The Case of Eco-Drive Education and Effect Analysis in ROKAF for Low Carbon and Green Growth

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Abstract: In line with the Korea government's efforts for reduction of green house gas, ROKAF aims to transform into green Air-force in the vanguard of eco-friendly national defense reform under the slogan of 'Me first', 'We together'. ROKAF has set three major goals, green work/life pattern, consciousness reform of ROKAF personnel and green life, to meet its aim and the government's determination. Especially, ROKAF's eco-drive education promoted as a way to attain green work and green environment, won the first prizes at the 2010~2012 ministry of environment competition and the eco-driving collaboration group by Korea Transportation Safety Authority. The scheme is the one of the ROKAF's achievements and critical policies which has been widely acknowledged and accepted for its' practicality.

This study aims to shed light upon eco-drive education, the capstone of ROKAF's green policy, and demonstrates the effectiveness and significance of the policy on the basis of statistical analysis.

Keywords: Green house gas, Green Growth, Eco-Drive

I. INTRODUCTION

1.1 experiment's Background and Purpose

For the last 100 years, earth has seen an increase of 0.74 degrees in its temperature and at this rate it seems like the temperature will further increase by 6.4 degrees in the near future. Climate change associated with the Global warming crisis is seriously threatening the earth, and as a measure to counter the desperate situation, the world is starting to embrace the idea of "Green Growth."

In order to find a solution to this international crisis, the international community and the UNFCC, found in 1992, has come together by emphasizing the immediate need to comply to the Kyoto Protocol's obligation to reduce world-wide greenhouse gas emissions. Accordingly, developed nations have gone forward with investments and tax reductions on eco-friendly vehicles and bio-fuel development to promote such green technologies. Meanwhile, the government will reduce the environmental and economic strains caused by heavy, unnecessary traffic by implementing a hi-tech Traffic Controls Program and defraying the costs of such traffic jams(Gyungah, 2010; Sanjin, 2010b). Republic of Korea was ranked 9th in the amount of green house gas emission at the time Kyoto protocol was signed in 2001(Youngwoo, 2005). And it is likely that Korea will be reclassified as a nation obliged to

meet the greenhouse gas reduction target along with Mexico among OECD countries. The Korean government, therefore, makes every effort from all angles to meet the target with an aim of a 4 percent reduction in greenhouse gas exhaustion by 2020 as compared with the statistics that existed back in 2005. Enactment of the Green Growth Act and the introduction of eco-friendly tax schemes are some of the graphic examples of the government's determination. As of 2013 in the post-Kyoto protocol era, Korea has turned into an example of a nation successfully reducing its required rate of greenhouse gas reduction. Table 1 shows that the government drives to become the world's 7th by 2020 and respectively 5th by 2050 in being nominated as a Green-friendly country, which immediately follows its visionary layout of "Green-development nation strategies and 5 year plan," the 3 practical methods and 10 following policy directions. The Green Development Organization hopes to make Korea's bright future into a reality by putting into action such strategic dispositions and daring policy directions(The Committee for Green Growth, 2011).

Table 1. 3-strategies and directions of policies for green growth

Strategies	Directions of policies
Preparation for climate change & independence of energy	- Reduction for green house gas - Strengthen for independence of energy - Strengthen of adaptation for climate change
Production of growth power	- Development of green technology - Promotion of green industry - Change for structure of industry - Furtherance of foundation for green economic
Improvement of quality for life & strengthen for power of nation	- Furtherance of a green country & transportation - Green revolution for life - Embodiment of exemplary nation for green growth

In line with the government's efforts, ROKAF aims to transform into a Green Air Force in the vanguard of eco-friendly national defense reform under the slogan of 'Me first,' 'We together.' ROKAF has set three major goals: green work/life patterns, consciousness reform of ROKAF personnels and green life in order to meet its aim and the government's expectations. ROKAF's eco-drive education, promoted as a way to attain green work and green environment, won first prize at the 2010 Ministry of Environment Competition, 2011 Eco-Driving Collaboration Group, 2012 Korea Transportation Safety Authority Award and other events. The scheme is one of the ROKAF's achievements and critical policy which has been widely acknowledged and accepted for its practicality(ROKAF Headquater, 2009, 2011; ROK Ministry of National Defense, 2011). Other than these achievements, ROKAF has introduced effective-low pollution transportation rules, electric cars and eco-friendly infrastructure to become a 'Green Air Force. The execution of eco-drive in the 'green era' is also showing progression towards a nation-wide agreement of a Green life and economy.
This study aims to shed light upon eco-drive education, the capstone of ROKAF's green policy, and demonstrates the effectiveness and significance of the policy on the basis of statistical analysis.

1.2 Experiment's Range and Directions

The following experiment's range of expertise can be sorted into two parts. The first consists of recording the efficiency of eco-friendly methods on newly enlisted soldiers at the Air Force

Education and Training Command. Secondly, after the soldiers finish their basic training and are transferred to their respective bases, the data of each soldier's economic productivity and waste will be analyzed. The reason for the two steps is because the materials taught in the Air Force Education and Training Command and the materials taught in each soldier's home base are quite dissimilar from each other. Therefore, it becomes difficult to generalize a standard or basis between the two different educational methods.
The One-way Layout used in this experiment is derived from the ANOVA analysis that comes all the way back from 1960 by Sheldon, who came up with it. The One-way Layout shows which test results from the ANOVA analysis have same or different factors in the statistical graph. This method is widely practiced to identify the difference between specimen groups coming from samples.

2. ECO-DRIVE

2.1 Definition of Eco-Drive

Eco-Drive drives to be an operation efficient in its environment, economy, safety, and convenience. This operation reduces fuel output and greenhouse gas emissions by altering the directions, habits, and make-up of public transportation. In the narrow sense, Eco-Drive attempts to change the habits of a driver, while in the wide sense of the term, Eco-Drive consists of conditioning transportation, rearranging the road, and making use of on-site traffic information and others. Even though the same driver drives the same car as before, Eco-Drive show the capability to lessen the amount of money used on fuel. When people realize the need to follow the Eco-Drive guidelines and apply these techniques to their use of transportation, the nation-wide greenhouse gas emission rate will slowly drop as an aftereffect. Afterwards, it is possible to improve the fuel exhaustion rate on the road periodically. Out of the Low Carbon Green Growth strategies, it is sole policy to see positive affect through the conscious conversion of the driver.

2.2 The Need of Eco-Drive

Our country's fuel consumption rate on public transportation alone takes 33 percent of the total amount of fuel consumption. This comes second to business-related fuel emissions, which falls at 55 percent of the total consumption rate. Also, 82 percent of transportation's fuel consumption happen on the road or highway and, unfortunately, the country does not fare well compared to European countries and other developed nations in efficiency of energy per mass. Traffic takes up 5 percent of the nation's fuel outtake for every year and it is constantly on the rise. As table 2 shows, around one ton of greenhouse gas was output in the year 2007 and this amount was 20 percent of the Total Energy Consumption rate. Public transportation shows to be lower than electric (35.5%), and Business-related (31.3), greenhouse gas exhaustion, but transportation is approximately two times bigger than housing, living (11.3%) greenhouse gas consumptions. Therefore, public transportation is an area that is essential to lower greenhouse gas intake in order to reduce the total consumption rate. Compared to the Sea (12.7%), Sky (8.9%), and railway (0.7%), 80 percent or most of the pollution in public transportation comes from the highways and roads(Sanjin, 2010a).
Our country has far exceedingly passed the OECD's average rate of 1.3 in greenhouse gas exhaustion by increasing 2.5 times from 1990 to 2005. It is, however, true that after 2002 the nation's rate has slowed down as less gas is used per car. Less cars are being registered for ownership and advanced car craftsmen ship are saving people from spending too much on

gas(Eunggwon and Sanggwon, 2011).

Table 2. Discharge quantity of green house gas in transportation

Year	1990	1995	2000	2002	2004	2005	2006	2007
Discharge quantity (Million ton of CO_2)	42.4	77.2	87.1	94.9	97.1.	98.1	99.8	101

2.3 ROKAF's Eco-Drive Educational Policy

Eco-Driving can be described as "Driving without breaking the three rules," and the three rules are as follows: 1. Sudden start, 2. Sudden acceleration, 3. Sudden start of the engine. By not breaking any of the three rules, one is able to reduce gas exhaustion from their cars, avoid accidents, lengthen the warranty on a vehicle and save much needed energy.
Eco-Drive is of course most effective as a method to be economically smart by lessening pollution and saving much energy, but it is also quite useful in the case of transportation safety as well. The Air Force has been forgoing with the Eco-Drive education system in four of its bases located in the country since January of 2010, and in 2011, this successful test has led to the decision of adding three more bases as recipients of the same education system. The list of bases in consideration of this trial continues to grow longer as the days of positive feedback increases.
The Air Force has started to enforce the Eco-Drive education on newly enlisted soldiers in the Air Force Education & Training Command base and the soldiers are continuing such education in their respective bases after basic training. Since the Eco-Drive Education process is introduced as one of the first educational courses to newly enlisted soldiers, soldiers maintain their consciousness of Eco-Driving habits by learning and continuing to practice this education for the two years of this service in the Air Force.

2.4 Eco-Drive in Air Force Educational & Training Command and Individual Bases

At the Air Force Education and Training Command, soldiers have to practice driving around a 5.8km course ten times in order to stabilize their driving habits and abilities. The soldiers are asked to drive according to their usual habits until the third practice run, when the soldiers drives with consideration of the results from the self-induction device that is analyzed by educational coaches. After the practice runs, the soldiers participate in a theory class about the positive and negative points of Eco-Drive and the working functions of Eco-Drive. From the third to tenth meetings, the educational coaches observe and compare the training driver's driving habits with the driving patterns of the self-induction driving device. Lastly, the individual characteristics from the retrieved data of the drivers are set to be revised with improved driving techniques.
The Eco-Drive education taught in an individual's actual base is the process of perfecting of the Eco-Drive lessons practiced in the Air Force Education and Training Command. So, after the soldiers go through basic Eco-Drive Education classes in the Air Force Education and Training Command, the transferred soldiers are taught about the Eco-Drive skills of adapting to the geographical terms and working environment. The difference from the Eco-Drive education taught in the Air Force Education and Training Command is that the Eco-Drive self-induction driving device measures the fuel exhaustion cost of each driver, which the education director breaks into parts for the drivers to improvise their driving techniques and respective characteristics while driving. The director assists in perfecting such improvised

driving skills and habits with the drivers afterwards. Since the driving courses at the Air Force bases may have some differences to the driving conditions and the layout of the cars, such base cannot possess the same practice conditions as the Air Force Education and Training Command; but the individual characteristics of the respective bases are taken into consideration in the education process.

Figure 1 shows the Eco-Drive step-by-step practice information. During every practice run, the observational data from the latest practice runs are used to improvise and improve the driving of the soldiers. As picture 1 shows, the Eco-table hung up in every base's practice area informs each driver to lengthen and improve their length of Eco-Drive driving habits and driving. The Eco-table is a decree enforced by the Traffic Safety Organization and the layouts of the sign can be seen as in table 3.

		
① Preparation of getting on a car	② Setting of equipment	③ Observation for a driving habit for a driver
		The END
④ Conformation of driving information in equipment (instructor)	⑤ Recording for a result of observation & fuel efficiency	

Figure 1. Procedure of Eco-Drive practice education

	
An ascent(slow acceleration)	A descent(fuel cut)

Figure 2. Eco-Drive sign on a load

Table 3. Means of Eco-Drive sign

Sign	Means	Sign	Means
	Slow Stepping on Accelerator		Taking of foot on Accelerator

3. ANALYSIS OF EFFECTS FROM ECO-DRIVE EDUCATION

3.1 Effects of Eco-Drive Education in Education & Training Command

1) Data needed for Analysis of Effects

The data for the per liter/kilometer gas exhaustion retrieved from the self-induction driving device is one of the most essential factors in analyzing the Eco-Drive performances of the drivers. The retrieved data is collected from observing normal sized car drivers from 12 classes, who passed the driving educational classes in the Air Force Education and Training Command in a full year.

The ten practice runs of each class are the standard for the data and such practice runs are in action from 9 to 16 o'clock with zero consideration of the weather or the time of the day. The first two practice runs come before the theory classes, so the soldier's drive with their usual driving habits; and this way, their fuel efficiency for the first two driving sessions can be examined in contrast to the other 9 driving sessions that come later. The method of interpreting such data is through the ANOVA analysis of variance, which uses distributed deployment of data. Graph 4 shows data from the twelve classes of training driver's who drove in 2010 at the Air Force Education and Training Command driving sessions with the self-induction equipment when they drove to measure the fuel efficiency per liter. The results clearly show that the fuel efficiency rate rose as the number of practice runs increased.

2) Fuel efficiency betterment from Eco-Drive Education

As one can see from looking at table 4, the fuel efficiency rate rose for the better as the number of educational class rose also; and by the tenth practice run, a 14km/liter fuel efficiency rate was generally seen by the drivers' performances. However, to truly know the trainee's capacity to drive "economically," there needs to be more specialized tests and statistics to analyze such improvements from the past.

As mentioned earlier, the ANOVA analysis that uses the unitary dispersion deployment experiment was used for the interpretation of all data. Tools for the analysis included the ez SPC 2.0**,** which was developed from the statistics quality-control laboratory in Hanyang University.

By contrasting the heed level a=0.05 with the double marks on the number of educational courses taken, emphasis was put on handling statistical data with much caution. Table 5 shines light on the improvement of fuel efficiency of the training driver's according to the number of practice runs they respectively drove. The shading area on table 5 indicates the point where the fuel efficiency rate improved from previous runs, and this area also indicates the point where the fuel efficiency rate gets smaller than the heed level a=0.05. Table 5 show that three significant improvements exist and after the start of Eco-Drive theory training, the 3rd, 6th,

and 9th exercised were statistically shown to have elevated fuel efficiency rates than previous exercise runs. From these statistical results, it makes sense to assume that the "Eco-Drive" educated trainees become self-conscious of the importance of Eco-Drive and, therefore, intend to make it a habituation in their driving; which translates into new driving habits and advanced techniques that for better fuel efficiency rates.

Table 4. An average of driver's fuel efficiency for a block

Unit : km/ℓ

	Before education	3	4	5	6	7	8	9	10
10-1	10.74	12.54	12.91	13.19	13.35	13.56	13.67	14.04	14.05
10-2	12.38	12.60	12.90	13.30	13.10	13.70	13.80	14.70	14.20
10-3	12.13	12.80	13.40	13.10	13.60	14.00	14.30	14.50	14.80
10-4	11.73	11.92	12.50	12.40	13.30	13.60	13.60	14.30	14.20
10-5	11.58	11.90	12.40	12.60	13.00	12.90	13.80	14.20	14.80
10-6	9.44	9.94	10.30	10.90	11.50	11.30	11.70	11.90	12.30
10-7	9.61	10.73	11.10	11.40	11.60	11.80	12.20	12.40	12.90
10-8	11.58	12.90	13.10	13.00	13.50	13.90	14.20	14.50	14.80
10-9	11.42	11.92	12.50	12.40	13.30	13.60	13.60	14.20	14.25
10-10	9.64	10.80	11.10	11.50	11.60	11.90	12.20	12.60	13.10
10-11	9.77	11.00	11.20	11.70	11.80	12.00	12.40	12.80	13.50
10-12	9.61	11.90	11.90	12.30	12.60	13.00	13.40	13.70	14.10

Table 5. An improvement effect for driver's fuel efficiency by Eco-Drive education (α=0.05)

	Before education	3	4	5	6	7	8	9	10
Before education	-	0.0357	0.0059	0.0009	0.0001	0.0000	0.0000	0.0000	0.0000
3		-	0.3623	0.1207	0.0159	0.0052	0.0005	0.0001	0.0000
4			-	0.5737	0.1316	0.0462	0.0068	0.0008	0.0001
5				-	0.2713	0.0935	0.0124	0.0012	0.0001
6					-	0.4964	0.1262	0.0150	0.0011
7						-	0.4268	0.0799	0.0103
8							-	0.2813	0.0510
9								-	0.4193
10									-

3) Effects of Education, By Class

The elevated fuel efficiency fro Eco-Drive education's skill improvement of students was verified through 2). Nevertheless, every class of soldiers has their distinctions and further tests were to explain the difference in each class' performance of fuel efficient driving. The plan was to analyze similarly to the interpretation of 2) by interpreting the pair-mark fuel efficiency of each class.

Table 6 is divided into groups according to each class' fuel efficiency improvement rates on the year 2010, so the 12 classes of soldiers are classified into two groups. The shaded areas in the graph indicates the group that had positive effects after taking the Eco-Drive education, and such classification into groups was made by comparing each group's performance with the standard of the heed level a=0.05. As already proven by graph 4, the group with better fuel efficiency rates before taking any Eco-Drive education classes was the group that acquired the educational standards faster.

Table 6. An improvement effect for groups fuel efficiency by classes (α=0.05)

	10-1	10-2	10-3	10-4	10-5	10-6	10-7	10-8	10-9	10-10	10-11	10-12
10-1	-	0.5896	0.3346	0.8289	0.7755	0.0004	0.0039	0.5070	0.7710	0.0063	0.0163	0.2612
10-2		-	0.5800	0.4050	0.3856	0.0000	0.0003	0.8331	0.3694	0.0006	0.0021	0.0946
10-3			-	0.2073	0.2041	0.0000	0.0002	0.7740	0.1904	0.0004	0.0011	0.0495
10-4				-	0.9324	0.0004	0.0040	0.3544	0.9321	0.0067	0.0184	0.3205
10-5					-	0.0007	0.0070	0.3383	0.9983	0.0111	0.0281	0.3748
10-6						-	0.2947	0.0000	0.0006	0.2390	0.1326	0.0162
10-7							-	0.0006	0.0057	0.8715	0.5873	0.0961
10-8								-	0.3252	0.0011	0.0031	0.0901
10-9									-	0.0093	0.0245	0.3636
10-10										-	0.7046	0.1292
10-11											-	0.2363
10-12												-

We tried to confirm an improved number of exercise tests with significant statistical data by observing each group's respective interpretations, but the samples were not enough to make the analysis dependable.
After more samples are secured for testing, further analysis is to be done in the future trials.

3.2 Effects of Eco-Drive Education in Bases

1) Data for Analysis Interpretation
The data needed for Eco-Drive interpretations stay the same as the ones required during training sessions in the Air Force Education and Training Command, which is the weighed-in fuel efficiency per liter standard according to the recording by the Eco-friendly self-induction device. The subjects are the newly transferred soldiers who have recorded statistics on their average fuel efficiency rate that was recorded in 2011 from January to Aril for 4 weeks. The purpose for selecting the 00 base was because the working environment and the geographical settings may contribute to an error of the interpretation of a whole base.
The soldier's are educated on the geographical features of their new bases and then they have three practice runs, before any educational courses taken, to record their average fuel efficiency rates. Interpretations of the driver’s performances are carried out by the same method the Air Force Education and Training Command uses with the unitary distribution deployment ANOVA analysis. Table 7 is the data of 12 newly transferred soldiers and their liter per average fuel efficiency measured by the Eco-friendly self-induction device. As the number of practice runs increased, the fuel efficiency rate also rises.
Contrasting with the Air Force Education and Training Command's last ten average fuel efficiency rates, 00 Air Force base's hybrid car did comparatively, far better than the Air Force Education and Training Command's normal-sized cars in getting better fuel efficiency rates on the eco-friendly self-induction devices attached inside the automobiles.

Table 7. An average of driver’s fuel efficiency by week

Unit : km/ℓ

	Before education	1-week	2-week	3-week	4-week
A	15.49	15.49	16.87	17.84	17.88

B	16.61	16.61	15.68	18.57	18.36
C	15.23	15.23	16.02	09.42	20.00
D	17.40	17.40	17.80	18.50	19.90
E	17.50	17.50	18.60	19.70	19.80
F	15.40	15.40	18.90	20.30	20.40
G	17.80	18.70	18.70	18.90	19.00
H	20.60	22.20	22.90	23.20	23.80
I	17.60	18.90	19.50	19.70	20.10
J	17.60	18.40	18.90	18.90	19.20
K	20.00	21.40	22.70	23.80	24.30
L	17.10	17.90	19.20	19.40	20.40

Contrasting with the Air Force Education and Training Command's last ten average fuel efficiency rates, 00 Air Force base's hybrid car did comparatively, far better than the Air Force Education and Training Command's normal-sized cars in getting better fuel efficiency rates on the eco-friendly self-induction devices attached inside the automobiles.

2) Fuel Efficiency Changes Brought on by Eco-Drive's Education

As Table 7 tells us, more weeks of education also brought on an elevated fuel efficiency rate, and generally by the 4th week, a fuel efficiency rate of 19km/liter was shown by the drivers. This interpretation followed the ANOVA analysis also used in the Air Force Education and Training Command, and the heed level of a=0.05 was compared to the numbers of weeks in education in order to identify the point of significant change in the experiment. Table 8 shows the progress of the students' improvement in fuel efficiency rates as the number of Eco-Drive practice runs increase also.
The shading area on table 8 indicates the point where the fuel efficiency rate improved from previous runs, and this area also indicates the point where the fuel efficiency rate gets smaller than the heed level a=0.05. Table 8 shows that there is a statistically important fuel efficiency improvement that happens in the third week as expressed on the graph, and this significant change in numbers is thought to be caused by better driving techniques and the habituation of Eco-Driving.

Table 8. An improvement effect for driver’s fuel efficiency by Eco-Drive education (α=0.05)

	Before education	1-week	2-week	3-week	4-week
Before education	-	0.4854	0.0842	0.0020	0.0007
1-week		-	0.3394	0.0298	0.0117
2-week			-	0.2259	0.1040
3-week				-	0.6000
4-week					-

4. CONCLUSION

The Air Force's Eco-Drive education program has been introduced to improve fuel efficiency rates on the road because eco-friendly driving habits were expressed through statistical interpretations, and these statistics proved to hold merit. During the driving sessions in the Air Force Education and Training Command, significantly increased fuel efficiency rates in statistics could be discovered on the third week in a newly transferred soldier's base.
However, the reasons behind the different fuel efficiency rates among distinct groups prove to be a roadblock for the experiment in the present, and will continue to be looked upon as a limit until enough samples arrive to give credit to the tests.
This experiment is ongoing in the Air Force bases around the country and it attempted to prove the program's education as effective by presenting statistical data on Eco-Drive. It expressed the magnitude of the Air Force's Eco-Drive education's widespread use and national embarkment. The program has been around for 2 years since 2010, and has done quiet well in popularizing itself. Also, the Air Force tries to promote green growth and find a stable foundation for a green economy by improving the lifespan of parts in automobiles, enlarging the use of fuel efficient cars, electric cars, and lastly but not the least important, educating about Eco-Drive.
Presently, soldiers in the Air Force serve for a length of 24 months. All of the Air Force's driver soldiers passed courses on Eco-Drive education and are all a major part in improving economic and environmental issues for the whole part of the Air Force by also improving consciousness of Eco-Drive and habits while driving.

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