Evaluation of the User Experience of a Web Tool that Allows Inferring the Learning Style and Personality of University Students in Mexico

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Abstract

Educational trends have evolved during the last decades, with the implementation of Information and Communication Technologies (ICT's) and the change of approaches in the teaching process, the need has arisen to create tools that can face the new challenges of teaching. Along with this process, the user experience (UX) must be considered in the development process of educational support tools, as a fundamental part of Human-Computer Interaction (HCI). Consequently, in the process of developing tools for this purpose, technologies, approaches or concepts that can result in a pleasant UX should be considered. The objective of this study was to evaluate the UX of a web tool, elaborated with the purpose of detecting learning styles and personality. The tool was developed under the principles of Responsive Web Design (RWD) and using the Material Design Guidelines (MDG). For the evaluation of UX, the User Experience Questionnaire (UEQ) was used. Subsequently, the data obtained were analyzed using a tool developed in MS Excel. The results showed that, in general terms, the UX is good, however, some metrics indicate that the results could vary if the number of participants in the study were increased.

Keywords: User Experience, Material Design, Responsive Web Design, HCI, UEQ

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1. Introduction

The contexts and methodologies applied to teaching no longer have the same approaches as in years past. The classic approaches, based on classrooms and activities proposed by teachers, have been transformed. Now, they are heading towards teaching based on the learning of knowledge and skills. Taking into account the autonomous activity of the students[1]. Consequently, it is important to have the necessary instruments to detect how learning occurs autonomously. Some authors have made efforts researching, analyzing and developing different instruments that help with the task of thoroughly knowing the way in which a student acquires learning individually [2],[3],[4], [5].

The last decades have been of great importance for the expansion of the Internet, this expansion has made various areas show interest in migrating their information to the cloud, this change has generated the need to create methods of innovation, in the creation of graphical interfaces functional, to present different contents on different types of devices, in all their shapes and sizes [6].

In the area of education and psychology is no exception. Designing interfaces for a correct Human-Computer Interaction (HCI) is a fundamental process.

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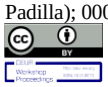

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The impact of Information and Communication Technologies (ICT's), on the development and construction of instruments for educational and psychological evaluation, has widely transformed the static and classic models of measurements through instruments made with pencil and paper, leading them to the possibility of applying the instruments in digital formats [7].

As mentioned by Pinandito et al., 2018, the need to adapt to the growing supply of different electronic devices (computers, laptops, smartphones, tablets), to consume content on the Internet, has generated a need for adaptation. Previously, applications and websites were offered in different versions, depending on the type of device and resolution from which they were accessed. However, this approach generates a series of problems, mainly in the adaptation of the content to screens of different resolutions [8].

In 2011, with the introduction of the concept and application of Responsive Web Design (RWD), a great offer of flexibility arose to adapt User Interfaces (UI), to the resolution of different devices, using the same design and adjusting it, depending on the type of device and resolution from which the user accesses the site or web application, using technologies such as HTML5 and CSS3 [8]. A web design can be considered adaptive if it meets 3 main characteristics: a flexible grid; flexible images and multimedia content and have CSS Media Queries [8].

As a result of the problem in the poor adaptation of the UI to the different devices on the market, international companies have made proposals that reduce the workload of web designers and developers, for example, the design language proposed by Google in 2014, Material Design Guidelines (MDG) [9]. MDG provides a series of best practices for the design of user interfaces so that the user has a unified experience on different platforms and devices, regardless of the final resolution of the device [8].

It is important that the design of the UI is suitable for any type of information that you want to display. Considering users is an extremely valuable resource when ICT's are designed, there is a great variety of methods for the evaluation of the user experience (UX) through the opinion of users [10].

This article presents, the procedure applied for the evaluation of UX of a web application that allows inferring the learning style and personality of university students in Mexico. The structure of the document is made up as follows: section II presents an approach to the related works; point III describes the materials and methods implemented (evaluated web tool, participants, evaluation tool and the procedure applied to evaluate UX), the point IV covers the results obtained and discussions made; finally, in section V the conclusions obtained are shown.

2. Related works

Human-Computer Interaction (HCI) is the discipline in charge of studying the main aspects surrounding the design, implementation and evaluation of computer systems with which the human being can interact [11]. The usability of an interface is the main area in the discipline of HCI, it focuses on the methods used for the evaluation and measurement of the ease with which a user uses and interacts with the interfaces of computer systems [12].

The evaluation of UX in web applications is a fundamental activity in HCI, which allows us to analyze if an application really fulfills its purpose. There is a great variety of research works, in which the need and benefits of implementing evaluation techniques to measure the performance of an application, site or web system can be observed. For example, the work done by Isherwood and Maguire (2018), where they propose a comparison of two evaluation methods, to detect usability problems on a website [13]. For their part, S. Hartomo and Bakal (2021), analyze the UX of an e-commerce site, used for the sale of cultural products from their country, through two validated instruments (Questionnaires of System Usability Scale (SUS) and User Experience Questionnaire (UEQ)) [14].

Considering the type of device, from where the content of a web application is viewed, can be a point of reference for the design of better UI's that work on any screen resolution. An example is the use of User Centered Design (UCD) and MDG, to measure the effectiveness and efficiency of web content delivery, in different resolutions, through RWD [8].

In the area of psychology and education, we can find the evaluation of an e-learning platform, through the UX evaluation technique, using the UEQ instrument [15]. Another example is the evaluation of a web system used for thesis management, where techniques such as: heuristic evaluations and the application of UEQ were used [16]. One more work describes the analysis that was made to user reviews, through data mining, to detect strengths, weaknesses and usability gaps. This study was carried out on 106 mental health applications, publicly available in the App Store of the Apple company and Google Play of Android [17].

3. Materials and methods

3.1 Web tool

The web tool that was used is the product of a research in process, developed within the *Autonomous University of Zacatecas (UAZ), Mexico*, whose purpose is to improve the instruments for the detection of learning styles and personality, using, artificial intelligence (AI) techniques. In this research, the *Myers Briggs Type Indicator (MBTI)* instrument was chosen [5]. *Myers & Briggs (1962)*, describe in their *MBTI* manual that personality can be classified into 4 orientations. In this way, each classification has 2 different opposing characteristics, which are measured dichotomously, through 93 questions. Consequently, *MBTI* results in 16 personality types [5]. A detailed description of the *MBTI* dimensions can be seen in *Table 1*. Here it is important to point out that the *MBTI* has been used to establish the relationship between personality and learning styles [18], [19]. Consequently, MBTI was the digitized instrument for data collection and subsequent analysis within the investigation. For digitization, the concept of *RWD* and *MDG* was used. These two approaches allowed the development of a web tool, adaptable to different resolutions, achieving data collection in a faster and simpler way. For the development of the web tool, the framework for web applications, *Angular* in its version 12.0.3 [20], was used, in addition to the use of other technologies, such as *HTML 5, CSS 3* and the *Angular Material Library* version 12.2.13. *Angular Material* provides *MDG* elements that guarantee performance and reliability [21]. The technologies implemented in the development of the web tool allowed the creation of user interfaces (*UI*), with the ability to function and adapt the content presented, on different devices and screen resolutions. For the storage of data that was collected with the *MBTI* instrument, the *Firebase platform* was used, which, through the *Cloud Firestore* product in its free plan, provides easy access storage [22]. The developed user interfaces consist of 4 main views. The first is a welcome interface to the application, where the specific purpose of its use is described; the second interface is a form to collect personal and social data of the participants; in the third interface, the applied *MBTI* questionnaire is shown, separated into 4 sections with dichotomous options to answer it; finally, the fourth interface shows the results obtained after processing the responses of the participants. A series of screenshots of the developed user interfaces show the adaptability to different resolutions and devices. We can visualize them in *Figures 1,2,3, 4 and 5*. The developer tool was used, which the *Google Chrome browser on Windows* has enabled. This allowed to visualize the interfaces, in different resolutions and devices. The general architecture of the web tool can be seen in *Fig.6*.

Table 1

Adaptive orientations of the MBTI indicator and its measured characteristics. Own elaboration, based on Myers & Briggs (1962).

Adaptive orientations	Characteristics
Interaction with the world	Extraversion (E) Introversion (I)
Capture of information	Sensation (S) Intuition (N)
Decision making	Thinking (T) Sentiment (F)
Organization	Judgment (J) Perception(P)

Figure 1: UI 1, PC View.

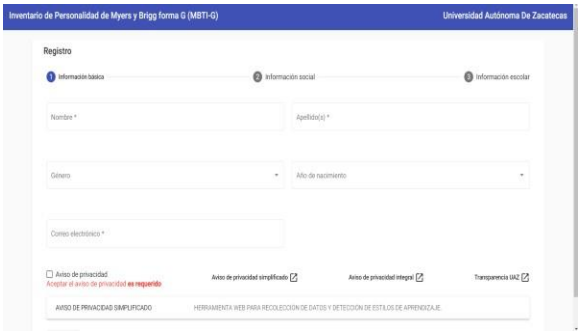

Figure 2: UI 2, PC View.

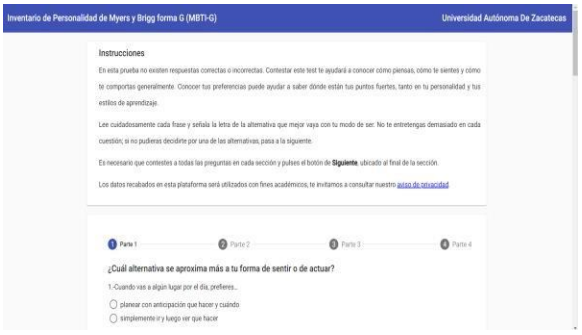

Figure 3: UI 3, PC View.

Figure 4: UI 4, PC View.

Figure 5: UI's 1-4, View on mobile devices (360 x 740 px).

Figure 6: Architecture of the web tool used. Own elaboration.

3.2 Participants

Due to the nature of the research project from which this study emerges, the participants were only students from the *Autonomous University of Zacatecas (UAZ), Mexico*, specifically from the *Academic Unit of Electrical Engineering (UAIE)*. Being the target population, it was necessary to limit the selection of the sample to this specific group. The characteristics of the participants are shown in *Table 2*.

Table 2
Characteristics of 12 participants, for the UX evaluation. Gender: Female (F), Male (M). Own elaboration.

Participant	Age	Gender	Degree	Device
1	22	F	Postgraduate	Laptop
2	25	F	Postgraduate	Laptop
3	24	M	Postgraduate	Laptop
4	29	F	Postgraduate	Laptop
5	19	M	Bachelor's	Laptop

			degree	
6	27	M	Postgraduate	Laptop
7	30	M	Postgraduate	Laptop
8	27	F	Postgraduate	Laptop
9	25	F	Postgraduate	Mobile
10	37	M	Postgraduate	Mobile
11	27	M	Postgraduate	Mobile
12	25	F	Postgraduate	Mobile

3.3 User Experience Questionnaire (UEQ)

The purpose of this study is to measure the user experience of a product developed for a specific purpose, in this case, a web tool to measure learning styles and personality. To fulfill the purpose, a *User Experience Questionnaire (UEQ)* was implemented [23]. *UEQ* provides a series of items, each with two opposite meanings (negative and positive). The questionnaire has 6 scales, measured through 26 items. We can group them into *pragmatic* (goal-directed) quality and *hedonic* (non-goal-directed) quality [23]. *UEQ*, measures different aspects of the user experience, the items are presented on a scale from -3 to 3, where -3 represents the most negative response, 0 a neutral response and 3 a positive response [23]. A description of each scale is shown in *Table 3*.

Table 3
Description of the scales of the UEQ tool. Own elaboration, based on information from Schrepp (2019).

Aspect	Scale	Description
Attraction (pure valence dimension)	Attraction	It is a general impression of the product. It tells us whether or not the user likes the product.
Pragmatic quality	Perspicuity	Measures the ease with which the user becomes familiar with the product.
	Efficiency	Can user's complete tasks effortlessly?
	Dependability	How much control does the user feel when using the prod- uct?
Hedonic quality	Stimulation	Indicates if there is emotion and motivation when using the product.
	Novelty	Is the product innovative and creative? Also, if it manages to capture the user attention.

3.4 Procedure

A. Application of User Experience Questionnaire

For the evaluation of *UX*, the *UEQ* [23] was applied. The procedure was carried out inside the *Laboratory of Interactive Technologies and User Experience (LITUX)*, located within the *Autonomous University of Zacatecas (UAZ)*, Mexico. The data obtained is a sample of 11 postgraduate students and one undergraduate student (n=12). To count on their participation, they were invited to collaborate and thus come to the laboratory. Within the laboratory, the process was as follows: In a controlled environment and without distractions, each of the participants was asked to complete the tasks of the web tool, subsequently and without any type of pressure or coercion, we asked them to, according to their experience in manipulating and completing the tasks of the web tool, they will answer the *UEQ questionnaire*. The study participants can be seen in *Fig. 7*. The procedure for the application of *UEQ* is detailed

in *Fig.8*.

Figure 7: Study participants, using the Web tool, inside the Laboratory. Own elaboration.

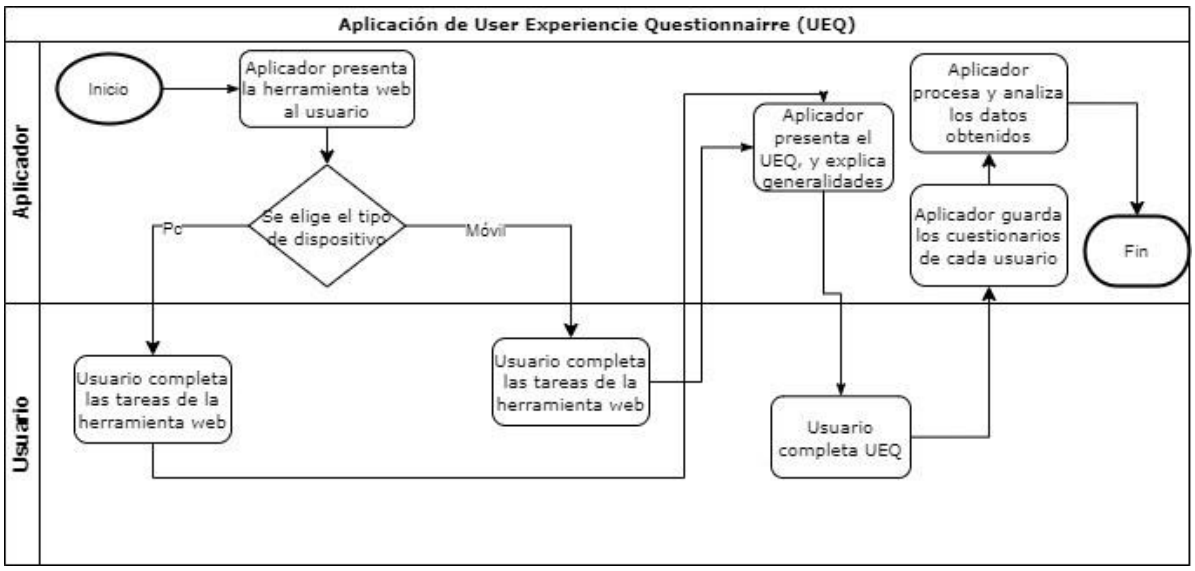

Figure 8: Flowchart of the UEQ application process. Own elaboration.

The study was developed with the intention of evaluating *UX*, of a web tool, developed under the principles of *RWD* and the use of *MDG*. In this context, the study was carried out, using different devices. To evaluate in a desktop environment, a single laptop was used, the evaluation in mobile devices, was done in different models and brands, with different screen resolutions. A detailed description of the devices used is shown in *Table 4.*

Table 4
Detailed description of the devices used in the study. Own elaboration.

Device type and model	Operating system	Characteristics	Browser	Resolution
Portable PC. Asus		Intel(R) Core(TM) i5-	Chrome.	

TUF Gaming F15	Windows 11 Home. Version. 21H2. 64 bits.	10300H CPU @ 2.50GHz 2.50 GHz. 16 GB RAM. Nvidia Ge-Force GTX 1650 Ti	Version. 102.0.5005 .63	1920 x 1080 px
Mobile. Xia- omi Redmi 10Note S	Android 11 + MIUI 12	MediaTek Helio G95. 6GB RAM	Chrome for Android. Version. 102.0.5005 .78	2400 x 1080 px
Mobile. iPhone11	iOS 15	Chip A13 Bionic. 4 GBRAM	Safari para iPhone. Version. 15	1792 x 828 px
Mobile. Xiaomi PocoX3 Pro	Android 11 + MIUI 12	Qualcomm Snapdragon860. 6 GB RAM	Chrome for Android. Version. 102.0.5005 .78	2400 x 1080 px
Mobile. Sam- sung Galaxy S10	Android 11 Red Vel-vet + Samsung One UI	Exynos 9820. 6 GB RAM	Chrome for Android. Version. 102.0.5005 .78	2960x 1440 px
Mobile. OppoReno 6 Lite	ColorOS 11.1 based on Android 11	Qualcomm Snapdragon662. 6 GB RAM	Chrome for Android. Version. 102.0.5005 .78	2400×1080 px

B. Data analysis

For the interpretation of the data, the *"UEQ Data Analysis Tool, Version 10 (DAT)"* was used, which is free to use and available on the website (https://www.ueq-online.org/). The tool is a product developed in *MS Excel*, which was designed for the statistical analysis of *UEQ* items and scales. You can calculate the reliability of *UEQ*, with metrics such as *Cronbach's Alpha*. The *Cronbach's Coefficient (Cronbach's Alpha)* is a very popular method. It is widely used to measure the consistency of the scores obtained, in the application of a questionnaire. In this study, *Cronbach's Alpha* was considered to measure the consistency obtained in each *UEQ* scale. To consider solid consistency, *Cronbach's Alpha must be > 0.7* [24]. It is also possible to obtain other statistical measures, for example, the statistical means or the standard deviation.

Another important metric that *DAT* allows us to obtain are the confidence intervals of each scale. The confidence interval measures the precision of the estimate of the value of the mean, for each of the scales. In this study, an interval of 5% is considered. The range of the confidence interval depends largely on the size of the sample obtained [23].

The tool provides a *Benchmark* for the evaluation of the answers obtained with *UEQ*. The *Benchmark*

classifies a product through 5 categories by scale. The categories that are classified by each scale are: *excellent; good; above average*; *below average and bad*. To consider the quality of a product, it is necessary to compare it with historical data of other similar products. In this context, the *Benchmark* provides a set of historical data. In total, 452 products have been evaluated with *UEQ* and 20,190 participants in all evaluations [23]. For each classification there is a corresponding interpretation. *Table 5*shows the interpretation for each classification.

Table 5
Description of the 5 Benchmark classifications, for an evaluated product. Own elaboration, based on Schrepp (2019).

Classification	Interpretation
Excellent	In the range of 10% of the best results.
Good	10% of the results in the reference set are better than the evaluated product and 75% are worse.
Above average	25% of the results in the reference set are better than the evaluated product and 50% are worse.
Below average	50% of the results in the reference set are better than the evaluated product and 25% are worse.
Bad	In the range of 25% of the worst results.

4. Results and Discussions

The results of the study were obtained thanks to the *UEQ analysis tool*. With the use of this tool developed in *MS Excel*, it was possible to obtain relevant data to check the reliability and consistency of the *6 UEQ scales*. To measure reliability and consistency, in this study, the *Cronbach's Coefficient (Cronbach's Alpha)* was considered. Thanks to the reference data set (*Benchmark*), it was possible to compare the results obtained to measure the quality of the product, through the *6 UEQ scales*. Thanks to the *MS Excel tool*, for data analysis, graphs were obtained, which allow a simpler interpretation.

4.1 Cronbach's Alpha

The results obtained from the *UEQ Data Analysis Tool (DAT)* and according to the *Cronbach's Alpha* values, which indicate that, to consider a solid consistency, the Alpha value must be > 0.7, it is observed that almost all the scales measured in *UEQ* show a solid consistency. The scales of *attraction; perspicuity; efficiency; dependability and stimulation*, show a fairly high consistency. However, the *novelty* scale shows the lowest result. *Table 6* indicates the values obtained for *Cronbach's Alpha*, in each *UEQ* scale.

Table 6
Cronbach's Alpha values, in each scale. Own elaboration, based on the information obtained with the MS ExcelDAT tool.

UEQ Scale	Cronbach's Alpha
Attraction	0.89
Perspicuity	0.79
Efficiency	0.94
Dependability	0.88
Stimulation	0.89
Novelty	0.75

4.2 Confidence intervals

For this study, the values obtained from the statistical mean of each of the 6 scales turned out to be outside the confidence interval. However, the results may indicate the need to modify the number of participants and probably narrow the range of the confidence interval and thus obtain a more precise estimate. The confidence intervals, the reliability of the estimate, the means and standard deviations, in each of the scales, are represented in *Table 7*.

For the interpretation of the results, the standard values are the following: for a neutral evaluation, the mean value for each scale must be a value between *-0.8 y 0.8*. Values >0.8 represent a positive evaluation, when an evaluation represents a negative user experience, the average values per category are <-0.8. In general terms, it can be seen that the *UX* evaluation of the web tool obtained a positive value, except for the novelty scale, which, according to the value obtained in the statistical mean, the *UX* evaluation is neutral. *Fig. 9* shows us a graphical interpretation of the statistical means and confidence intervals, for each scale.

Table 7

Confidence intervals of the data obtained from the 6 UEQ scales. Own elaboration, based on the informationobtained in DAT.

Scale	Average	Standard deviation	N	Confidence	Confidence Interval
Attraction	1.611	1.286	12	0.727	0.884
Perspicuity	1.847	1.494	12	0.845	1.002
Efficiency	1.896	1.498	12	0.848	1.048
Dependability	1.375	1.604	12	0.908	0.467
Stimulation	1.083	1.490	12	0.843	0.240
Novelty	0.396	1.565	12	0.885	-0.489

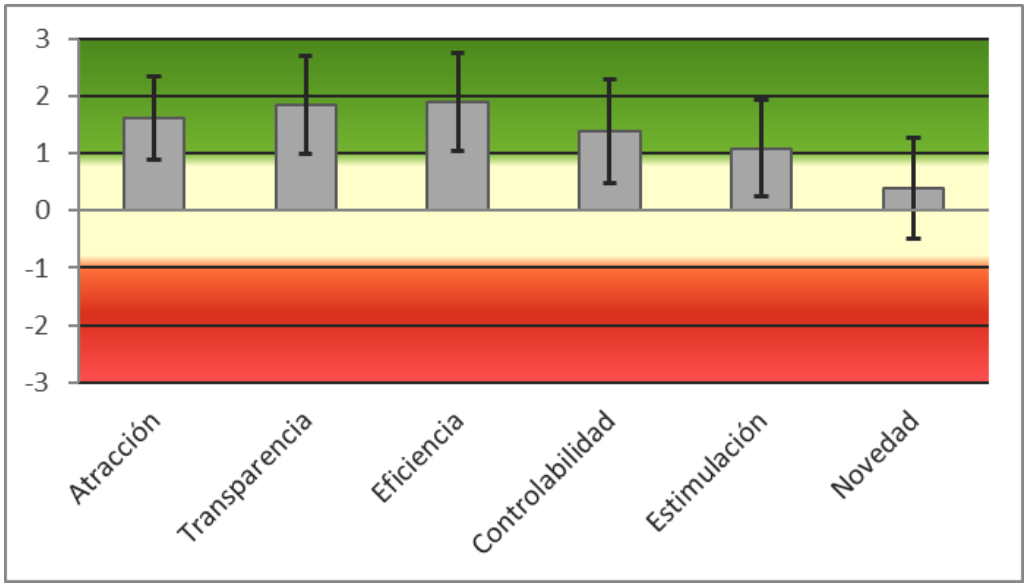

Figure 9: UX results, in the 6 UEQ scales, mean values and 5% confidence interval. Taken from the MS Excel tool, for UEQ data analysis.

4.3 User experience results based on Benchmark

Having a *Benchmark*, for the evaluation of *UX*, is necessary to be able to compare the results obtained when applying *UEQ*. This task was carried out, thanks to the *MS Excel* analysis tool with which we are working. The tool has a data set that classifies the *UEQ* scales in 5 categories; the categories that it evaluates are: *excellent; good; above average; below average and bad*.

When processing the information with the *UEQ Data Analysis Tool (DAT)*, in general terms, it can be seen that the web tool obtained a positive evaluation. For the classification of each of the scales, it is observed that, in the *Attractiveness* and *Perspicuity* scale, the product is *good*. *Efficiency* is rated as *excellent*; *Dependability* and *Stimulation* are *above average*. However, on the *Novelty* scale, we can see that it was classified *below average*. *Fig.10* shows the results of each category, for each scale. The comparison of the data obtained in this study, directly with the *Benchmark*, of the analysis tool, together with the interpretation of each result, can be found in Table 8.

Table 8
Classification of the UEQ scales, through comparison with the Benchmark. Own elaboration, based on the information obtained with the MS Excel DAT tool.

UEQ Scale	Average	Benchmark Comparison	Interpretation
Attraction	1.61	Good	10% of the results in the reference set are better than the evaluated prod-uct and 75% are worse.
Perspicuity	1.85	Good	10% of the results in the reference set are better than the evaluated product and75% are worse.
Efficiency	1.90	Excellent	In the range of the top 10% re-sults.
Dependability	1.38	Above average	25% of the results in the reference set are better than the evaluated product and 50% are worse.
Stimulation	1.08	Above average	25% of the results in the reference set are better than the evaluated product and 50% are worse.
Novelty	0.40	Below average	50% of the results in the reference set are better than the evaluated product and 25% are worse.

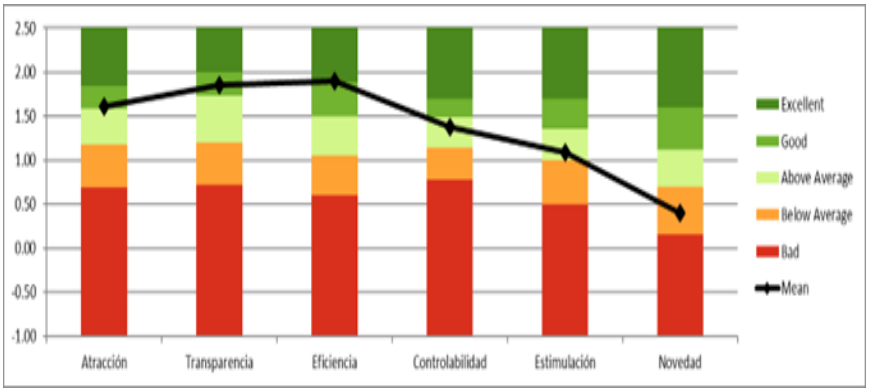

Figure 10: Benchmark classification, for each of the 6 categories. Taken from the MS Excel DAT tool.

5. Conclusions

This paper aims to evaluate the user experience *(User Experience, UX)* in the web tool, which was developed for the detection of learning styles and personality. The selection of the sample was limited only to the students of the *Academic Unit of Electrical Engineering of the Autonomous University of Zacatecas, Mexico*. This limitation influenced the number of participants in the *UX* evaluation, through the *User Experience Questionnaire (UEQ)*. The results to measure the reliability of the answers obtained in *UEQ*, indicated that many of the values of the statistical means, obtained in each of the 6 scales, did not belong to the confidence interval, however, increasing the number of participants in the study, could narrow the confidence intervals and obtain greater precision. On the other hand, the data obtained, to measure the consistency, using the *Cronbach's Coefficient (Cronbach's Alpha)*, indicate that the consistency of each scale is solid, being that, in all the scales, the value obtained is > 0.7. The data obtained, with *Cronbach's Alpha*, give an encouraging result.

The evaluation of the 6 scales, for the classification of each of them, in the 5 categories, which through the data set (*Benchmark*), available in the tool to analyze the *UEQ* results, shows that in general, the evaluated product, in compared with the historical data of other evaluations, it has a good general performance, however, according to the classification obtained, it is necessary to propose solutions, to improve the scale of innovation.
To conclude, it is recommended that, in future work, the sample of participants be larger and another academic profile be included, also that the number of devices be increased, where the web tool is evaluated to obtain better results. Finally, it is proposed to use the data obtained in this study to consider increasing the performance of the evaluated scales, where the result shows a low performance, for example, in the innovation scale.

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