Raspberry Analysis in the Teaching of Computer Sciences

Johnny Paúl Novillo Vicuña
Technical University of Machala, Machala, Ecuador.

Fausto Fabian Redrován Castillo
Technical University of Machala, Machala, Ecuador.

Freddy Leonardo Espinoza Urgilés
Technical University of Machala, Machala, Ecuador.

Jimmy Rolando Molina Ríos
Technical University of Machala, Machala, Ecuador.

Abstract

Due to the increasing facilities that users today demand to perform systemized operations by creating applications, the need arises to combine application functionalities by using raspberry Pi, with the aim of stimulating the teaching of computer science, Giving rise to the choice of the best version of raspberry to be adopted to the needs in the areas of computing. This research presents a comparative analysis of raspberry versions, taking into account the utility in different areas or companies and certain factors based on hardware and software characteristics that help the development of the computational area.

The main objective of this article is to analyze the use of Raspberry in teaching the education sciences, by comparing the different versions that exist of Raspberry. For this purpose, the analysis was formulated using an evaluation model based on the quality characteristics proposed in ISO / IEC 9000. The results showed the strengths and weaknesses of each version of Raspberry Pi and was the basis for Determine which version is best for teaching development implementation of computer science. Before realizing an evaluation it is considered indispensable to know and understand the operation of the Raspberry devices, for it is recommended to use tables for the comparison of the characteristics, having as a reference reliable websites that contribute documentation on raspberry types and the use of standards of quality for its determination.

Keywords: Raspberry, arduino, ISO/IEC 9000, evaluation model.

INTRODUCTION

In recent times, the evolution of the electronics and the field of portable computers have been increasing considerably, being that every year a new electronic device appears that replaces an existing one thanks to the improvement of certain characteristics, which implies to facilitate each More people's lives.

One of the important aspects that is observed in the technological advances that day by day has been the field of the same microcontrollers that have inside the powerful and well-known microprocessors, which perform a number of functions through the use of different Instructions which are stored within these microcontrollers and are encoded in a type of programming language.

Raspberry Pi is the name given to a SBC (Single Board Computer) model launched in 2011. The Raspberry Pi project was launched in 2006 by Eben Upton, Rob Mullins, Jack Lang and Alan Mycroft, when they decide Create a low-cost computer aimed at children to promote the teaching of computer skills among younger students. Thus, in 2009 they created the charitable organization Raspberry Pi Foundation. This card or laptop computer consists of USB, auxiliary, HDMI, Ethernet, RGB, and an SD card slot as a storage system. You can also adapt a USB hub to expand ports and connect other important devices such as the keyboard and mouse.

The applications or products when they are released to the market are always estimated to have some degree of acceptance among users, for it will depend on the characteristics that the user considers important. From the point of view of the utility of raspberry Pi in a common area of development, one of the main characteristics that must have is the verification of the version that best suits the needs of the requirements of the area where it is going to be implemented. Therefore, it is relevant for users to evaluate the characteristic of each version of Raspberry Pi.

The quality of the electronic devices is taken into consideration according to the attributes specified in the ISO / IEC 9000 standard and to define it it would be worth to measure the list of quality attributes, which include the functionality, reliability, usability, Efficiency, maintainability and portability.

What version of raspberry Pi brings with it useful and interesting characteristics for the development of teachings in the area of computer science?

H1: The Raspberry Pi provide the best performance for the development of teaching in the area of computing.

THEORETICAL FUNDAMENT

Embedded systems today are implemented in various areas using programming languages and computer tools that are the fundamental part in conjunction with the hardware that divide complex tasks with the use of devices that integrate and solve complex tasks.

According to [1] Most often the use of specialized systems, which were built and programmed to perform particular tasks. The goal is to divide large tasks into much smaller ones and thus build subsystems that specialize in this type of tasks. The concept of embedded systems takes strength in this approach, and for this reason many manufacturers build boards with higher capacities and different types of interfaces. For the implementation of an information system [2] it implements an embedded system as the main monitoring device, and the Python-based application.

The use of programming languages is indispensable in the creation of applications that allow to control the actions of the hardware involved in the embedded system. Among the most used are Java, Python and C because they have important features such as object orientation, control and management of GPIO ports and for the design of algorithms in Arduino.

Raspberry Pi

It is a low-cost minicomputer which has different input and output devices that allow it to interact with other components. You need a power source with 5v output and an SD memory card where you will have the Linux operating system installed for your operation.

According to [3] the Raspberry Pi is a credit card sized computer with versions that cost between 20 and 35 euros, runs a complete version of the Linux system. Their records are kept on an SD card that usually has between 2 and 32 gigabytes of data. While connected to a power supply, a USB keyboard and mouse and connected to a TV through an HDM. It behaves like a normal laptop. Programs for it can be written in different languages like Python, C and Java.

Features of Raspberry Pi

The general characteristics of Raspberry pi according to [3] are as follows:

Table 1. General features of Raspberry

Features	
CPU	700MHz ARM1176-JZFS
GPU	Broadcom VideoCore IV

Memory	256MB LPDDR2-800
Video	HDMI, composite
Audio	HDMI, stereo analog
USB	2 x USB2.0 (model B)
Storage	SD card
Networks	10/100 Ethernet
Power supply	5V micro USB

The Linux systems that can be installed to be executed in the Raspberry Pi are varied since for being of free code the programmers can make modifications that allow to improve the performance and different functions.

Raspbian

According to [2] Raspbian is a Debian-based operating system optimized for Raspberry Pi hardware released in July 2012. Raspbian is an unofficial port for Debian wheezy armhf (ARM Hard Float). Port is the process of adapting a program to run in a different environment, in this case, with a different hardware platform. ARM Hard Float is an ARM along with hardware support for floating point operations called VFP (Vector Floating Point).

There are a variety of Raspberry models with different features and improvements in their latest versions that add more components.

Raspberry Pi Zero

According to [1] The Raspberry Pi Zero is half the size of a Model A +, with twice the usefulness. A small Raspberry Pi that is affordable enough for any project.

Table 2. General features of Raspberry Zero

Features	
CPU	1Ghz, CPU de un solo núcleo
GPU	Broadcom VideoCore IV
RAM	512 MB
Ports	Mini HDMI y puertos USB On-The-Go
Audio	HDMI, stereo analog
USB	Potency Micro USB
Video	Composite video and restart headers
Connectors	40-pin connector compatible with HAT

Camera	CSI camera connector (v1.2 only)

Raspberry Pi 1 B+

According to [2] the Model B + is the final revision of the original Raspberry Pi. It replaced the Model B in July 2014 and was replaced by the Raspberry Pi 2 Model B in February 2015. Compared to Model B it has:

Table 3. General features of Raspberry Pi 1B+

Features	
GPIO	The GPIO head has grown up to 40 pins, maintaining the same pinout for the first 26 pins as model A and B.
USB	It has 4 USB 2.0 ports, compared to the 2 that owns the B model, and better hotplug and over current behavior.
SD	The old friction adapter for SD cards has been replaced by a much more pleasing push-push micro-push version.
Lower energy consumption	Lower energy consumption: By replacing the linear regulators with the switching regulators, the energy consumption between 0.5W and 1W has been reduced.
Audio	The audio circuitry incorporates a dedicated low noise power supply.
Cleaner form factor	The USB connectors are aligned with the edge of the board, the composite video moved in the 3.5 mm connector and we add four directly mounted mounting holes.

Raspberry pi 2 B

According to [3] the Raspberry Pi 2 Model B is the second generation of raspberry Pi. Replaced the original Raspberry Pi 1 Model B + in February 2015. Compared to the Raspberry Pi 1 it has:

Table 4. General features of Raspberry Pi 2 B

Features	
CPU	An ARM Cortex-A7 quad-core 900MHz CPU.
RAM	1 GB RAM
Ports	4 USB ports
GPIO	40 GPIO plugs

Port	Full HDMI port / Ethernet port
Interface	Camera Interface (CSI) / Display Interface (DSI)
Conector	3.5 mm combined audio and composite video connector.
SD	Micro SD card slot
Video	VideoCore IV 3D graphics core

Raspberry Pi 3 B

According to [4] the Raspberry Pi 3 is the third generation of Raspberry Pi. Replaced the Raspberry Pi 2 B model in February 2016. Compared to the raspberry Pi 2 has|:

Table 5. General features of Raspberry Pi 3 B

Features	
CPU	ARMv8 quad-core 64-bit 64-bit and 1.2 GHz.
Network	802.11n wireless LAN
Bluetooth	Bluetooth 4.1 / Bluetooth low energy (BLE).
RAM	1 GB de RAM
Port	Full HDMI port / Ethernet port
USB	4 USB ports
GPIO	40 GPIO plugs
Conector	3.5 mm combined audio and composite video connector
Interface	Camera Interface (CSI) / Display Interface (DSI)

Raspberry Pi 3 has a shape factor identical to the previous Pi 2 (and Pi 1 Model B +) and has full compatibility with Raspberry Pi 1 and 2. Raspberry Pi in its new models has been improving features from Raspberry Zero to The model 3 that implements a superior processor of 64 bits and 1.2 GHz to the previous versions, bluetooth 4.1 and wireless LAN 802.11 that considerably improve the processing capacities as well as their connectivity.

ISO 9000 standard

"The ISO 9000 standard is an international standard for the evaluation of electronic devices. The standard is divided into four parts, which addresses, respectively, the following topics: quality model, external metrics, internal metrics, and quality in the use of metrics. The ISO 9000 International Standard has been prepared by the ISO / TC 176 Technical Committee, Management and Quality Assurance, SC Subcommittee 1." [5]

This standard proposes the quality model that allows to evaluate the quality of a product, which is divided into four important aspects such as: quality model, external metrics, internal metrics and quality metrics in use.

Among the characteristics of this model are 6 parameters: Functionality, reliability, usability, efficiency, maintainability and portability.

Quality Management Criteria

These criteria belong to ISO: 9126 which covers the quality of electronic devices in the final product. These patterns are primarily aimed at evaluating device quality. There are several patterns that are evaluated with the criteria covered by this standard.

Table 6. Characteristics and sub-characteristics according to ISO / IEC 9126

FEATURES	DEFINITION	SUB-FEATURE
Functionality	It seeks to measure the contributions of a Raspberry usage pattern.	Accuracy Adequacy Interoperability Security
Reliability	Calculate the contribution of the software patterns to solve the shortcomings of the Raspberry and be able to recover after these problems.	Maturity Fault tolerance Recoverability
Usability	It seeks to fulfill the function of evaluating the ease of using a given pattern.	Understanding Operability Learning capacity
Efficiency	Performs the evaluation of the performance of a system with in a determined time.	Behavior over time Resource Behavior.
Maintenance	Cumple con la It fulfills the function of evaluating the realization of corrections, or some kind of change in functionality, performed under the evaluated software pattern.	Ability to test Stability Modifiability
Portability	It seeks to fulfill the function of evaluating the ease of adaptation and replacement.	Replaceability Instability Adaptability

METODOLOGY

For the corresponding investigation the following research methods were used:

Analytical method: it is used because it allows a detailed analysis of particular facts, in this case the analysis was performed taking into consideration the characteristics of the quality metric according to the international standard ISO / IEC 9126 and in this way determine what is the Raspberry that best fits to work in the teaching of computer science.

Descriptive method: it is used when describing the benefits, technologies, tools that the raspberry possesses taking into account each one of the characteristics according to the metric of quality of the standard ISO / IEC 9126, to later carry out an exhaustive analysis of the results, to This way to emit criteria that are of aid and enrich the knowledge.

Bibliographical method: it is used in the search of information on specific questions that in this case is the impact that has to use raspberry in the teaching of computer science, looking in reliable sources as it is indispensable for the progress of research.

Taking into account all these methods, it is analyzed by ISO / IEC 9126, since it is an international standard to evaluate the quality of this type of electronic device; This standard consists of six characteristics, which allow us to determine the best framework for the development of web applications.

Definition of indicators

Characteristics and sub-characteristics of evaluation

The characteristics and sub-characteristics to be evaluated and that are immersed in the evaluation of the frameworks were taken from the international standard ISO / IEC 9126 of the quality of the software which are:

Functionality: Raspberry's ability to provide the necessary services to meet the functional requirements.

The functionality is in itself in how the Raspberry adequately meets the needs for which it was designed or used.

Reliability: Raspberry's ability to provide the services needed to perform with the functional requirements.

The reliability is taken into account fault tolerance, the way Raspberry can operate fault-free during a certain time and environment, ie the probability of how far the Raspberry can perform its function with the required accuracy.

Usability: Effort required by the user to use the product satisfactorily.

Usability plays an important role because it is linked to the quality that a Raspberry should have. Based on the international standard ISO / IEC 9126, usability can be defined as "the degree to which a Raspberry is used by users to achieve specific goals with effectiveness, efficiency and satisfaction in a given area.

Efficiency: relationship between the performance of Raspberry and the requirements for its use.

Maintainability: effort required to adapt to new specifications and software requirements.

This feature is defined as the ability of a Raspberry to be modified, such modifications can include corrections, improvements or adaptive to new working environments, ie, maintainability refers to the attributes that allow to measure the effort required to perform Modifications in the same, either by correction of errors or by the increase of functionality.

Portability: ability of the software to be transferred from one environment to another.

Portability is defined as the ability of a Raspberry to be adapted from one environment to another, that is to say that regardless of the programming language the Raspberry is coupled to the functions of another language and does not undergo transformations or failures when being used.

Implementation of evaluation criteria

To evaluate the Raspberry versions taking into account the characteristics of the ISO / IEC 9126 standard, the Likert scale is used, with the purpose of quantifying the quality taking into account the characteristics mentioned above and to determine what is the Most feasible framework for use. Then the scales of evaluation:

Table 7. Likert Scale

Evaluation Criteria	
Value	**Definition**
1	Very deficient
2	Deficient
3	Regular
4	Good

5	Excellent

Fuente: The authors

Selection of a pilot study area

The study area where the research is based, which is considered appropriate for the respective study of the "Raspberry Evaluation" were all the companies that use Raspberry in the city of Machala.

Figure 1. Pilot city for the respective study

According to the information originated, this city has five main companies that implement mini pc's for automation in their embedded systems.

Table 8. Companies that work with Raspberry

Nº	Companies
1	Laservision Cía. Ltda
2	Empresa eléctrica
3	Corporación Blacio
4	Banco Machala
5	Farmacia Cruz Azul

Fuente: The authors

MATERIALS AND METHODS

To verify the hypothesis raised will be necessary the application of a method that will allow to establish an orderly sequence of actions that will allow to establish the conclusions on the use of the best version of Raspberry Pi.

To obtain pertinent and necessary information for the research, data were collected, which were obtained through the developed surveys and interviews with the developers in charge of the different organizations, to whom the questions of the surveys were applied. In the surveys that were formulated a series of questions were established which were based on the use of Raspberry that use them taking into consideration the international standard ISO / IEC 9000 for which their results

were obtained through evaluation criteria in order to estimate The characteristics raised by the quality metric.

Finally, to evaluate the hypothesis was taken into account the version of Raspberry with higher score, which resulted from the sum of the pre-established indicators.

RESULTS

Through the collection of information obtained from surveys conducted to companies that own Raspberry in the City of Machala, it was possible to determine which Raspberry is the best presence in the area of computer science.

At present there has been an increase in the creation of cards like the Raspberry Pi that are offered to the market at affordable prices with prices below 100 dollars.

It should still be kept in mind that even if price levels are similar, user experience, functionality and flexibility are different at the highest point. These cards are now famous names such as Raspberry Pi, Arduino, Beagle Board or Tower. Each has advantages and disadvantages to try to meet the demanding demands of the current designers. The Raspberry Pi platform is undoubtedly the best known of these platforms. For only $ 25, it has a GNU Open Source integrated development environment (IDE) card and community ready to help.

Based on the information that was collected, it was obtained that the Raspberry Pi can be adapted to a great variety of projects for the automation integrating different hardware devices since it has modules that can be added by means of the use of the incorporated pins and that Provide additional functionality.

The following table shows a comparison of the different reduced plate computers that exist in the market with characteristics similar to the Raspberry Pi:

Table 9. Comparison of different models of Raspberry pi

Zero	Pi 1	Pi 2	Pi 3
1Ghz, Single-core CPU	ARM11 ARMv6 700 MHz.	A 900MHz quad-core ARM Cortex-A7 CPU	A 1.2GHz 64-bit quad-core ARMv8 CPU
512MB RAM	GPIO header has grown to 40 pins	1GB RAM	1GB RAM
Mini HDMI and USB On-The-Go ports	push-push micro SD	4 USB ports	4 USB ports
	0.5W and 1W.	40 GPIO pins	40 GPIO pins

Micro USB power	256 MB LPDDR SDRAM 400 MHz	Full HDMI port	802.11n Wireless LAN
HAT-compatible 40-pin header		Ethernet port	Bluetooth 4.1
Composite video and reset headers		Camera interface (CSI)	Camera interface
CSI camera connector (v1.2 only)		Display interface (DSI)	Full HDMI port
		Micro SD card slot	Micro SD card slot
		VideoCore IV 3D graphics core	

Fuente: The authors

In the new versions of have been implemented considerable improvements until the model pi 3 that counts on a better processor with 1.2GHz surpassing to its previous versions.

In addition to considerable versions in other features that provide extra features.

According to [6] to measure the popularity of the different models of Raspberry in the last year a comparison was made.
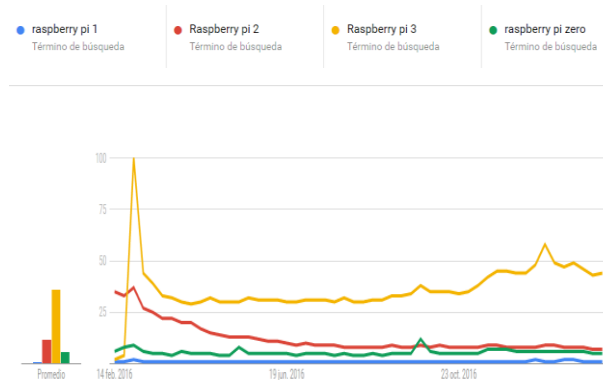

Figura 2. Comparison of Raspberry models

Comparison of different Raspberry Pi models in companies according to metrics.

Table 10. Evaluation of Raspberry pi 0

Raspberry pi 0			
METRICS			
PORTABILITY	5	5	10
INSTABILITY	5	5	10
USABILITY	4	4	8
RELIABILITY	4	5	9
FUNCTIONALITY	5	4	9
MAINTENANCE	5	5	10
TOTAL	9		

Table 11. Evaluation of Raspberry pi 1

Raspberry pi 1			
METRICS			
PORTABILITY	4	4	8
INSTABILITY	4	4	8
USABILITY	5	5	10
RELIABILITY	4	4	8
FUNCTIONALITY	4	5	9
MAINTENANCE	5	3	8
TOTAL	8		

Table 12. Evaluation of Raspberry pi 2

Raspberry pi 2			
METRICS			
PORTABILITY	5	3	8
INSTABILITY	5	3	8
USABILITY	4	4	8
RELIABILITY	4	5	9
FUNCTIONALITY	5	4	9
MAINTENANCE	4	3	7
TOTAL	8		

Table 13. Evaluation of Raspberry pi 3

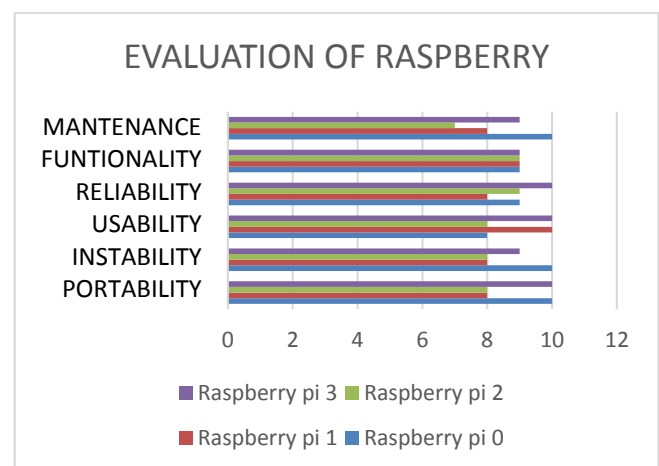| Raspberry pi 3			
METRICS			
PORTABILITY	5	5	10
INSTABILITY	5	4	9
USABILITY	5	5	10
RELIABILITY	5	5	10
FUNCTIONALITY	4	5	9
MAINTENANCE	5	4	9
TOTAL	9		

Figure 3. Evaluation of Raspberry

Evaluation of the Raspberry for each of the characteristics of the quality metric

It can be demonstrated the great advantage that has the Raspberry pi 3 in most of the characteristics of applied quality metrics, implying that it is the best that fits the embedded systems, because the evaluation metrics have a lot Of advantage in its portability, reliability and usability on the others Raspberry Pi.

In the research process, it was found that the study population consisted of 5 companies, all of them using systems embedded in their different areas for the automation of specialized tasks, and it was obtained that

CONCLUSIONS

In the present investigation, it is evident that the quality model of the ISO / IEC 9126 standard is correctly adapted to the evaluation of the use of Raspberry in the teaching of computer science, determining as an important tool to guarantee what is development Technological advantage of companies that wish to make the leap to the automation of their processes.

A fundamental process for the application of a quality model is the assignment of values of importance that is given to each of the characteristics and sub-characteristics, which determines which characteristics are more relevant when choosing a Raspberry. Without the allocation of these values that are granted through surveys conducted it is impossible to determine in which area is best developed each Raspberry selected.

Determining in this way that Raspberry Pi performs in the best way with the characteristics, denoting functionality, reliability, usability, efficiency, maintainability and portability to the rest of Raspberry evaluated.

Raspberry Pi is a good choice for the construction of applications both on the web and desktop, because after the application of the quality model, it is observed that it maintains good scores on important points evaluated, which companies that wish to implement it Must take into account how are the functionality and usability to improve performance based on the technological advances they possess.

Bibliography

[1] D. Rolando et al., "embebidos Raspberry Pi y Arduino para el manejo de un brazo robótico mediante una aplicación Android," no. 2015, pp. 69–96.

[2] A. C. Sari, A. Rahayu, and W. Budiharto, "Developing Information System of Attendance and Facebook Status for Binus University's Lecturer Using Raspberry Pi Architecture," Procedia Comput. Sci., vol. 59, no. Iccsci, pp. 178–187, 2015.

[3] N. Kortas, H. Azzabi, A. Ben Arbia, and J. B. Tahar, "Communication within Cloudlet using the Raspberry," Procedia Comput. Sci., vol. 73, no. Awict, pp. 193–198, 2015.

[4] raspberry.org, raspberry Zero.

[5] raspberry.org, raspberry Pi 1 B+.

[6] raspberrypi.org, raspberry Pi 2 B.

[7] r. P. 3, raspberry pi 3 B.

[8] Á. P. C. R. José Luis Manzano Zumba, «Análisis comparativo de framework software libre para el desarrollo de aplicaciones de escritorio en java.,» Riobamba, 2014.

[9] g. trends, «google trends,» [En línea]. Available: https://www.google.es/trends/explore?date=today%2012-m&q=raspberry%20pi%201,Raspberry%20pi%202,Raspberry%20pi%203,raspberry%20pi%20zero.

[10] M. Degiovannini, «Comparativa de Frameworks Web,» *JavaHispano.com,* vol. II, p. 3, 2011.

[11] C. G. R. R. Manuel Mirana Chinlli, «Repositorio Institucional de la Escuela Superior Politécnica de Chimborazo,» 2015. [En línea]. Available: http://dspace.espoch.edu.ec/handle/123456789/4581. [Último acceso: 08 Agosto 2016].