.6	0.3	0.6
			11	2.86	2.90	5.50	5.50
Productivity		Dynamics	Weights	Point (0 - 1.0)	Adjusted Point	Point (0 - 1.0)	Adjusted Point
22	Reaction to Error		2	0.7	1.4	0.5	1
23	Navigation		2	0.3	0.6	0.7	1.4
24	Easy to Control		2	0.3	0.6	0.5	1
25	Devices Connectivity		2	0	0	0.7	1.4
26	Easy developing Scenario		5	0.5	2.5	0.7	3.5
27	Easy developing Mission data		4	0.5	2	0.7	2.8
28	Automated storage and analysis of engineering data		2	0.7	1.4	0.7	1.4
			19	8.14	8.50	12.21	12.50
			93	27.90	28.6	55.25	55.7
			100	30.00	30.8	59.41	59.9

Motivation	Core Drive	Weights	Point (0 - 1.0)	Adjusted Point	Point (0 - 1.0)	Adjusted Point
1	CD1: Epic Meaning and Calling	3	0.3	0.9	0.7	2.1
2	CD2: Development and Accomplishment	5	0.3	1.5	0.7	3.5
3	CD3: Empowerment of Creativity and Feedback	5	0.3	1.5	0.7	3.5
4	CD4: Ownership and Possession	2	0	0	0.7	1.4
5	CD5: Social influence and relatedness	5	0.3	1.5	0.7	3.5
6	CD6: Scarcity and Impatience	4	0.3	1.2	0.5	2
7	CD7: Unpredictability and Curiosity	3	0.3	0.9	0.5	1.5
8	CD8: Loss & Avoidance	1	1	1	0.5	0.5
		28	2.80	8.50	5.00	18.00
		100	35.00	30.36	62.50	64.29

6.3 Results Analysis

In each usability evaluation, Falcon game scored higher than the current simulator and more than doubled the gap, especially in attractiveness and interactivity. Based on the conversion of 100 points from the total score, the current simulator scored 30.8 points and the Falcon game scored 59.9 points, doubling the score gap. One thing to note is that there is not much difference between the adjusted points that applied weights based on the data obtained from the survey and the simply measured point. Even in the total score of each of the Attributes points combined, the simply measured points and weighted points showed a difference within one point. From this point of view, it seems that applying each of the Attributes weights is not very important, but based on the total score of the items corresponding to each of the Attributes, it can be seen that the current simulators do not greatly satisfy users in terms of gamification.

Table 25 Results of Gamification Usability

Gamification Usability		**Current Simulator Program with curriculum, human instructor**		**Falcon 4.34 BMS (Serious Game)**	
Attributes	Total point	Point (0 - 1.0)	Adjusted Point	Point (0 - 1.0)	Adjusted Point
Learnability Total	35	10.50	10.50	16.33	16.80
Attractiveness Total	28	6.40	6.70	21.20	20.90
Interactivity Total	11	2.86	2.90	5.50	5.50
Productivity Total	19	8.14	8.50	12.21	12.50
Total	93	27.90	28.6	55.25	55.7
Adjusted Total	100	30.00	30.8	59.41	59.9

In terms of motivation, Falcon game was also seen as stimulating core drives related to motivation more than twice as much as current simulators. The difference between the weighted points and the simple measured points was greater than usability, which is believed to be due to the size of each weight, instead of fewer motivational items with eight. Therefore, the weights for each item are shown significantly.

Table 26 Results of Gamification Motivation

Motivation		**Current Simulator Program with curriculum, human instructor**		**Falcon BMS, Serious Game**	
		Point (0 - 1.0)	Adjusted Point	Point (0 - 1.0)	Adjusted Point
Total	28	2.80	8.50	5.00	18.00
Adjusted Total	100	35.00	30.36	62.50	64.29

CHAPTER 7: DISCUSSION AND FUTURE RESEARCH

7.1 Discussion

The research was done on the gamification of simulators to build a more effective training environment. Accordingly, a gamification framework was developed and a survey of pilots showed pilot needs and motivations patterns in areas corresponding to usability and motivation of the framework. The gamification framework of flight simulator consists of usability with four technologies that represent the environment for gaming and motivators with eight core drives. Our main purpose of the gamification is to personalize learning and training patterns, including e-learning systems that can be learned in flight simulators, so that self-efficacy learning and training can be performed, and when various motivational mechanics are included in the training program, pilots are expected to be interested in the training program and the usability will be able to sustain the individual and group satisfaction.

Satisfaction and motivation increase the time to use the system and cause the system to continue to be used from a long-term perspective. The increase in total hours of use means an improvement in flight skills, so if users invest more time in simulator training and learning on average in a set period, they will be able to improve their skills faster in a period. This could ultimately save time and money in training elite pilots and could replace certain sensitive live flight training with simulators.

The framework was developed in the direction of gamified simulators by conceptively approaching what gamification is, and made a gamification evaluation form by scoring each element of this framework. When this was applied to current military simulators and commercial flight simulators, the Falcon BMS, a commercial flight simulator in terms of gamified simulator,

scored more than twice as high as the military flight simulators. In light of this situation, it is believed that if a more detailed application of a similar form to the Falcon BMS and various gamification usability to the gamified flight simulator, a higher level of gamified simulator can be created while at the same time creating a program that shows a significant level of motivational patterns.

However, given that the evaluation form, which includes weights to create more satisfied usability by reflecting the pilot's needs in gamified flight simulator, was simply no different from the simply measured points, and that there was some difference in the core drive for motivation, usability in the gamification evaluation form does not seem to have to be applied weight, and the weight for each core drive seems to be valid.

7.2 Future Research

I have developed a conceptual gamification framework. The next area of study is to identify the effectiveness of each item of attributes. It is also to create a real-world, gamified flight simulator to perform usability tests and motivational tests. This could be judged using various sources rather than simply judging individual motivation through surveys. For example, access time, time spent on a particular interface, major activity history, and communication patterns will help to determine whether individuals are motivated.

The survey on motivation, needs and propensity was conducted only on fighter pilots of the South Korean Air Force. Next time, it can be expanded as commonly applied gamification theory by comparing cargo or helicopter pilots with fighter pilots and also between nations.

Second, research has been done on whether satisfaction with usability and motivation factor leads to increased use time, but more detailed research is needed on how much it affects the effectiveness and efficiency of training.

Third, it is necessary to verify how effectively current IT and computer graphics technology can demonstrate visualization of flight display. Although the visual performance of latest desktop computer performance is believed to have caught up with current complex and expensive military flight simulator. there is still a limit for VR capability such as resolution and latency even in top-end desktop computer. Therefore, it will be necessary to study how much visual performance can be embraced without much impact on flight training.

Finally, Research on infrastructure and organizational composition is needed to construct a gamified simulator. The advantage of gamified simulators is that users can physically use the system 24 hours a day with minimal instructor intervention and technician. However, constant updates and management are needed for usability and motivational elements to play a lasting role in the long term. Accordingly, instructor pilots and programmers who require professional knowledge will need to be present in one department in a central approach. Therefore, research on detailed manpower management will also be needed.

7.3 Conclusion

At the start of the research, gamification was expected to be a new boost in military training. Interest in gamification has steadily increased for about 10 years and research has been done on the application of gamification in many areas. However, there was no research field related to gamification in the Republic of Korea Air Force. Therefore, it is believed that the study

of the gamification of flight simulators to suit the nature and necessity of Korean pilots could serve as a cornerstone of future research on the gamification of the military sector.

Gamification does not necessarily have to be done like video games on a computer. There comes a situation in which we get a lot of motivation in our lives. There are many cases in which military training is also motivated. The purpose of training or education is not to enjoy, but it is to motivate people by giving them elements to enjoy. It is hoped that organizing these motivational elements and consisting usability attributes that satisfies users or trainees will be a device that will increase user immersion and usage time in other areas other than this flight simulator.

APPENDIX A:
QUESTIONAIRE OF PILOT'S NEEDS AND MOTIVATION FACTORS

A Survey on the Motivation Factors and the Application of Gamification Theory for the Korean Air Force Fighter Pilot

- Participation in the survey is voluntary. It will not affect your career.

- The survey requires (average) 7 - 10 minutes or less to complete

- There are 15 main questions and sub-questions.

- Information you submit is confidential. Results will never be released in any identifiable form.

Click the "Continue" button below to begin the survey. Close the browser window or tab if you wish to stop anytime.

Demographic information

The demographic questions of this section will help us better understand the participants for our survey. Recognizable name or your identity, gender, date of birth here are not included.

1. Squadron
2. Age
   - ☐ 20 – 25
   - ☐ 26 – 30
   - ☐ 31 – 35
   - ☐ 36 – 40
   - ☐ 41+
3. Rank
   - ☐ Second Lieutenant
   - ☐ First Lieutenant
   - ☐ Captain
   - ☐ Major
   - ☐ Lieutenant Colonel
4. Qualification
   - ☐ TP
   - ☐ WM
   - ☐ 2L
   - ☐ 4L
   - ☐ IP
5. Flight hours
   - ☐ - 100
   - ☐ 100 – 200
   - ☐ 201 – 300
   - ☐ 301 – 500
   - ☐ 500 – 1000
   - ☐ 1000+

6. How much average time have you spent learning theoretical knowledge associated with flight skills in a week.

- ☐ < 2 hours
- ☐ 2-4 hours
- ☐ 5-8 hours
- ☐ 9-12 hours
- ☐ 13-16 hours
- ☐ 17-24 hours
- ☐ 24+ hours

7. How much average time have you taken flight simulator training in a week(number)?

Pilot perception of simulators.

8. What reason makes you flying simulator

- Training Requirement
- a sense of accomplishment in one's skill development
- a desire to try something new
- the pressure of a lack of flight skill
- an infrequent opportunity
- Response to an emergency situation that is not known when it will occur
- The idea that I want to fly better than other
- Etc.

9. Do you think the curriculum for theoretical knowledge, the flight simulator training , and the live flight are enough to improve your skills? (Current Status)

Strongly Disagree --------- Strongly Agree						
1	2	3	4	5	6	7

10. Learning and training contents are currently being developed through e-learning systems in various fields, including education, healthcare, and business. Do you think it would be more efficient than the current system if content incorporating theoretical knowledge (T.O., tactics, aircraft identification, emergency treatment, etc.) and flight simulator training were developed? (expectations)

Strongly Disagree --------- Strongly Agree						
1	2	3	4	5	6	7

11. Assuming there is no time and space constraints, what capabilities do you think this integrated system would be useful if it includes? (Desktop-based with VR device) Please check regardless of number.

Staged theoretical education and learning content (T.O., emergency procedure, procedural training, operational training, etc.)

Theoretical evaluation and simulator evaluation tools associated with flight knowledge (replaces existing theoretical and simulator evaluations)

Demonstrate data on pilot learning progress and training patterns

Recommend missions and notifications regarding various qualification maturities

Saving and replaying training sortie

Q&A Menu for Sharing Flight Knowledge and skills

Integrate multiple training and evaluation content (T.O., emergency procedures, tactical knowledge and skills, aircraft identification, etc.)

11.1 If you want to include in addition to the particular function description, feel free to describe.

Pilot perception of games

12. The following questions ask you about your game and your awareness of the existing flight simulator. Please Check the number that represent how you feel about.

	Strongly Disagree --------- Strongly Agree						
	1	2	3	4	5	6	7
I enjoy video games, computer games, or mobile games.							
I wish the existing flight simulator had game-like features. Ex) Level, Ranking, Explosive Effect and Sound Effects, Interface like Falcon 4.0, Story and Voice for Weapon control and ground control.							

13. What kind of game do you prefer?

Check all that apply

- ☐ MOBA (Massive Online Battle Arena): ex. League of Legneds
- ☐ RPG (Role-Playing Game): ex. Pokemon, Final Fantasy
- ☐ MORPG (Massive Multiplayer Online Role-Playing Game: ex. World of Warcraft
- ☐ RTS (Real Time Strategy): ex. Starcraft
- ☐ Shooters: ex. Call of Duty, Sudden Attack
- ☐ Fighters: ex. Tekken, Street Fighters, King of Fighters
- ☐ Puzzle: ex. Candy Crush, Tetris
- ☐ Racing: ex. Need 4 Speed
- ☐ Survival: Battle Ground, Fortnite
- ☐ Sandbox/Open World: Minecraft

Sports Games: NBA2K, FIFA, Winning 11

Others

Gamification of simulator

The following is a discussion about adding gamification to the Learning and Training Integration platform.

14. Please check how much you agree to include the following gaming features. Check any number of functions you wish to have in the simulator.

	Strongly Disagree --------- Strongly Agree						
	1	2	3	4	5	6	7
Interface display using Familiar images and designs							
Visualization of Explosion effects, fellow pilots in a cockpit, blackout at high-G							
Background music in the starting interface and introduction of mission							
AGSM sounds and similar noise when pilots are in a cockpit							
Sound effect associated with switch and button operation							
Changeable Interface: Sound Volume, Graphic Resolution, Brightness, Font, Various Voice Choice for Constructive(Ground controller, Weapon Controller), etc.							
Changeable Character design: Aircraft color, Pilot Avatar, Call sign Patch, Helmet Sticker, etc.							
Changeable Difficulty in a same mission: Increase in enemy aircraft or SAM, Increase in Detection rate from enemy, Complex 3 dimensional maneuver, etc.							
Personalized storage of knee board data related to flight procedures and mission data (DTC) that can be loaded onto an aircraft							
Saving Template for mission briefing materials, flight data, and flight mission data stored on aircraft							

14.1 What other game-like features would be better if included in the flight simulator? Feel free to describe.

Motivation

15. We ask indirect form of questions to find out what type of motivational factors you are positively influenced by. Think about what form of motivation you are primarily had when you play video games, sports, or other competitive actions.

	Strongly Disagree -------- Strongly Agree						
	1	2	3	4	5	6	7
I enjoy something that make me feel like I am serving a higher purpose. Ex. Help people, Donation							
I enjoy Games that make me feel like I am fighting for a greater good. Ex. Saving the world, Defeat Evil Enemy							
I am proud to see my character become stronger by leveling up or upgrading my skills in games							
When I play games or learn something, I tend to work harder if there is a system that allows me to see at a glance what I have achieved. Ex. Progress board							
When I get used to games or sports, I tend to want to change things with more creative ideas.							
I enjoy games that give me feedback. Ex. Success Rate, Reasons for failure							
I sometimes keep playing games to complete a collection in a game. Ex. Collections, Character Cards							
I feel satisfied when I can decorate a character in a game or make a appearance according to my own style. Ex. Avatar, Decoration							
I tend to be more enthusiastic when I stand out in games or sports than others. Ex. Leader Board							
I enjoy playing games with friends. Ex. Likes button, Team play, Groups, Guilds							
I tend to spend more time playing games to get it when there is a limited event period or when there is an exclusive prizes							
I tend to spend my time trying to get something that is very difficult to achieve or difficult to obtain.							
When I play games, I often log on in case there is a sudden reward or mission.							
When I read a book or watch a drama, I can't stop because I'm curious about the next story.							
Sometimes when I use a program like SNS, I can't easily quit because I've been working on it for a long time.							
There are times when I do something for fear of punishment or for fear of losing the opportunity.							

We thank you for your time spent taking this survey.

Click "Back" to revise your answers.

Click "Submit" to end the survey and submit your answers.

If you would like to be contacted about any matter related to this questionnaire, please send email to noldaehoucf@gmail.com.

APPENDIX B: EVALUATION CRITERIA FOR GFS

1. **Gamification Technology (Requirement)**

	Attributes	Dimensions	Guidelines	Meets O / X
1	The number of simulator platforms	Does it provide a sufficient number of simulator platforms?	A total of eight computers and peripherals for training four allies and four enemy units by squadron	
2	Anytime availability	Is this platform available at any time?	24/7 operation of servers and systems, Offline availability	
3	Interoperability	Is this platform interoperable with existing simulators?	Works with existing simulators	
4	Compatibility	Is this platform capable of training with different kinds of training platforms?	Compatibility with other type of training: Ground controller, Weapons controller	
5	Connectivity	Can this platform be connected to a device that provides sufficient visual views for training?	Connectivity of visual field of view enhancer, such as AR, VR devices	
6	Capability for procedural and operational training	Does the platform have a system to carry out procedural and operational training?	Visualization of inside cockpit for procedural and operational practice, Tracking sensors that enable the execution of procedures without tactile components	
7	Network	Is this platform available without delay or error when multiple networks are connected at the same time?	Network play with other players up to 100 entities	

2. **Gamification Usability**

Learnability	Dynamics	Dimensions	Guidelines	Weights	Measures (0 - 1.0)
1	Personal Progress Tracking	Is it possible to monitor the progress of individuals continuously?	Individual ID and Password, Storage of personal status and data	3	
2	Phased Learning Contents	Can the contents convey sufficient knowledge before or during training to acquire the skills required by the user?	Maintenance knowledge, aircraft technical knowledge, Weapons, normal procedures, emergency procedures, basic flight tactics, advanced flight tactics	4	
3	Phased Training Contents	Can the contents provide enough training for pilots to perform procedural and operational skills	Normal procedures, emergency procedures, basic flight tactics, advanced flight tactics	4	

4	Non-flight Knowledge and Skills Training	Does it include other training courses that are indirectly related to flight but are essential?	Enemy aircraft identification training, return training, emergency radio operation training, parachute operation training, biochemical attack preparedness training, etc.	4	
5	Library system	How much / what information can I search or identify for knowledge and training here?	A library of documents, books, videos, etc. related to flight and operations, tactics, Etc.	5	
6	Archive system	How much / what information can I search or identify for knowledge and training here?	Save and Replay mission, Sharing experience	4	
7	Assessment system	How much can an assessment in this system replace an existing assessment?	Evaluation of flight knowledge and skills, Substitution of existing theoretical and simulator flight assessments	3	
8	Support for various play modes	Does the system support a variety of play modes?	Learning mode, Single play mode, Custom play mode(Custom difficulty), Multi-play mode, replay mode	5	
9	Qualification Support System	Can the system provide information and mission recommendations for pilot qualification management?	Recommendation of learning and training contents for retention of knowledge and skills, Notification of expiration date for flight, weapons and equipment qualification.	3	
			Learnability Total	35	
Attractiveness	**Dynamics**	**Dimensions**	**Guidelines**	**Weights**	**Measures (0 - 1.0)**
10	Familiar Design	Does this system utilize familiar and comfortable designs?	Familiar picture and Icon, text	5	
11	Realistic Visualization	Does the system express the desired visual effects well?	Explosion effects, fellow pilots in a cockpit, blackout at high-G	4	
12	Realistic Sound effects	Does the system express the desired sound effects well?	Breathing sounds and similar noise when pilots are in a cockpit	4	
13	Background music	Does the system use attractive background music in interface or story mode?	Attractive music giving immersion	3	
14	Interactive sound effect	Does this system provide a sound effect for buttons, knobs, and clicks?	Sound effects that are not heard in the real world but help interact with it. Ex) adjusting knob, pushing button	4	

15	Custom Design setting	Does the system authorize users to change designs on their own for specific objects?	Visualization device that can influence belonging and immersion ex)Aircraft color, Pilot Avatar, Call sign Patch, Helmet Sticker	4	
16	Custom Interface setting	Does the system have a menu and a setup window to set the interface?	Sound/Music Volume, Graphic Resolution, Brightness, Font, Voice	4	
			Attractiveness Total	28	
Interactivity	**Dynamics**	**Dimensions**	**Guidelines**	**Weights**	**Measures (0 - 1.0)**
17	User Activity	Does the system have the tools to enable users to communicate or share information with others?	Forum, Chat, Notification board, Group Communication	3	
18	Troubleshooting support	Does this system have various channels to solve problems in the system?	Q&A menu, Update plan, Help option, Provide System state	2	
19	Organized and Integrated contents	Does the system allow you to view multiple different content during training?	Document and related knowledge available during training	2	
20	Voice Autogenerate	Does the system allow automatic communication with objects or entity without live person's intervention?	Autogenerated voice of Constructive Ground controllers, Weapons Controllers, Commanders using text-to-speech solution	2	
21	Other type of player connectivity	Does the system enable communication with other live objects or other types of training systems required during flight training?	Interconnectivity with Virtual Ground controllers, Weapons Controllers, Commanders	2	
			Interactivity Total	11	
Productivity	**Dynamics**	**Dimensions**	**Guidelines**	**Weights**	**Measures (0 - 1.0)**
22	Reaction to Error	When using this system, are errors at acceptable levels and are recorded automatically?	Automated Error report, Acceptable error rates, errors that do not cause serious problems with use.	2	
23	Navigation	Is this system intuitive and easy to navigate?	Intuitive design, Keyword search, Simple dialogs, Shortcut	2	
24	Easy to Control	Is it easy to control this system?	Easy to Install, Start, Cancel, Return, Redo, and End	2	

25	Devices Connectivity	Is the system easily able to recognize and connect peripherals?	Plug and Play, Connectivity with peripherals, ease of connection with VR equipment and tracking sensor	2
26	Easy developing Scenario	Is it easy to create scenarios and missions on this system?	Scenario development Tool, Developed Template sharing system	5
27	Easy developing Mission data	Is it easy to create mission data and share it on this system?	saving personalized mission data, sharing mission data	4
28	Automated storage and analysis of engineering data	Can all records that occur on this system be stored as engineering data?	Data accumulation for updating learning and training programs and for developing tactics and Comparing Performance Between Pilots	2
			Productivity Total	19
			Total	93
			Adjusted Total	100

3. **Motivation**

Motivation	**Core Drive**	**Dimensions**	**Guidelines**	**Weights**	**Measures (0 - 1.0)**
1	CD1: Epic Meaning and Calling	Does the system include stories in training content to give meaning?	Main Story: Step by step training, the process of becoming a pilot, Sub Story: Story for Qualification of Weapons and Equipment, Narration: Heroism	3	
2	CD2: Development and Accomplishment	Does this system meet the core drive of developing skills, overcoming challenges, and making progress?	Personal Status for progress record of theoretical education and training time, Various records and figures showing personal accomplishment, Skill trees for flight (qualification system), Rank system (Mission points and total training time),	5	

3	CD3: Empowerment of Creativity and Feedback	Can the system allow activities such as engaging in creative processes and give immediate feedback?	Missions with a wide selection of options, Missions with a low probability of success, Mission and Scenario development tool and sharing system, White Feedback: Mission success, Heroism, Elitism, Black Feedback: Mission Failure, Problems Caused by Wrong Decision Making	5
4	CD4: Ownership and Possession	Does the system make users feel that they own or control something?	Avatar / Decoration: Helmet design, Camouflage painting design for aircraft, Collections: Recognitions, Coins, Insignias, Medals, Certificates	2
5	CD5: Social influence and relatedness	Does this system include social factors such as social relationships and cooperation, competition and feedback?	Groups for Squadron and Wing, Group-specific aircraft design and squadron mark / patch for pilot suits, Competition in squadron and with other squadrons, Missions that require team or large forces, Acquiring more points when completing mission as a team, Comments or Like feature for individuals' play	5
6	CD6: Scarcity and Impatience	Does it have an element that makes users want something they lack or can't get easily?	Pop-up missions that are only capable of participating in a specific time or condition, Limitations of eligibility to participate in a particular mission, Rewards that can only be obtained on a specific mission or condition	4
7	CD7: Unpredictability and Curiosity	Does this satisfy the desire to identify something unpredictable?	Sudden Missions, Secret Missions, Random Rewards	3
8	CD8: Loss & Avoidance	Does this have an element that makes you act for something you want to avoid or don't want to lose?	The accumulation of visible data over a long period of time, Disqualification when not connected for a long time, Narrate the bad results caused by poor skill or mission failure, Indication of training requirements for a particular subject, disadvantages when failing to perform	1
			Total	28
			Adjusted Total	100

APPENDIX C: INSTITUTIONAL REVIEW BOARD APPROVAL

UNIVERSITY OF CENTRAL FLORIDA

Institutional Review Board
FWA00000351
IRB00001138, IRB00012110
Office of Research
12201 Research Parkway
Orlando, FL 32826-3246

EXEMPTION DETERMINATION

February 21, 2020

Dear Daeho Noh:

On 2/21/2020, the IRB determined the following submission to be human subjects research that is exempt from regulation:

Type of Review:	Initial Study, Exempt Category 2
Title:	THE GAMIFICATION OF MILITARY FLIGHT SIMULATOR FOR EFFECTIVE LEARNING AND TRAINING ENVIRONMENT
Investigator:	Daeho Noh
IRB ID:	STUDY00001419
Funding:	None
Grant ID:	None
Documents Reviewed:	• HRP 258_Memo Cultural Appropriateness(signed).pdf, Category: International; • HRP-254-FORM Explanation of Research(1.1).pdf, Category: Consent Form; • HRP-254-FORM Explanation of Research(Korean).pdf, Category: Consent Form; • HRP-256 Translation Verification.pdf, Category: Translation Verification; • Introduction of Survey(Korean).docx, Category: Recruitment Materials; • Introduction of Survey.docx, Category: Recruitment Materials; • irb_HRP-255-FORM-RequestforExemption(1.1).docx, Category: IRB Protocol; • Survey on Fighter jet Pilots in Republic of Korea Airforce(1.2).docx, Category: Survey / Questionnaire; • Survey on Fighter jet Pilots in Republic of Korea Airforce(Korean)v2.0.docx, Category: Survey / Questionnaire;

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 submit a modification request to the IRB. Guidance on submitting Modifications and Administrative Check-in are detailed in the Investigator Manual (HRP-103), which can be found by navigating to the IRB Library within the IRB system. When you have completed your research, please submit a Study Closure request so that IRB records will be accurate.

If you have any questions, please contact the UCF IRB at 407-823-2901 or irb@ucf.edu. Please include your project title and IRB number in all correspondence with this office.

Sincerely,

Adrienne Showman
Designated Reviewer

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