Article **Journal of Technology and Innovation**
December 2021, Vol.8 No.23 26-34

Evaluation of driving technics using learning taxonomy in the Big-Rig HD 2. 0 driving simulator

Evaluación de las técnicas de conducción usando la taxonomía de aprendizaje en el simulador de manejo Big-Rig HD 2.0

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DOI: 10.35429/JTI.2021.23.8.26.34 Received July 30, 2021; Accepted December 30, 2021

Abstract

This research work evaluates the driving skills of new drivers and drivers with previous experience or basic driving knowledge. In the evaluation, use is made of a BIG-RIG 2. 0 driving simulator belonging to the Logistics and Transportation Engineering study program, which has a software that offers different driving scenarios and environmental effects very close to reality. In hardware, the simulator is equipped with 30-inch monitors with 180-degree vision and an audio system that together manage to reproduce with a high level of realism the vision and environmental sounds. It is also equipped with a seat belt, lights, brakes and other devices and instruments of a vehicle. The evaluation of driving techniques is carried out by applying as methodology the three domains of the learning taxonomy: cognitive, psychomotor and affective, which are important in the teaching-learning processes. The results obtained allow us to know the results achieved in each of the criteria of the domains of the studied population, in particular with the acquired knowledge, the development of skills and adaptation to the environment and the management of emotions.

Driving simulator, Taxonomy of learning domains, Training

Resumen

En este proyecto de investigación se evalúan las habilidades de manejo de nuevos conductores y conductores con experiencia previa o conocimientos básicos de conducción. En la evaluación, se hace uso de un simulador de manejo BIG-RIG HD 2.0 perteneciente a la Ingeniería en Logística y Transporte, el cual cuenta con un software que ofrece diversos escenarios de conducción y efectos ambientales muy cercanos a la realidad. En hardware, el simulador está equipado de monitores de 30 pulgadas con visión de 180 grados y un sistema de audio que en conjunto logran reproducir con un alto nivel de realismo la visión y sonidos ambientales. Adicionalmente está equipado con cinturón de seguridad, luces, frenos y otros dispositivos e instrumentos propios de un vehículo. La evaluación de las técnicas de manejo, se realizan aplicando como metodología los tres dominios de la taxonomía de aprendizaje: cognoscitivo, psicomotor y afectivo, los cuales son importantes en los procesos de enseñanza aprendizaje. Los resultados obtenidos permiten conocer el logro alcanzado en cada uno de los criterios de los dominios de la población de estudio, en particular con los conocimientos adquiridos, el desarrollo de habilidades y adaptación al entorno y manejo de las emociones.

Simulador de manejo, Taxonomía de aprendizaje, Capacitar

Citation: CORTÉS-MALDONADO, Ismael, ÁGUILA-FLORES, Arturo, BAÑOS-CABRERA, Karina and GONZÁLEZ-SALAZ, Christian Daniel. Evaluation of driving technics using learning taxonomy in the Big-Rig HD 2. 0 driving simulator. Journal of Technology and Innovation. 2021. 8-23:26-34.

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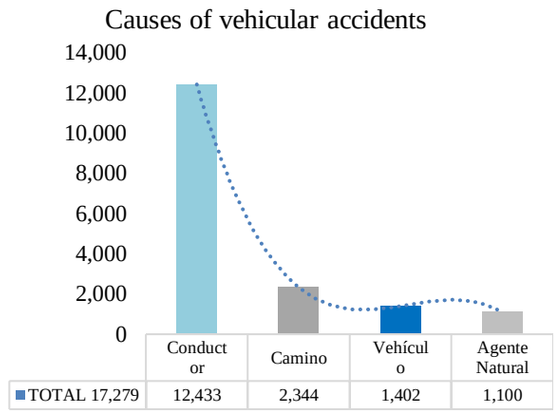
Introduction

At present, technological advance in the driving and operating systems of the latest generation engines in the motor transport sector requires greater and better knowledge. In this regard, the training of operators to acquire and develop skills in driving vehicles, particularly in heavy vehicles, driving simulators turn out to be very useful tools in the improvement of these techniques (Romero et. Al. 2004). It also allows evaluating the response capacity of operators in adverse situations and scenarios. In the case of experienced drivers, simulators make it possible to reduce erroneous driving techniques that affect the wear and tear of the units. Likewise, the skills acquired allow operators to achieve optimal returns on resources such as fuel among other operating expenses.

Unlike using a real unit, a simulator allows the use of a vehicle without using any fuel for its operation, it also gives the operator an important degree of safety by not suffering damage when colliding with other vehicles, retaining walls or else other objects that, when using a real vehicle, not only the vehicle would suffer damage, but also the driver.

The topic of vehicle driving has different edges of study which are based on the interests of the sector or area of attention. In the literature it can be found that the topics focus on aspects of resource optimization (fuel, timing, tires, maintenance, among others). For companies, driving is directly related to the person, the vehicle and the road and for this system to work in the best way, it is not only important to emphasize the vehicle or the road, but also on the human factor emphasizing the control and management of emotions to take responsibility for the task of preventing mistakes and driving properly (Antoñas JL, Lope A. Salavera C., Bericat C. 2019). The consumption of illicit substances or the misuse of drugs represents another problem, because driving under these factors can cause a negative effect on the direction of the vehicle, (National Institute on Drug Abuse, 2019), because it is not only The driver is at risk, as well as passengers and third parties who share the road (National Institutes of Health, 2019).

The importance of knowing how to drive a vehicle is essential, only in 2020 3,826 people died in a traffic accident (INEGI, 2020). Graph 1. shows the behavior of collisions caused by various factors according to the Statistical Yearbook of Accidents on Federal Highways (2015-2019), where an average of 17,279 total multi-causal circumstances were reported (driver, road, vehicle, natural agent).



Graphic 1 Causes of vehicular accidents
Source: Own elaboration with data from INEGI

The previous graph shows the results of the analysis of the multi-causal circumstances that originate a traffic accident, registering 12,728 road accidents in that period. An average of 12,433 causes related to the human factor (main cause) were registered, prevailing recklessness, excessive speed, not yielding the right-of-way, lane invasion, not keeping an appropriate distance; The road is in second place in importance with 2,344 causes, followed by the vehicle and natural agents with 1,402 and 1,100 causes, respectively. Until the year 2021, there are no statistical data in the statistical yearbook of accidents on federal highways, however, a forecast is made with the simple linear regression method with historical data from the statistical yearbook of accidents on federal highways from 2015 to 2019 to obtain figures for the next two years. In the year 2020, 12,066 total multi-causal circumstances are forecast, which contribute to 9,664 road accidents registered in that period of time, and 8,986 causes related to the human factor were identified. In the same way, for the year 2021, a forecast was made with the same method mentioned, taking up historical data from the 2015-2020 period, and 10,328 total multi-causal circumstances were obtained, which contribute to 9,642 road accidents registered in that period of time, and 7,837 were identified. causes related to the human factor.

ISSN: 2410-3993

Similarly, an investigation revealed that there are six main causes that cause an accident, one of the factors being the distraction of drivers when driving, which represents 40% of accidents. This makes it the number one cause of road accident fatalities. Second is aggressive driving, accounting for up to 31% of accidents. Third, there is the lack of expertise that accounts for 11% of accidents. Fourth, driving while tired, which corresponds to 7%. In fifth place, there is alcohol which represents 7% and lastly corresponds to external conditions (weather, road conditions, mechanical failures, etc.) which represents 4% of accidents. (Cortés, 2018)

According to the foregoing, the importance of adequately acquiring driving skills through training programs for new drivers and training of professional drivers that involve from the theoretical knowledge of the processes to the physical and affective skills required are more than evident. due to its influence on the activities of the economic sector and road safety. To this end, the training programs seek to promote compliance with the domains of the learning taxonomy, thus enriching the skills of drivers in the operation of cargo, passenger or private use vehicles.

The elements established in the learning domains lead to the development and improvement of driving techniques, which are closely related to the scientific method, because they explore mechanisms that allow them to observe, measure and experience scenarios that can be presented in real situations using technological and multimedia resources to support methodological needs (Jaramillo Andrade, PA, 2021). Other authors refer to the scientific method applying action-research activities to analyze the causes of accidents and address strategies for their reduction (Jaramillo Sangurima, W., and Muñoz Sotomayor, V. A., 2017).

This research work specifically addresses the instructions for driving vehicles following the learning taxonomy which includes the three areas that potentially affect the driver's safety at the wheel, these are: cognitive domain, psychomotor domain and affective domain and that they are also a strong influence in the learning processes and the acquisition of new knowledge, in particular the teaching-learning process of driving vehicles.

This research document is organized as follows. In Section I a description of the Big Rig HD 2.0 driving simulator used for the elaboration of this work is presented. Section II refers to the applied methodology based on the learning taxonomy. In Section III the results obtained through the applied methodology are presented, and finally in Section IV the conclusion of this research is shown.

Vehicle driving simulators

Information and Communication Technologies (ICTs) have provided an environment in constant change of teaching-learning processes. Its incorporation in various educational plans and programs or in education and training programs has generated a more dynamic way of acquiring knowledge (Vivas Campusano, M. A., 2021). On the other hand, these new technologies provide new options in resources and strategies to carry out tasks and learn according to the needs of the participants and exchange information of interest.

In turn, virtual teaching and learning environments that support students in the creation of spaces for the acquisition of new knowledge and experiences, have achieved greater relevance in educational programs and training of human resources (Zapata Ancajima, JC 2021), where analysis, reflection and appropriation is part of learning to solve applied problems. In this context, the business sector requires human talent with skills in logistics operations, such as storage, transportation and distribution of raw materials and finished products, as well as management of computer resources for inventory control, vehicle tracking just to mention some. These knowledge and skills can be developed through virtual reality equipment where the learning objectives obey Bloom's taxonomy (Rodríguez Villalobos, A., Sempere Ripoll, M. F. 2021).

The practical approach suggested by Parkes (2005) states that there are three important elements that should drive decisions about the use of simulators within the education and training process:

- The efficiency and acceptability of learning in the simulator.

- Transfer of learning to the real world.

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- Retention of learned skills or knowledge.

In this context, a driving simulator is currently considered as a tool to train, train or evaluate expert drivers in a comprehensive way that includes attitudes to take risks, defensive driving and reaction in emergency situations that require greater attention (Lee, et al, 2002).

Learning to drive a vehicle with a driving simulator actually involves experiential learning environments. This type of learning is a process of reconstruction of knowledge experiences and is a holistic approach in which it involves the influence of experience, emotions, cognition and environmental factors in the learning process. (Kolb, 1984)

Big-rig HD 2.0 driving simulator

To carry out this research, it was assumed to use the Big-Rig 2.0 simulator as shown in Figure 1, which complements the theoretical aspects of the training with the firm purpose of identifying and reaffirming the principles of highway driving.

Figure 1 Driving Simulator Big Rig 2 HD
Source: Engineering in Logistics and Transportation. UPTrep

The elements that make up the driving simulator equipment are described below:

- Panoramic vision system with 180 degree range of vision capable of virtually reproducing driving scenarios. The system is equipped with three 30-inch monitors. The operation is carried out through an extreme gamer computer that receives the signals from the PC computer and builds a graphic simulation of vehicles traveling in a virtual road scenario.

- Audio system to recreate real driving situations, both environmental and vehicle. This system has stereo speakers with subwoofer and 80W audio translator with amplifier.

- Power steering motorized system capable of reproducing the turning movements of the vehicle by the driver in different scenarios. The steering wheel controls are connected to sensors that, when activated, send signals to a computer so the driver will have a greater interaction with the simulation.

- System of components for the driver's management such as the clutch, brake pedal, and the switches that are part of the driving equipment.

- Mutual action system with serial task menu. In this part, the driver receives in real time the detailed information of the errors committed, infractions between warnings among others, in order to notify the coaches about their performance.

Methodology

To carry out this research work, a taxonomy oriented to the training of drivers is applied, emphasizing mainly on an adequate preparation of their skills and knowledge. While driving, we must correctly interpret the surrounding space to avoid leaving the lane limits or colliding with other vehicles. In other words, having a good perception of space is being able to locate oneself, to move in space, to take multiple directions, to orient oneself, to analyze situations and to represent them (Blázquez and Ortega, 1984).

From another perspective, the author Mesias Vivas, P. B (2019) addresses the learning taxonomy in relation to competencies according to the level of performance of the students and also oriented to the curricular design, taking care of the consistency between the achievement indicators of the specific competences of the subject. In terms of education and training, the taxonomy consists of formulating a classification of the goals of the educational process, identifying three “domains” of educational activities (Bloom, B. S. 1977, Huitt, 2011): Cognitive Domain, Psychomotor Domain and Affective Domain.

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Cognitive domain

This domain is related to a group of activities that have to do with the development of attitudes and mental skills, which allow drivers to understand the basic processes and concepts for driving a vehicle.

This area is understood as the intellectual part or thought process, it is integrated of three criteria or main levels in driving.

- **Knowledge.** Mastery of technical information about vehicle operation, operating principles (turning it on, mastering gear lever, mastering pedals, among others) and rules of the road (knowing the meaning of signage, guidelines for the use of indicators such as directional lights and intermittent, infringement cases, among others).

- **Understanding.** Assume vehicular communication understanding the guidelines carried out in driving implicitly and explicitly, such as: lane change, use of turn signals, change of lights, interpretation of signage, among others.

- **Application.** Execute the information understood from the knowledge, in the development of the activities of the driver's activity.

Psychomotor domain

It is made up of physical procedures that an individual uses in daily life and to participate in complex physical activities for work and recreation (Marzano, R. J., & Kendall, J. S. 2007). In terms of driving techniques, a vehicle driver must necessarily have an education and training that allows the driver to achieve a good performance by acquiring the skills of the relevant psychomotor domain.:

- **Imitation.** It contemplates that the fundamental knowledge of the taught skill was understood and acquired by the drivers to later carry out an execution of the vehicle similar to a demonstration that is given to them, repeating the basic principles of operation such as: starting the vehicle, making adequate speed changes, respect signs, pause use of indicators, to mention a few.

- **Handling.** In this stage, the driver performs repetitions of the techniques to maneuver according to the needs and conditions of the environment. At this point, the degree of uncertainty in the vehicle's operation is reduced.

- **Precision.** Verify that the driver provides accurate results with a minimum number of tests deemed necessary. Being capable of conducting with the required degree of accuracy.

Affective domain

The affective domain is closely related to positive or negative emotions, which are manifested in the driver's behaviors and techniques. Inattention in this domain is a factor that influences road accidents, in addition to human errors and environmental conditions in general. (Ceci, et. Al. 2001; Alexander, et. Al. 2002).

In this regard, driving simulators allow knowing the level of affective mastery obtained during the training stage or acquired empirically in the operation and capacity of their vehicles. The criteria that are addressed for this research are ordered as follows:

- **Reception.** Able to recognize his own emotions according to the moment in which he is, such as: euphoria, anger, sadness; as well as their attitudes: aggressive, passive, intuitive, to name a few. Identifying in this way risk situations both internal (emotional situation of the driver) and external (eventualities in the environment).

- **Answer.** You must attend visual, auditory and physical stimuli showing reaction to them, generally the response will be motor such as pressing the brake, turning the steering wheel, agilely performing a maneuver. In the same way, the response can be affective, such as showing a passive attitude to avoid a conflict or situation of tension.

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- **Assessment.** The ability to assign value to situations or things is shown, in this way the driver clearly shows an involvement or commitment when reacting to situations such as: road accidents, vehicle or environment conditions, accidents, among others.

In carrying out this research, a population under study was considered to be made up of 30 students from the academic program of Engineering in Logistics and Transportation of the Polytechnic University of Tlaxcala Region Poniente, 17 being female and 13 male.

For the purposes of this study, a probability sampling was used, starting from the following formula to determine the effective size that the sample should have given by the following expression (Aguilar, 2005)

$$n = \frac{N \cdot Z^2 \cdot p \cdot q}{d^2 \cdot (N-1) + Z^2 \cdot p \cdot q} \quad (1)$$

| Where:

$N =$ Total population, in this case the 30 selected students.

$Z =$ Desired confidence level. For the purposes of this study and having a high level of security is considered a confidence level of 95%, which has a Z value of 1.96

$p =$ Estimated proportion. In this case p = 0.5 corresponding to 50% to maximize the sample size.

$q =$ Proportion of the reference population $(1 - p)$.

$d =$ Absolute precision.

When considering a confidence level of 95%, it is possible to have a margin of error of 5% that corresponds to a value d = 0.05. Therefore, substituting the values in equation (1), we obtain:

$$n = \frac{30 \cdot (1.96)^2 \cdot 0.5 \cdot 0.5}{(0.05)^2 \cdot (30-1) + (1.96)^2 \cdot 0.5 \cdot 0.5} \quad (2)$$

$$n = 27$$

Which represents the effective size of the student sample, and also allows us to check our study with 95% certainty and 5% sampling error. On the other hand, if a confidence level of 90% and a sampling error of 10% is applied, this would be reflected in the size of the sample, going to 22 students, that is, there would be a decrease of 5% of certainty in the research work.

Results

The description of the results follows the order of appearance according to the methodology described in section II: cognitive domain, psychomotor domain and affective domain.

In the evaluation of the cognitive domain, the results are shown in Table 1, where the criteria for obtaining information refer to the knowledge and understanding that the driver has in the operation of a vehicle.

Criterion	No. of students	%
Knowledge	11	40.7%
Understanding	16	59.2%

Table 1 Evaluation of the cognitive domain
Source: Own elaboration

In the criterion of knowledge, these were acquired by the operators according to some type of procedure or method. In this study, it was obtained that 11 students corresponding to 40.7% had previous knowledge or basic concepts in driving vehicles. The understanding criterion is related to the ability of the operator to understand and interpret information through an explanation and / or demonstration. In this case, as shown in Table 1, 16 students representing 59.2% of the total population acquired the relevant knowledge of driving techniques through understanding the instructions during the process of preparing this study. In the evaluation of the psychomotor domain, it was determined to use the criteria of imitation, manipulation and precision. The results obtained for this domain are shown in Table 2.

Criterion	No. of students	%
Imitation	8	29.6%
Handling	15	55.5%
Precision	4	14.8%

Table 2 Evaluation of the psychomotor domain
Source: Own elaboration

ISSN: 2410-3993

The first criterion imitation indicates if the student can repeat the exercises and actions provided during the explanation in the driving simulator. It is observed that only 29.6% of the total sample of those evaluated were able to adequately imitate the actions and exercises provided in the training.

The manipulation criterion refers to the ability of the student to adapt and adjust to the teaching process when performing vehicle maneuvers. In this criterion, 55.5% of the students were able to improve manipulation of the simulator using their own skills and adapting to the environment that the driving simulator recreates.

Finally, in the Precision criterion, the accuracy of the student to operate a vehicle is evaluated. From the data obtained in the simulator, only 14.8% of the students were able to precisely maneuver the vehicle using as measurement parameters: seat belt use, proper use of lights, respect signs, correct gear change and finally the identification of the revolutions per minute (RPM).

Regarding the affective domain related to emotions and moods, these become relevant in the driver's attitudinal behavior in front of the wheel due to their influence on road accidents generated by aggressive driving or aggression between drivers. The results of the evaluation are described in Table 3 where the criteria receive, respond and assessment were taken into account.

Criterion	No. of students	%
To receive	12	44.4%
Reply	8	29.6%
Assessment	7	25.9%

Table 3 Evaluation of the affective domain
Source: Own elaboration

The first criterion, receiving, consists of the attention paid to the environment or environment, in addition to the affective state due to internal or external circumstances (emotional situation and conditions of the vehicle or environment respectively). In this domain, it was identified that 44.4% of the students, according to the environment that the simulator recreates, is affected by internal or external circumstances of the driver as received. These circumstances can be fatigue, tiredness, nervousness, road conditions, weather conditions.

The response criterion refers to the student's ability to think about possible solutions to circumstances or problems that arise while driving. In this regard, 29.6% of the evaluated students managed to identify some type of solution. The evaluation criterion determines the commitment to solve situations that affect the driver's driving performance. In this criterion, 25.9% of the students managed to act opportunely and correctly in various situations that arose during the driving simulation exercises.

Finally, Table 4 contains the final information of the participants evaluated in this research and it was obtained that the performance at the end of the use of the Big-Rig Simulator 2.0 represents a viable option for driving training since the final performance of its use It is 59.2%, which under the evaluation criteria used corresponds to a good performance.

Performance rating	No. of students	%
Excellent	5	18.5%
Okay	16	59.2%
Regular	4	14.8%
Deficient	2	7.4%

Table 4 Final performance evaluation
Source: Own elaboration

At the end of the training of the students in the simulator, it was possible to develop the following skills and understand the knowledge:

- Recognize control elements (steering wheel, pedals, gear lever).
- Recognize buttons and windshield components, etc.).
- Know fuel and temperature indicators.
- Turning a vehicle on and off.
- Seat adjustment.
- Learn to make gear changes.

ISSN: 2410-3993

Conclusions

The learning taxonomy is a method that can be applied at various levels and training areas due to its convenience to organize and classify the knowledge and skills of an individual in training or professional. In addition, it allows to know the degree of creativity capacity reached to respond to problems and situations with the environment. In the context of this research, the taxonomy allowed evaluating the driving techniques of a population of students according to the three learning domains: cognitive, psychomotor and affective. The results show that in the cognitive domain, 59.2% managed to acquire knowledge in management techniques during the training stage compared to the rest of the sample that had previous knowledge. In the psychomotor domain, 55% of the students managed to drive in the simulator using their own skills and adapt to the environment that the simulator recreates. For the affective domain, 44.4% of the students managed to recognize their own emotions according to the environment that the simulator generated, such as: fatigue, nervousness, among others. Finally, the use of the Big Rig 2 driving simulator allowed it to be a useful and didactic tool for measuring each of the criteria of the learning domains.

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