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Green Information Technology influence on car owners' behavior: Considerations for their operative support in collaborative eLearning and social networks

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ABSTRACT

The study of the influence of the Green Information Technology (GIT), using their potential to reduce the negative impact of the exhaust emission produced by light-duty vehicles, attending verification compliance to circulate in urban areas, is the main topic of the present contribution. Data collected through surveys answered by car owners in Mexico City, place the attention over the knowledge of the official exhaust emission test, their general acceptance, and the understanding of the exhaust test context, once they have received information from the proposed GIT (pGIT). The surveys consider the behavioral intention, attitude toward behavior, perceived usefulness, social influence and volitional control constructs to estimate response of car owners to the concerns about the pollutant emission and their willingness to change their position toward the pollutant emission reduction. The results show the interest of car owners to participate in a collaborative process, and develop positive attitude to cooperate in a social dilemma by considering the use of social networking.

1. Introduction

Transportation is an indispensable activity in the developed and developing countries, because many human needs require of this service to support the complexities of living in the 21st century, shaping modern, service-based economies to reach wealth and prosperity. However, the impact of the demographic and economic changes and the negative implications in the use of fossil fuels, to the environmental deterioration and human health, are considerable (Andersen et al., 2011, 2012; Brunekreef et al., 2009; Riley, 2002; Sigman, Hilderink, Delrue, Axel Braathen, & Leflaive, 2012). In many OECD countries, the effects of anthropogenic activities contributing to the air pollution are demanding special attention; so the design, creation, application and follow of local, regional, and global environmental regulations are essential tasks headed to the reduction of the environment deterioration (Marchal et al., 2012; OECD, 2008a,b,c; Sigman et al., 2012).

In the case of Mexico, and according to the SEMARNAT (Mexican Ministry of Environment and Natural Resources), the National pollutant emission in 2005 report that 61% of air pollution in Mexico comes from mobile sources (SEMARNAT, 2012). One of the initiatives, to solve the problem in cities like Mexico City and neighbor municipalities, is that drivers must get a low emissions level certificate so that their vehicles have the right to travel in the urban area. This certification process has their link to the Mexican normative, which establishes the maximum levels of pollutant emissions from mobile sources. This normative is called NOM-041-SEMARNAT-2012 and was designed in order to standardize the amount of gaseous pollutants from vehicles (Secretaria del Medio Ambiente y Recursos Naturales., 2007). Despite this certification process applied to automobiles, the most recent results from Mexico City's Air Quality Report are not good. Indeed, this suggests that the certification processes and mechanisms to regulate air pollution need improvements (Blackman & Guerrero, 2012; Blackman, Lahiri, Pizer, Rivera-Planter, & Muñoz-Piña, 2010) or alternative solutions like applying carbon and fuel taxes, reforming vehicle taxation and regulating vehicle standards to improve the environmental performance of the transport sector (OECD, 2008c).

Alternatively, the presence and use of the Information and Communication Technologies (ICT) has a profound impact over the way global cities organize their procedures and activities to face the demands of society. ICT offer possibilities for the creation,

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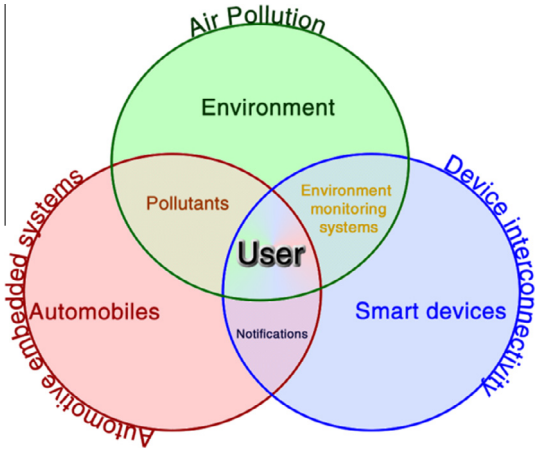

Fig. 1. The user and the vehicle emission control context.

distribution, and management of the information used for the sustainable development and environmental management (Akçura & Avci, 2013; Piro, Cianci, Grieco, Boggia, & Camarda, 2014). However, the consideration to use ICT and regulate vehicle pollutant emissions requires the study of those factors and policies that matter in the decision taken by the individuals and government initiatives to accept ecologically oriented approaches (Boarnet, 2010; Capra, Francalanci, & Slaughter, 2012; Moore, Staley, & Poole, 2010; Nordlund & Garvill, 2003; Winkelman, Bishins, & Kooshian, 2010). Most of the time, individuals require knowing and accepting of economical, psychological, and behavioral implications to use solutions that reduce their vehicular pollutants emissions production and encourage pro-environmental behavior (Steg & Vlek, 2009). The use of Green Information Technology (GIT), for the purpose defined in this paper, has the goal to be part of the intelligent solutions to contribute actively in the reduction of pollution emissions. The participation of the different actors has the user as a central role, like it is shown in Fig. 1, where IT is included in the solution to the environment problems derived for the activities of the transportation sector.

The above can be reach considering the use of knowledge-based information systems, providing the support conditions to deal with the complexity relationships among technology, knowledge and society. By using software technologies solutions, knowledge society have options to face their way of living, working, learning, innovating, and collaborating in today's complex world (Lytras & Ordóñez de Pablos, 2011; Ordóñez de Pablos, 2012).

Beside the input response triggered by humans, by using the collaborative learning and software technologies solutions together, sensors are being providing information about environment weather conditions, both indoor and outdoor, fixed or mobile, wired or wireless, specialized or not, single or distributed as a group, automatically or autonomously activated, among others operation conditions that provides information for the decision taken. Upon that complexity variation of inputs to the solution required to reduce pollutant emission, software technologies solutions require to have an input to the system that let people provide their support conditions and take response accordingly.

This work considers both, the Technology Acceptance Model (TAM) (Davis, Bagozzi, & Warshaw, 1989) and The Theory of Planned Behavior (TPB) (Ajzen, 1991), to determine the reception of the proposed GIT as a tool and the impact in the user's behavior respectively into a specific context: the exhaust emission tests. The main constructors of the proposed model are attitude, behavioral intention, volition, perceived usefulness, social influence, and ease of use.

The following sections cover important points, organized as follows: the second section provides the related works in the field and describes the background theory used in the experiments. The proposed scheme is presented in Section 3 as well as a brief description of the prototype. Sections 4 and 5 provide discussion and conclusions, respectively.

2. Related works

Social networking make use of knowledge-based information systems, providing the support to let people share comments and ideas, to know and react over events around the world by using applications on mobile technologies like smartphones or tablets. When those technologies incorporate the use of sensors, and individuals use them in their activities, such applications are often referred to as crowd-sourcing, participatory sensing or social sensors applications (Sagl, Resch, Hawelka, & Beinat, 2012; Tilak, 2013), and consider the citizen participation or power of the masses (or 'crowds') to achieve their goals, covering aspects like health, disasters, nutrition, among others. They are becoming increasingly common these days, thanks to the rapidly growing affordability, availability and adoption rates of Internet-enabled and location-aware mobile devices (Boulos, Wheeler, Tavares, & Jones, 2011).

Examples of efforts on the line of using IT oriented to the study and application of social networking are worth of mention like GeoChat (http://geochat.instedd.org), Ushahidi (http://www.ushahidi.com). Both of them has their impact to provide support in collecting data from the crowd and visualizes what happened, when and where. Initiatives like Common Scents project in the SENSEable City Laboratory, involving Service Oriented Architectures, proposes an open, standards based and modular infrastructure. The characteristics of interoperability, portability and flexibility ensure the participation of those social sectors, considered in the research, to respond to concrete needs of the inhabitants in Cambridge, MA US (Resch et al., 2011).

Mobile phones are playing an important role in the knowledge society era. Their capabilities to let us communicate, their increase in computational power, and the extension of our perception by the inclusion of sensors and applications, provides users the opportunity to collect, share and remix the information of actual conditions experienced locally instead of only get average measurements by accessing the web (Paulos, Honicky, & Hooker, 2008). This fact provides a fertile land where collaborative learning is increasing their importance, taking support from the interaction of different social activities that improves processes and policies through learning (Lytras & Kurilovas, 2014; Zhuhadar, Yang, & Lytras, 2013). Such platforms, like the Personal Learning Environment, Learning Management Systems, and Service-Oriented Architectures has been used to define systems considering (Lytras & Ordóñez de Pablos, 2011).

There are examples of the use of social networks to promote behavioral changes in the way countries contributes to climate change and global warming: 350 (350.org), Bioneers' Global and Education for Action programs (bioneers.org), Green Living and Social Activism (Care2.com), Transition Us (transitionus.org), Treehugger (treehugger.com). Tom Szaky, founder of Treehugger, provides a note on that sense:

> 'Social media can help to substantial awareness, but the true threat is that people will think retweeting or clicking "Like" will be enough, there is no learning on that. Social media is best used as a "nudge" in the right direction – inspiring behavior, spreading positive ideas and helping to spawn change in the real world. It's bad and ineffective when people find gratification solely by tapping that "Like" icon – because that "Like" in

most cases, won't do anything but display your time spent on the computer. It is uncertain how much "good" social networking can really do for the environment. Clicks "Like" on TerraCycle's Facebook page, or retweets a Treehugger.com tweet, that's fantastic. But it doesn't take down carbon output or bring back a demolished forest.'

However, here it is important to say that social networking pursue an active participation from individuals to solve problems. Social networking aims to form communities of members with common interests or goals. Society, businesses, and governments connect and communicate with each other on a personal level by creating and distributing valuable content which can be shared. Creating and distributing educational, inspiring content that helps society make better decisions will create the conditions to reduce the emission of pollutants by the use of learning. Online conversations can convert people into environment advocates because they feel their opinions are being heard and that they are receiving something back in return. Thus it is worth investing time and money into it. But if you cannot measure its returns, you should not be doing it.

The proposal of this work is to analyze the response of car owners' behavior to be added to the social networking and generate value to solve emission pollutant problem. Social networking is ready to include the monitoring of electronically earth' sensations in cities, wildlife, ships, highways and fleets of trucks, conversations, among others stuff with the Internet of Thinks. When the causal factors related to a specific environmental behavior has been identified, intervention strategies can be targeted toward pro-environmental actions, promoting attitude changes through the use of GIT. The use of social networking can provide valuable information oriented to reduce environmental impact, changing the behavior of car owners. Modern Social networking can be used to inform change agents about the need to refine or replace a particular behavior change intervention. They can provide feedback to the target population so as to inform them about the effectiveness of their efforts to reduce pollutant emissions and improve environmental quality. This may reinforce car owners' commitment to change their behavior, and to maintain the changes already implemented.

The constructors used in this paper, for identification purposes of the decision taken by vehicle owners to the use of GIT, are described in the following subsections.

2.1. Behavioral intention

The measurement of the likelihood that express if a person will get involved in a given behavior, provide the behavioral intention, involving those motivational factors that influence a behavior (Ajzen & Fishbein, 1980). Based on the conceptualization and measure of the constructs, the support of the action performed, the target at which the action is directed, the context in which is performed, and the time at which it is performed, a model of behavioral prediction has the opportunity to emerge (Fishbein & Ajzen, 2011) and provide relevant information for research purposes. The prediction of the behavior intention is defined when the person has the yes or no intention to attend that behavior. In the case of study, the uses of ICT options like tablets or cell phones increase the likelihood to employ the proposed application to reduce vehicle pollutant emission (Ajzen & Madden, 1986).

2.2. Attitude toward the behavior

Attitude toward the behavior denotes person's judgment about behavior position: if it is good or bad, if he is in favor or against performing the behavior (Ajzen & Fishbein, 1980). The person's believe that performing a given behavior will conduct positive results will possess a positive attitude toward performing the behavior. At the opposite, performing the behavior will lead to negative consequences will hold an unfavorable attitude. "Attitudes toward the behavior are found to correlate well with the corresponding behavior, and because they can be assessed ahead of time, they can be used to predict behavioral performance, ... and enhance our understanding of the reasons why people exhibit or fail to exhibit a certain behavioral tendency" (Ajzen, 2005).

2.3. Perceived usefulness

Perceived usefulness can be defined as "the prospective user's subjective probability that using a specific application system will enhance his or her job or life performance". A system ranked high in perceived usefulness is that one which a user believes in the existence of a positive use-performance relationship. In contrast, perceived ease of use refers to "the degree to which a person believes that using a particular system would be free of effort" (Davis, 1989). Perceived usefulness and perceived ease of use were identified as determinants of attitudes toward use in TAM, while perceived usefulness and attitude toward use were predictors of behavioral intention to use. Persons are driven to adopt an application primarily because of the functions it performs for them, and secondarily for how easy or hard it is to get the system to perform those functions (Davis, 1989; Davis et al., 1989). The reason persons have to use web-based application system or exploit mobile applications is that they find those applications so useful that improves their performance. Several studies support the effect of perceived usefulness on behavioral intention to use.

2.4. Social influence

Social influence is consider as an important determinant of behavior, and is "defined as the degree to which an individual perceives that important others believe he or she should use the new system" (Venkatesh, Morris, Davis, & Davis, 2003). According to theory, this determinant shapes user behavior. And the work reported in (Venkatesh et al., 2003) suggest that subjective norms in the Theory of Planned Behavior (TPB), TRA and TAM2, social factors in the Model of Personal Computer Utilization, and image in the Innovation Diffusion Theory are analogous, and all are related to social influence. Potential users may decide on to use a technology if the people who are important to them say that they should use it, even if they are not favorably inclined toward the behavior.

2.5. Volitional control

"In everyday life, many behaviors of greatest interest to personality and social psychologist can be thought of as being largely under volitional control" (Ajzen, 2005). People can easily perform these behaviors if they are so predisposed, or desist from performing them if they decide against it. The important point about willful behaviors of this kind is that their occurrence is a direct result of deliberate attempts made by an individual. The process involved can be described as follows: A person forms a purpose to take part in a certain behavior. This intention remains a behavioral disposition until, at the appropriate time and opportunity; an attempt is made to translate the intention into action. Assuming that the behavior is in fact under volitional control, the attempt will produce the desired act. This is reflected in the intention to perform the action under consideration (Fishbein & Ajzen, 1975; Fisher & Fisher, 1992; Gollwitzer, 1993; Triandis, 1977).

The study conducted here measure the attitude toward social issues like protection of the environment, health, and vehicle's maintenance and their driving way. The factors that influence

behavior are indicators of how people consider the use of technology in order to adapt their behavior to an environmental friendly attitude.

3. Materials and methods

3.1. Case of study

This work considers Mexico City car owners as a case of study, for such reason we primarily considered their major concerns in relation with air pollution produced by their vehicles during the development of the platform; this information was acquired from a simple survey applied in a Mexican exhaust testing station to about sixty car owners. This survey was made before and after the official exhaust test. The purpose of this survey is the knowledge of the official exhaust emission test general acceptance and later compares the related car owner behavior.

Another survey was made to evaluate the understanding of the users about the exhaust test context once they have received information from the proposed GIT (pGIT). An important characteristic of this survey is that the car owners that agree to participate showed a positive attitude in order to know alternative exhaust test results.

The surveys were made for few questions related to car performance, fuel consumption, maintenance, taxes, vehicle standards, health, air quality, greenhouse gases and environment. In Addition, we use the aforementioned Mexican Standard NOM-041-SEMARNAT-2006 (NOM-041) because its applicability in Mexico City. We used a five point *Likert scale*, as a tool for these surveys; this scale also considers that the respondent could have not knowledge about certain issues (see Tables 1 and 2).

3.2. Research model and hypotheses

This work aims at determining if the implementation of an information technology, as a complement to official exhaust tests in Mexico City, could influence the level awareness of a group of car owners about exhaust emissions. The information technology app has the purpose to reduce the amount of pollutants from vehicles by means of vehicular maintenance.

We consider both, the Technology Acceptance Model (TAM) and The Theory of Planned Behavior (TPB), to determine the reception of the pGIT as a tool and the impact in the user's behavior respectively into a specific context: The exhaust emission tests.

3.2.1. Hypotheses and constructs

For TAM we considered the following constructs and hypotheses:

- Behavioral Intention to Use (BIU): These are the indicators about the people's intention to use the technology and provide information about if the respondent will join in a given behavior. In this case, the use of the pGIT is voluntary as a complement of the official verification emission test to learn more about pollution from vehicles.
- Attitude Towards Use (ATU): Every respondent, volunteer, considered that the pGIT is something good in order to know more about the vehicle, so we hypothesize:
  - H1: The attitude toward use will have a positive effect on BIU.
- Perceived Usefulness (PU): As a complement of the official verification emission test, the pGIT allow the user know more information about a successful or unsuccessful emission test.
  - H2: The perceived usefulness will have a positive effect on BIU.
  - H3: This construct will have a positive effect on ATU once the pGIT provide information related to vehicle.
- Social Influence (SI): This construct depends on others beliefs about the use of the pGIT; in this case the usage of mobile computing for exhaust emission tests is something new in this specific context that can attract other interested persons.
  - H4: This construct will have a positive effect on BIU.
- Perceived Ease of Use (PEU): The mobile application must be really simple and informative. The development of a simple user interface is an important consideration.
  - H5: On the one hand this construct will have a positive effect on PU if the information is properly displayed. On the other hand, this construct will have a negative effect on PU and consequently on BIU (see Table 3).

Moreover, regarding TPB these constructs and hypotheses (see Fig. 2) were considered:

- Behavior (B): The pGIT influences the car owner's concept about exhaust emissions by means of giving more information related to their concerns. Regular vehicle maintenance is a responsive behavior in order to reduce exhaust emissions from vehicles.
- Intention (INT): Continuous maintenance will reduce the need of exhaustive vehicle maintenance; this has an important effect in the car owner's economy.
  - H6: This construct will have a positive effect in BI if vehicle maintenance is simplified as a general benefit.
  - H8: This construct will have a negative effect in BI if the economic factor is determinant, for instance the need of exhaustive maintenance.

Table 1
The demographic profile of the respondents to the first survey.

Gender (%)					
Male: 87		Female: 13			
Age					
Max: 62		Min: 25		Typical: 37	
Education level (%)					
Primary School: 3		High School: 48		Undergraduate School: 49	
Mobile devices knowledge					
None: 1%		1–7 years: 85%		More than 7 years: 14%	
Car knowledge (%)					
a: 25	b: 10	c: 8	d: 13	e: 7	f: 37
Air pollution knowledge (%)					
a: 0	b: 5	c: 10	d: 35	e: 10	f: 40

a = very much, b = much, c = moderate, d = little, e = very little, f: none.

Table 2
The demographic profile of the respondents for the second survey.

Gender (%)					
Male: 60		Female: 40			
Age					
Max: 55		Min: 35		Typical: 40	
Education level (%)					
Undergraduate School: 0.0		High School: 80		Postgraduate: 20	
Mobile devices knowledge					
None: 0%		1–7 years: 100%		More than 7 years: 0%	
Car knowledge (%)					
a: 0	b: 0	c: 40	d: 0	e: 40	f: 20
Air pollution knowledge (%)					
a: 0	b: 60	c: 20	d: 20	e: 0	f: 0

a = very much, b = much, c = moderate, d = little, e = very little, f: none.

Table 3
Construct and items (TAM).

Construct	Item
Behavioral Intention to Use (BIU)	I intent to use the results... • To verify the results with the official ones • To learn about emission tests • To know if my vehicle is in need of maintenance • To maintain low exhaust emissions • To know how much pollutants come from my vehicle
Attitude Towards Use (ATU)	• Use the mobile application is a good idea • Is good to know enough about exhaust test • I like to have information about my vehicle in my smart device • Have alternative results is important for me • This is something I'd like to try
Perceived Usefulness (PU)	• Using the mobile application would enable me to know my car • This tool let me pre-test my vehicle • The mobile app provide me relevant information about exhaust emission test context • Using this mobile app I would increase my car's success during official test
Social Influence (SI)	• I think this kind of test is unusual new that I want to share • I think that my family would be benefited by using this complement to official test • People important to me will support the use of this • This would be useful for people I know • Other people should not try alternative tests
Perceived Ease of Use (PEU)	• The user interface is not clear • Learn to use the mobile app would be easy for me • The results and the information are logical • I would find the app easy to use • The app works as I would expected

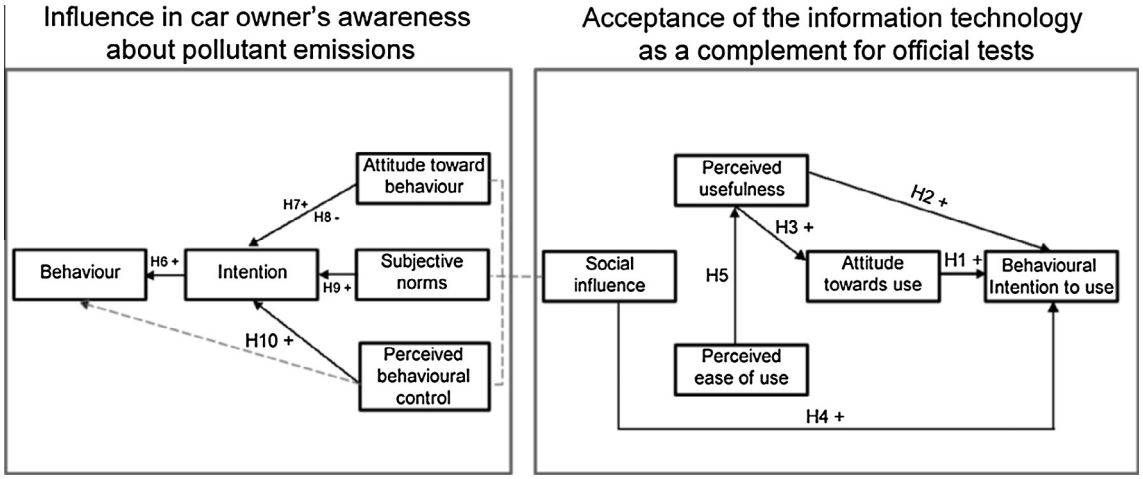

Fig. 2. Hypotheses and constructs.

- Attitude Toward Behavior (ATB): If a vehicle is in good conditions, the car owners think in health by means of improving air quality. Also, vehicle's performance and fuel consumption are important as factors.
  - H7: This construct will have a positive effect in INT considering the related factors.
- Subjective Norms (SN): The principal influence will came from persons that in some way share the vehicle. For the case of study we consider that this has a direct relation with family and friends.
  - H9: This construct will have a positive effect in INT.
- Perceived Behavioral control (PBC): This work considers two scenarios in the case of study. During the official test, car owners have no choice about perform the tests, while by using the pGIT they become volunteers. Also they are completely free to accept or reject the provided information and results by means of the mobile app.
  - H10: This construct will have a positive effect in INT as well as in Behavior.

Table 4 shows the constructs and the items. It was considered a random order of items to increase a carefulness responding during the surveys.

3.3. Tested vehicles

For the experiments, we tested carburetor and fuel injection vehicles using the platform described below. To select the test vehicles we considered those that were representative of the actual vehicle fleet of Mexico City considering the kind of technology, e.g. fuel injection systems with old and renewed emission control systems such as catalysts. In addition, these vehicles were classified in view of the model year according to NOM-041 Standard.

For testing purposes, the experiment considered fifteen vehicles. Case A: five vehicles with carburetor technology (model year 1995 and earlier, representative of some public and private transport). Case B: five vehicles model year 2009 and earlier with fuel injection systems (probably in need of maintenance). Case C: five vehicles model year 2012–2014 (technically without problems). This vehicles were tested following the scheme of the following section, in other words, all the exhaust tests were performed during a real driving cycle unlike the Mexican exhaust testing station standard procedure.

3.4. Vehicle emission control scheme

The scheme of operation of this section is designed to acquire information about the amount of pollutants from vehicles during real operation. Although this work focuses in the behavior of the car owners related with the amount of pollutants from vehicles, this section explains the considerations to acquire information from the vehicle.

We proposed a Vehicle Emission Control Scheme (VECS) based on ubiquitous computing that allows the creation of a Green Information Technology intended for air quality improvement in urban areas. An important consideration during the development of this scheme was: in most cases a narrow relationship between automobile failures and pollutant emission exists.

The VECS consists of three phases, (1) an on-road emission test, (2) data evaluation, (3) information technology and results. Although the VECS was designed for different scenarios of operation, this work considers the procedure 'user-request' described further; for example, other scenarios of operation includes the participation of Environmental authorities by means of cloud based services based on statistical analysis.

3.4.1. On-road emission test

This phase considers an on-road emission test to determine how much pollutants come from the vehicle continuously. To achieve this, gas sensors or advanced computing methods are required to determine the concentration of different gases from the exhaust pipe of the vehicle according to the specification of a national or international Standard. The on-road emission test occurs during a real driving cycle, into a non-specific route, without any restriction to the driver or traffic conditions considerations, in other words, the on-road test considers the way the user drive every day. All the exhaust tests were performed during a real

Table 4
Construct and items (TPB).

Construct	Item
Behavior (B)	• I will considerate regular vehicle maintenance to improve my economy
	• I intend to consider air quality and health when my vehicle needs maintenance
	• High emissions reduce the quality of life of people important to me
	• A regular maintenance would improve my vehicle's performance
	• I intent to consider regular maintenance to improve the environment
Intention (INT)	• A vehicle in good conditions does not consume excessive fuel
	• Bad conditions would increase the amount of money to repair the vehicle
	• I intend to consider taxes when the vehicle is in need of maintenance
	• Regular maintenance is not necessary, only ensure a successful emission test is important
Attitude Toward Behavior (ATB)	
	• Regular maintenance improves vehicle's performance
	• I think regular maintenance is necessary
	• Regular maintenance is convenient for me
	• I think regular maintenance improves the possibility to have a successful emission test
Subjective Norms (SN)	
	• I think than others expect me to have a no-pollutant vehicle
	• I think that important people for me will appreciate a vehicle in good conditions
	• People important to me consider environment and health very important issues
	• I think in the health of somebody important to me
	• Regular maintenance is convenient for people important to me
Perceived Behavioral control (PBC)	
	• The test is not official, so, I have not to pay taxes
	• Through mobile app, I would be able to request information when I need it
	• If I know some problems about my vehicle I can try to fix it
	• Regular maintenance let me know if something is wrong before the official test

driving cycle unlike the Mexican exhaust testing station standard procedure.

3.4.2. Data evaluation (Platform)

During the on-road emission test, an automotive embedded system determines if a vehicle surpasses the maximum permissible established on Standards such as European Emission Standards Specifications. For this work we consider five gases from exhaust for data evaluation according to NOM-041 Standard described later.

3.4.3. The VECS user-request procedure and used platform

The 'user-request' procedure, based on VECS scheme, considers that the car owners are interested predominantly in know the conditions of their vehicles in order to obtain a diagnostic. Also an important consideration is: traffic congestion may or may not be present. This procedure begins a car owner wants to know the status of a vehicle in order to obtain an exhaust emission pre-diagnostic, then the platform begins to acquire information from the exhaust pipe during a real driving cycle. Finally a mobile application shows the results giving information about the status of the car according to the above section.

To work under the VECS and according to such scheme, the used platform uses: (1) a portable automotive five gas analyzer, (2) an automotive embedded system featuring wireless capabilities such ad-hoc network support, and (3) a mobile devices such a smart phone or tablet, using at least Android 2.1, with a specific mobile application. The platform enables an information tool over mobile computing.

3.4.4. Information technologies and results

After the test, mobile devices like smartphones or tablets receive the results, where the car owner can observe a simplified report. The purpose of the pGIT is the delivery of information to the car owner about the condition of the vehicle's exhaust emission test, and the comparison with standards in order to determine if such material influences the understanding of the car owners in relation to the air quality. The GIT take their roles as an application running in smart devices, to help to explain in just by consider the following questions: What is a pollutant? What Standard is used and why the vehicle exceeds the maximum levels? What to do to avoid air pollution? What is the relation between air quality and health? Is regular vehicular maintenance necessary?

The results shown by the mobile application use the NOM-041 Standard as a reference, and also assist the user to determine if the vehicle requires maintenance.

Furthermore, as shown in Fig. 3 the scheme present an alternative for transmitting the information to a wireless node included in a city road-side infrastructure such as traffic lights or environment sensor networks as an extended overview of VECS. In both cases, the expectancy is influence the behavior of the users by means of extending their knowledge about a specific theme related to daily life, in other words, the influence of this information tool in the decision-making of the car owners.

3.5. A mobile application as a part of VECS

This sub-section describes some parts existing into the mobile application used as information resources for the proposed case of study. One of the purposes of this application is increase the understanding of vehicular emissions by means of different perspectives (see Fig. 4).

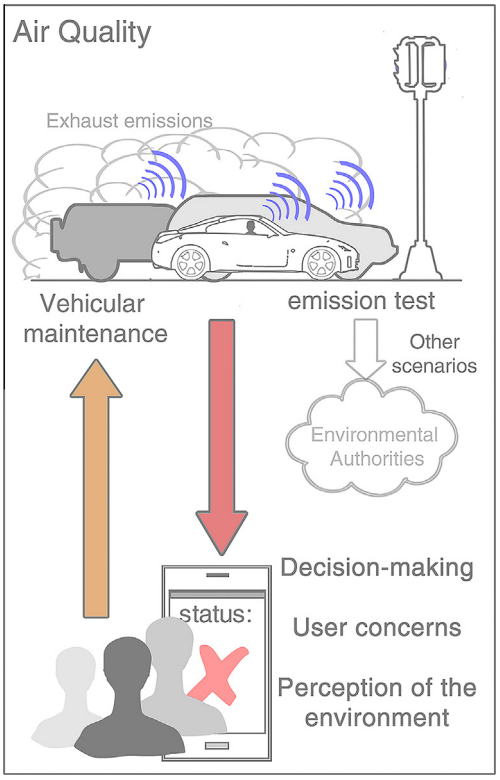

Fig. 3. The simplified vehicle emission control scheme.

Fig. 4. The mobile application screenshot.

Table 5
NOM-041-SEMARNAT-2006.

NOM-041-SEMARNAT-2006	Units					
	Parts per million (ppm)		Volume percent (%VOL)			
Gaseous species/model year	HC	NO_X	CO	O_2	$CO + CO_2$ dilution	
					Min.	Max.
1990 and earlier	150	2500	1.5	3.0	13	16.5
1991 and latter	100	1500	1.0	3.0	13	16.5

3.5.1. Air pollution

Air pollution refers to the presence of external substances that affect the original air composition. The vehicles produce five major air pollutants, which are: carbon monoxide (CO), hydrocarbons (HC), nitrogen oxides (NO_X), particulate matter (PM) and also carbon dioxide (CO_2) (considered a pollutant in high concentrations). CO and HC are commonly related to problems of the combustion process whereas CO_2 is an expected result of such process. NOX are precursors of ozone, which as well as particulate matter causes respiratory problems.

3.5.2. Mexican Standard NOM-041

One of the Mexican Standards related with exhaust emissions is the NOM-041; this evaluates the concentration of CO, CO_2, NO_X, HC and also oxygen (O_2) because is an indicator of the performance of the vehicle. If a vehicle produces higher concentrations than the specified in such Standard then is in need of maintenance (see Table 5).

3.5.3. Vehicular preventive maintenance

A section of information related for vehicular maintenance was developed. This section indicates that regular maintenance contributes not only to fuel saving but also to reduce the excessive pollutant emissions caused by failures, for instance, a damaged catalytic converter in those cars that incorporate one. In Mexico City, the emission test is every six months (twice per year). However, the rest of the time there is no control over the vehicle conditions regarding air pollution; this could impact directly on health and also in the economic factor.

The design of the mobile application was made expecting that some users would be motivated after using it, principally those that actively may propose collaborative efforts to reduce vehicular emission levels.

4. Results

The results from the first survey provide indicators about the generalized concerns in the context of Mexican exhaust tests in Mexico City. This survey provides evidence about the user's preponderance of certain factors over others, specifically considering environment, health, economy and the vehicle itself. The results of the first survey before and after the official exhaust test, shown in Figs. 5 and 6 respectively, characterize how the car owners conceptualize the whole official test. The survey answered before the official test shows that most of car owners expressed their concern principally about economy and exhaust emissions from their vehicle but considering principally only the economic aspect, and the problems related to have a vehicle not eligible for circulating in the city. Moreover, the survey answered after the exhaust test shows that the car owners' concerns depend on the approval of the vehicle. If the vehicle pass the official Mexican test, the principal concerns are fuel consumption and health while, if the vehicle fails the test, the main worries are taxes; in both cases the preoccupation for exhaust emissions decreased significantly.

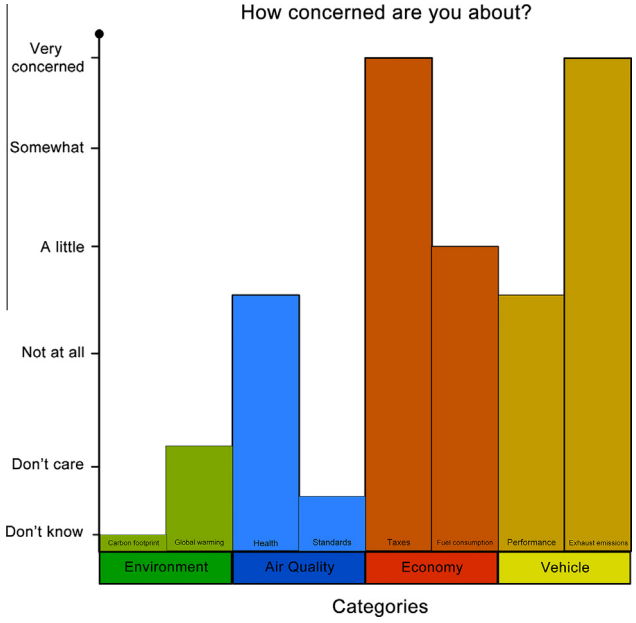

Fig. 5. First survey results before the official verification emission test.

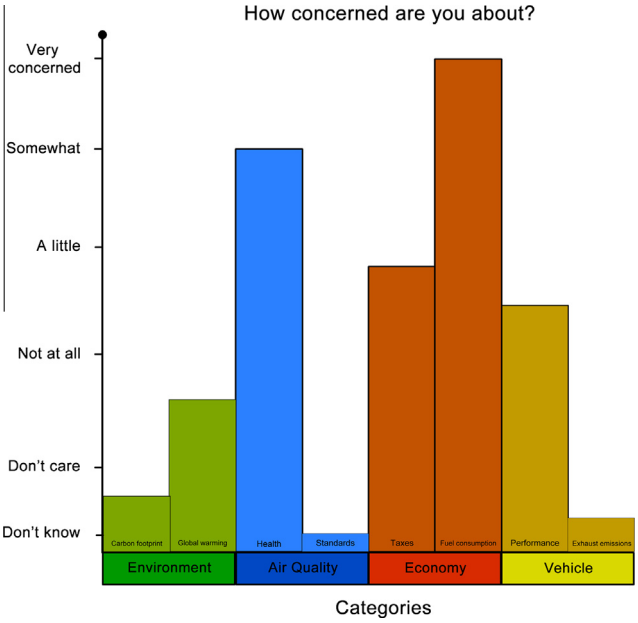

Fig. 6. First survey results after the official verification emission test.

The results before and after official verification emission test also show that, in general, car owners have not knowledge about the applicable Mexican standards, which deliver information about the official exhaust test. In addition, those results show that the user seems to have little importance to environmental care link to the exhaust emission tests context.

In relation to the second survey, and considering the demographic profile of the respondents (each respondent has family), the results indicate that the answers before the VECS test were emotionally charged. Indeed, their beliefs about the exhaust emission test were influenced by the kind of vehicle they have; Fig. 7 shows that car owners do not know if a vehicle is really

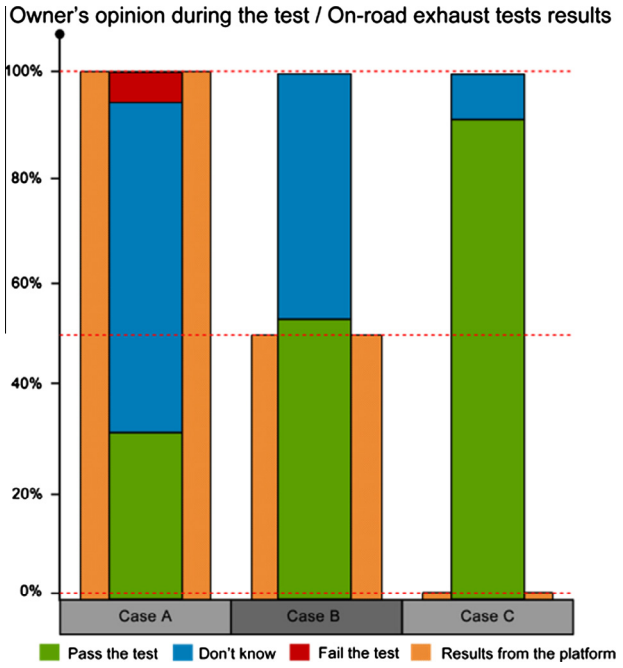

Fig. 7. Vehicle owner's beliefs during the use of mobile application and real-world emission test results.

contributing to air pollution, when in fact, all the vehicles in case A and the half of case B were exceeding the Mexican Standard. Before testing pGIT, the owners' beliefs about other exhaust emission test such as VECS, were no different from those related to official exhaust test.

After the use of the pGIT, a general increase in the level of awareness about environment standards, health and exhaust emissions topics were predominant. In addition, car owner's understanding about exhaust emissions had higher relation with the vehicle itself and the Standards (see Fig. 8).

The most accepted hypotheses regarding the acceptance of the pGIT, considering a volitional factor, was H1. Hypotheses H2 and H3 were accepted totally after the tests, while hypotheses H4 and H5 played an important role during the evaluation of the pGIT. The social influence (SI) had more than 65% of influence in the acceptation of the technology; also, the perceived Ease of Use contributed with the total acceptance because the respondents consider the user interface as friendly.

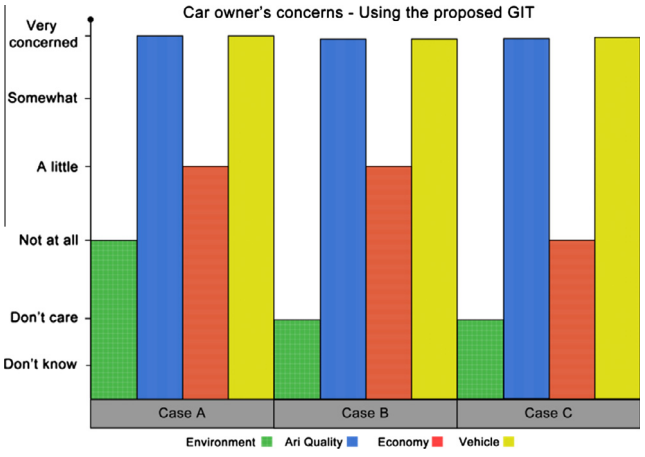

Fig. 8. Influence in user concerns after the use of mobile application.

The hypotheses about the behavior of car owners regarding regular maintenance were accepted. About 60% of the respondents consider vehicle performance through H6 as relevant, while almost 95% contribute in the acceptance of H9. In other words, vehicular maintenance is important to them. In the case of H8, is important to consider that, probably under different conditions, this hypothesis could have a significant effect in the behavior regarding regular maintenance.

After the tests, all volunteers shared their opinions, experiences and beliefs to each other. The effect of contributing with information about pollutant emissions traces the re-evaluation of the vehicles' performance by their owners. The exchange of information between participants generated new ideas to diminish air pollution and also improved the way they formerly understood the information. However there was no evidence about any collaborative effort to reduce emission levels from vehicles as estimated.

5. Discussion

On several occasions has been heard with a great certainty of the opportunities that exist to change attitudes, on various occasions has been heard with a great certainty of the possibilities that exist for changing people's attitudes and even to transform the mind-set of an entire people (Duran Pacheco, 1988). It has even gone so far as to argue that the social character is very adaptable, that there is a considerable plasticity in the attitudes and ways to react to human beings. Meaning that should be reviewed carefully, because human behavior is complex; it is built from meanings and interactions with objects and social subjects, but it is also highly influenced by what is built within its context. Influence that it is not always positive and that on many occasions catches the group mentality to the degree of build in linear way of life that do not contemplate the changes and much less prepares the individual to take a potential variation in the way they behave (Álvarez, 2010)

The results from the first survey include facts about the general level of awareness of people about exhaust emissions. Indeed, it seems that the respondents perceive the official exhaust emission procedure as something useless and forced, in other words, as something negative. Using information technology is an alternative way to expose the reasons behind the aforementioned test process, even another kind of approaches based on this would influence positively in car owners' behavior and attitudes not only about vehicles but also for other environment agencies initiatives.

Attitude is closely linked with obvious or observable behaviors, it directs and stabilizes them. It is a trend of the person to behave in a certain way in front of an object, group, or idea (Ajzen, 2005). It is something like a motor that moves the behavior of the person in a certain sense, although in a particular circumstance the person is afraid to express openly that inclination, many times by uncertainty or ignorance toward what they are facing. This was the case of the respondents (car owners); they have unclear ideas about vehicles emissions, the official test and in some cases, the economic factor was the only perceived truth. Previous this work, we considered that an important portion of the attitudes regarding exhaust emission tests were because of the lack of popular, intuitive or common channels of information about this. Anyway we believe that is necessary more evidence about successful implementations of information technologies regarding vehicular maintenance in other places because, as mentioned earlier, in other factors might play an essential role in owners' decisions.

The forms to react of the human being is derived from the malleability of their nature, which from an educational psychology perspective develops during the first five years of life, on the basis of the received education, mainly from the family, which is the primal group in which he learns to live and cope with other people. It

is important to mention this, because it is through the habits, customs, and values transmitted during this stage, that the person learns to behave assertively in the society that subsequently will be its circle of coexistence. We suppose that the pGIT was being able to influence the opinion of car owners in a positive way because of the general perception of the official verification emission test. But what could be the response of car owners in places were official exhaust emission tests are positively accepted? What kinds of conditions are present in such places? How important is automotive industry in such place in terms of urban mobility?

The person will be expressing in an active way and above all positive, and at the same time, that person will have the elements that allow her or him to recognize the changes as part of its own evolution as a human being. For the behavioral sciences, it is not possible a radical transformation in the ways of thinking and behavior of the individual; but it is possible to start a new learning process to replace the cultivated attitude, but only on the condition that the person will be motivated and based in accordance to their needs. The learning is constantly part of a problem or the difficulties of the subject to cope with a specific situation. Therefore, it is essential to instill the benefit that this will give and thus originates the acceptance and willingness to transform the conduct.

Implementing a new rule, that governs the conduct of a social group, invariably leads to a change, which consequently and inherently brings a psychosocial impact, generating a significant diversity of reactions and actions before the novelty. The result can be negative, otherwise provide the opportunity to develop new social skills, through which may form habits or practices that benefit the community. In such case, Information Technologies approach is a novel way to implement solutions for specific areas of interest. For this case of study, there was a collaborative process involving mainly face to face conversations about the results, which led to the analysis of the variables behind the tests for each vehicle. The participants had the opportunity to share their experiences about the tests and the implemented technology. Although they proposed new ideas to diminish air pollution, we found there are other important motivations required to stimulate the creation of collaborative efforts to reach the same purpose.

What impact will the study have in the pollutant emissions?

Considering the answer placed by car owners, the analysis shows respondents' behavior impacts in the following: (a) the knowledge about the standards (b) owners' changes in their perception about the norm; (c) official exhaust test conditions learned; (d) the awareness about environmental standards and the effectiveness of studying; (e) the acceptance of learning through IT; (f) the ability to focus on the most important learning objectives; (g) the degree of collaboration among car owners; and (h) the owners' motivation to change their perceptions and attitudes toward environment care behavior.

According to the results, all the respondents widely consider to share their opinions on internet using social networks although it was not specified if using smart phones or another kind of devices. The participants of the on-road emission tests showed an amplified motivation to share what they learned and their experiences in social networks.

The respondents accepted completely to use any device, especially mobile devices, to learn about vehicle emissions and exhaust tests. The provided information through the mobile application allowed the users to focus on a greater panorama of the problematic around pollutant emission, thus the user was able to change their point of view about vehicle exhaust emissions. However, the major motivation that changes their perception and attitudes toward environment care behavior was definitively health.

All the respondents shared their opinions about the whole problematic of pollutant emissions from vehicles. They discussed seriously about learned standards, the real effect of exhaust tests, and shared opinions and ideas to diminish the impact of vehicles in the environment. In all the cases the collaborative learning process begun after the users understood particular topics from the proposed GIT (pGIT), thus the exchange of opinions, concepts and proposals enhanced the car owners' knowledge about vehicles and environment.

Each respondent of every survey showed an increased awareness about environment, a renewed interest in their vehicles in terms of maintenance, and a remarked interest in share what they learned about vehicle emissions.

6. Conclusions

This work show the acceptance of Mexican car owner's regarding a Green Information Technology planned as a complement of the official Mexican exhaust test, and the influence of such GIT in car owner's behavior about regular vehicular maintenance. The results show the positive effects of providing information about the relation between environment standards and human health. An important factor is the volition of the user to adopt a specific behavior. Giving information to the users and let them share their experiences, improved the way they understood a broad overview of vehicular emission tests and preventive vehicular maintenance.

During the surveys, it was not consider any specific profile attached to technology or automotive specialists for instance, but only people around a Mexican official exhaust test station with or without knowledge about mobile devices. As a general statistic in this study, more than 95% of the respondents do not know about the Mexican Standards that determine if a vehicle is eligible to circulate in the city. In addition, most of the respondents showed a negative attitude towards the official verification emission tests. Moreover, after providing enough information about the official exhaust emission test, beyond the economic factors such as taxes, car owners begin to consider other conditions that were no obvious previously, such as environment and Standards. Even without the use of the proposed platform, car owner's concerns are directly related with what they know about exhaust emissions. The results show that the level of awareness for specific issues, such as environment and health, increased after the interaction with the mobile application.

An important variable for this specific case of study was the consciousness about health of a car owner considering *important people*; the subjective norms-social influence had the higher influence in the adoption of the pGIT and regular maintenance behavior. In other words, there was a wide acceptance of the mobile application as a Green Information Technology among professionals with a family. In relation to regular maintenance, some user's beliefs changed positively; this is a convenient indicator linked with the adoption of Green Information Technologies as a strategy to mitigate air pollution in cities such as Mexico City. We conclude that good implementation of GITs can influence the user's behavior if the information has enough clearness using a specific context where the relation between factors really involve the user.

The potential in the use of smartphones applications involved with environmental issues and the potential use of social networking, where car owners can express their points of view and suggestions to others, provide a significant opportunity to develop a set of tools for improving learning processes and collaboration in managing them to reduce the negative impact in the use of vehicles to the environment. But with the recommendation to not rest only over the technology as the solution by just placing "likes" or "dislikes" opinions and think that only with those actions the problems will be solved. Indeed, there is the menace of "viral noise" misinformation, resulting from human nature that must be considered as an adverse factor in the goal to reduce pollutant emission.

The active and positive participation of the car owners in the conditions of their vehicles, are opportunities to collaborate and share the learning obtained in the process toward the reduction in the pollution emission control of their vehicles. The transformational impact can be derived from the continuous activities and ideas that every car owner wants to place to the eyes and the thinking of others by means of social networking to generate solutions around the pollutant problem.

The behavior of people, measured by using communication devices and social networking, provides a 'social sensor' data richness that is the line of research under revision. The scenario provides opportunities to influence the mind of those car owners to reduce the pollutant emissions production of their vehicles.

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