Aulacast: A Single Board Computer Platform to Support Teaching

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Abstract: The use of mobile technologies in educational environments has potential to promote relevant changes in teaching and learning process. Aulacast is proposed as a solution which can aggregate concepts of educational mobility and Internet of Things. It is based on insertion of software and hardware suitable with embedded technologies in an educational context, offering support devices for teachers to obtain, present and manage educational objects with multimedia content. The solution was implemented on low cost single board computers using an open architecture and independent network infrastructure, allowing the interaction between mobile devices and multimedia presentation devices. This paper presents the motivation of the project, the applied strategy to build the prototype of Aulacast and results of observation of its use.

1 INTRODUCTION

Mobile technologies such as smartphones and tablets have a great potential of use in teaching and learning processes (Milrad et al., 2013). The decrease in the prices of these products since 2010 (Viberg and Grönlund, 2013) has allowed people of different social economical profiles to have greater access to these tools, specially teachers of various teaching levels in urban areas. Computers of generic use called "single board computers" have arisen in this low cost context with high capacity of processing, low energy consumption and small dimensions. These computers are capable of providing a bigger flexibility in the implementation of tailor-made solutions to the demand of individuals included in teaching and learning activities.

Mobile tools have directed educational techniques focused on the students, a strategy that has demanded new abilities to be developed. In projects of information and communication technologies insertion, it is possible to observe a great effort regarding the adaptation of teachers to those tools(Direne et al., 2012). Considering that the success of these tools depends on how capable teachers are to operate them (Dole et al., 2015). It is also possible to notice that there is not enough emphasis on the development of devices more appropriate to educational needs that consider the different users profiles.

When the educational environment completeness is analyzed, it can be defined as an ecosystem (Chang and West, 2006). Giving a greater importance to the recognition of the roles represented by the elements which this ecosystem is composed of, paying attention to the relationship established among them, in a way in which the improvement of the environment can be promoted harmoniously. The concept of ecosystem can be used as a metaphor to a structure of the system that can be generalized and created by a set of components that interact with one another in their environmental context (Pearce and Ahn, 2010). In an ecosystem like this, the software tools of information and communication technologies (ICT) become an important interaction facilitator element, promoting interoperability among several devices nearby.

The role performed by a teacher in an educational ecosystem requires, besides direct interaction with teaching activities, administrative abilities, organizing time, constructing the contents for the lesson plans, participating on the decisions making process regarding the school's structure, among others. A technology that provides support only to the content management, used on the basic activities of teaching and learning, presents a blank space between the activities performed by the teacher and the daily demands of their professional activities. Therefore, a combination of academic and management activities when introduced like any application that people use on their smartphones, is a strategy to avoid the opposition to changes and to reduce the effort demanded to learn the product use (Anshari et al., 2017).

One of the traditional uses of computers in schools

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is the computer lab, a place where there are computers to be used in specific activities, in which students and teacher must go to the lab to use the machines. This was an important setting to provide access to ICT in the 2000's, including cases that have had a great success such as the project "Paraná Digital" (Castilho et al., 2007), although it got outdated because of other technological advances. A model that uses new tools provides a new level of interaction capable of reversing the old setting, that is, allowing the ICT's tools to go where the students and teacher (Liu et al., 2017) are, promoting a more efficient use of the resources.

This project proposes the creation of an integrated educational environment based on a basic computing infrastructure focused on all the aspects of educational system, differing from other attempts to insert technologies focused only on specific aspects of teaching and learning activities. Bonilla (Bonilla, 2009) presents arguments that differ the demands of digital inclusion using ICT tools from the use of supporting tools in teaching activities. Instead of including tools, an educational ecosystem depends on the identification of strategies of process improvement by implementing devices that can be used as problem solvers or as activities optimizers.

The use of ICTs has a strong link with teaching and learning activities. In addition, the concepts and tools of Internet of Things (IOT) allow a qualitative leap, considering that they provide a natural flow of information exchange between the physical and the virtual world (Vihervaara and Alapaholuoma, 2017). All the options given by devices with well-defined functions and particular uses may reduce the cases of resistance to change and also reduce common difficulties found in the process of learning how to deal with projects based on tools that offer generic interfaces and those with several functions, such as computers. Another aspect that can be observed in this new pedagogical model is the capacity of integrating tools as they become popular.

The aim o this paper is to present Aulacast, an element to be inserted in the teaching ecosystem in order to act as a supporting tool to the teachers activities, using single board computers connected to smartphones that do not depend on a network infrastructure or other computers. Its prototype illustrate the possibilities offered by the concepts of IoT applied to an element of an educational ecosystem model.

This paper is organized as follows. Section 2 presents the related works. Section 3 describes the Aulacast tool and results of observation of its use. Section 4 discuss the potential application of the presented tool. Finally, Section 5 concludes with considerations and future work.

2 RELATED WORKS

2.1 Technological-educational Mobilities

Nowadays, mobile devices are constantly used by students and not always this use has an educational aim. Researches made by Quinn (Quinn, 2011)Sharples (Sharples, 2002), Kukulska-Hulm (Kukulska-Hulme and Traxler, 2005), Sharples et. al (Sharples et al., 2005) are the basis of studies about uses of mobile devices in education. In their researches, the authors theorize about the organization of these types of learning in formal and informal spaces which support the mobile learning. Researchers also consider some of the impacts that these tools cause on learning process. According to Vavoula et. al (Vavoula and Sharples, 2009) the use of mobile technologies constructs a new background and promotes changes on the paradigm of learning, since it makes new models of learning in different contexts a possible goal. Sharples (Sharples, 2002) and Kukulska-Hulme (Kukulska-Hulme and Traxler, 2005) defend that the learning is deep and enriching when the students can choose among various resources and ways to conduct their studies.

When organizing the methodology of an educational activity using technological-educational mobility, Sharples et. at. (Sharples et al., 2005) defend that the relation between teacher, students, content, time and space must be assessed. The mobility allows the relation between students and teachers to be temporal, with learning taking place beyond class time. Analyzing the practice of teachers, Veiga (Veiga, 1996) defends that the pedagogical practice is a social procedure and, by consequence, it must be oriented through objectives and learning purposes and it must also be incorporated in the context of a social practice. In other words, the pedagogical practice is defined by the current social conception, considering the historical and social model nowadays.

Sung and Liu (Sung et al., 2016) point out that there is a great diversity of equipment and also advantages obtained using computers in teaching and learning, specially those based on mobile technologies. The promotion of interoperability among several structures offers possibilities of constructing richer environments to support educational activities.

Sharples and Spikol (Sharples and Spikol, 2017) present a set of challenges to be solved in an environment where there is a great variety of devices and medias available in a learning context based on mobility. On their text, the authors discuss topics related to educational objects and how these objects contribute to a learning process that occurs outside school context using mobile devices. However the authors support that this technology answer one out of many nuances inside teaching and learning process.

2.2 Single Board Computers (SBCs)

The popularization of smartphones has allowed a great increase on the industry of systems on chips (SOCs) of low cost, high process capacity and interaction with many kinds of sensors (Lewis et al., 2016). SBC is a kind of computer implemented on a printed single board that uses the capacities SOCs in its modeling. It also allows data storage in an external unit and offers several interfaces to interact with other electronic devices.

Among all the most popular SBCs, Raspberry Pi (Lewis et al., 2016) stands out. Constructed as a tool to support programming learning, it became one of the main references on developing tool prototypes that requires processing power similar to traditional computers, which merge a great number of interfaces with other electronic devices.

The most popular mobile devices, tablets and smartphones, are produced giving priority to demands of communication, entertainment and personal organization. On the other hand, some projects based on SBC, more specifically Raspberry Pi, which was created to be used in studies of computer science (Heeks and Robinson, 2013), have arisen as devices suitable to teaching and learning processes. The project of uses of Raspberry Pi for the construction of low price computers using the product functionalities have already been presented with lower processing capacity versions (Ali et al., 2013), but with a very similar proposal to projects such as On Laptop Per Child (OLPC).

2.3 Ecosystems

An ecosystem can be defined as a metaphor to a general system structure, which can be reproduced and constructed through a set of parts that interact with one another in their delimited environmental context (Pearce and Ahn, 2010), inhabited by species that interact with one another and with the environment itself, aiming at personal gains (Boley and Chang, 2007).

Digital ecosystems can be defined as open communities where there are no central controls, being capable of redefining themselves according to the necessities found inside the system. Some definitions of digital ecosystems present a model of ecosystem abstraction to represent digital environments. Digital ecosystems present a model that anticipates the existing species and virtual environments – created and maintained by computers – considering the presence of living beings working either as elements that generate input events or as agents that consume the outputs of a system.

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2.4 Projects to Include Computers in School

Reconsidering solutions embraced on projects to include computers as supporting tools to educational process such as One Laptop per Child (Kraemer et al., 2009) or UCA (de Macedo Guimarães et al., 2013), it is possible to see the focus on technologies based on devices supported on specific projects of hardware that promotes a project of social-digital inclusion focused on the access to low cost computers. These proposals did not present an appropriate computational ecosystem to the support of teaching and learning process in a context that meets the set of species included on formal educational activities on educational environments, not only to students and teachers (Uden et al., 2007).

The recent migration to other types of computer technologies based on mobile devices represents an important element so that the hardware model used by programs that also use XO structure (James, 2010) can be reconsidered. The modern mobile devices' price together with their increasing popularity and ease of transportation and handling demonstrate that this kind of device has a tendency to be more adequate to the use considering one computer per students (Hockly, 2016) instead of the laptops used by classmates or XO.

The use of single board computers (SBC) for the construction of prototypes and for making experiments using interfaces in order to connect with external devices can be done with ease, providing results that help comprehending events (Vida et al., 2016; Benevides et al., 2015). A possible solution to the challenges found because of the necessities regarding mobility and interaction between user and peripheral and also between user and educational use sensors is the use of SBC. This type of devise allows the construction of equipment that are adequate to several situations related to teaching and learning process in a model that demands a greater interaction with teachers.

3 Aulacast TOOL

In this work we propose Aulacast, an SBC used as an integration tool between the teacher's smartphone and the device that presents the content, such as an overhead projector or a television. It is based on a proposal called third technological wave. Aulacast uses Linux operating system, Debian distribution with graphic interface X FVWM as a window manager. We use Omxplayer to play video files, Libreoffice or Evince for presentations, and Eye of Gnome (EoG) for presenting images. The programs activation is controlled by an application developed in Python which interacts with operating system by means of Popen library functionalities, responsible for the application instantiating and management, and Xdotool to simulate keyboard and mouse.

The requirements of Aulacast are: offering a mobility model that allows the teacher to bring the content to be shown with certain facility, not depending on network infrastructure or other hardware devices; ease of use in several output interfaces, low acquisition price, ease of use and software upgrade possibility. These characteristics allow the teacher to have access to a tool that can be used in various physical spaces and a smaller use of tools as classrooms with computers, smart TV or multimedia projector.

The environment offered in this implementation is an integrated tool capable of making the presentation of content and educational objects easier, those that were conceived to be used in traditional computers, but mainly, it offers a resource that can expand the potential uses of new technologies that support learning processes. The first implemented version aims at presenting the possibility of implementing an integrated tool using simple acquisition hardware tools which are suitable for the multimedia content presentation and also suitable for the integration with traditional mobile devices.

In this study, set boards developed by Raspberry project were used with no alterations on the original hardware and no input of sensors or extra interfaces. This option allows to test in a more simple way, since the only requirement is the use of the model and the SBC. The software used was from the Raspbian repository and installed by the apt package manager.

The Aulacast integration uses an application for Android operating system installed in a smartphone which offers an interface that interacts with the device by means of tcp/ip connection with its content management functionalities, besides simulating a touchpad and keyboard so that the user can interact with the operating system as if they were physically connected to the device. The Android application tried to offer a friendly interface and to use the teacher's knowledge about applications in this operating system to expand its potential use (Anshari et al., 2017).

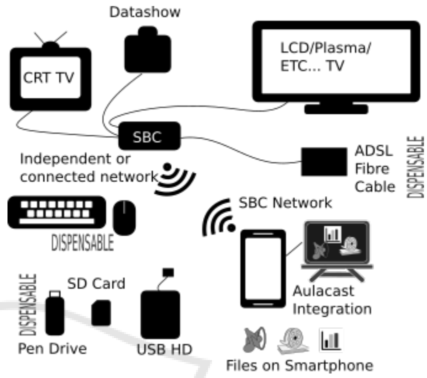

Figure 1: The ecosystem model of Aulacast.

This solution's implementation used a network structure that allows the connection between a smartphone and SBC regardless of the available infrastructure. The SBC itself can provide a hotspot presented with a name, Service Set Identifier (SSID) that can be identified by other devices that implement specifications 801.11. Having its own network infrastructure has shown to be an adequate tool to solve deficiencies identified (Moreira et al., 2013) regarding the access to computer network infrastructure. The device implemented on SBC is available being preconfigured to expose its connectivity information on video output device. By doing this, the access configuration between the smartphone and the device will be easier and it will also allow users who are capable of connecting to wireless internet connection to have previous knowledge to establish connection with SBC, according to what it was shown on image 1.

3.1 The Use

For implementing the prototype's solution, simplicity during the installation was suggested and also the application's use by means of resources that, as soon as energized, allow the device – constructed through Raspberry Pi Model 3 – to provide all the necessary functionality so that the teacher can present the content that was previously stored on their smartphone.

When activated, the SBC stars to inform services and functionalities through multicast messages, using a tool for discovering names (Cirani et al., 2014) and a set of techniques presented on Zero Configuration Networking. This strategy allows new devices to be added to the educational ecosystem or replaces without causing great impacts over the environment in which they are included.

The prototype was capable of reproducing videos on several resolution settings of the output device, such as HDMI interfaces and composite video, from files stored on the user's smartphone, allowing interactions like pause, advance, return, stop, by means of the application. Presentations in PDF format and images were also successfully performed through the interaction with the representation of a remote control that the application has. Web browsing with touch pad simulation on smartphones provided a suitable interface for the interaction with SBC.

The capacity to insert new peripherals by means of USB interfaces or by using GPIO pin offers an environment that contains a greater interaction between user and hardware, allowing a usability expansion without losing the mobility characteristics offered by the device's size. SBC allow equipment such as televisions, screens and audio devices to have a kind of revival through input and output interfaces which allow them to be integrated to non-existent technological resources when they were acquired.

Another aspect that offers a great flexibility to SBC applied to education is the use of an open source code and relatively popular operating system as Linux. There is a great amount of software available to perform several tasks on Linux, such as XO laptop, which used this operating system in its implementation (Kraemer et al., 2009).

The use of an open hardware decreases the financial cost related to depreciation, since it is created in a modular way, in which some parts of the equipment can be replaced, allowing a constant adequacy to new tools. For example, new processors or boards can be exchanged maintaining their video output interfaces. This proposal presents a structure that represents not only a cost reduction but also an appropriation of technology approach, specially those that are created for teaching and learning purpose.

The interface maintained on smartphones offers some facilities to make the interaction with the device easier and faster, such as the button and menu display that corresponding to actions that are activated on the device. Actions like return, pause in video or image files, graphic interfaces closure, among other controls can be executed directly through the smartphone screen, no browsing need, using only touchscreen simulator. This strategy has allowed the application to present a remote control behavior and mouse simulation simultaneously.

It was also implemented a board simulator model where the teacher is capable to type texts on their smartphone and send it to the screen that is showing the multimedia content. All application controls on SBC have been developed using scripts in Python language, re-evaluated with smartphone interaction, by socket, or with functionality callback in the operating system.

One of the aspects that deserves a highlight is the success obtained during the integration between the device and old televisions apparatus, called TV Pendrive, which are available in almost all the classrooms on public schools in Paraná, Brazil (Camargo et al., 2016), and it is rarely used due to its accurate technological delay. Using SBC's composite video output, it was possible to adapt this old resource into a tool with similar – or even better – capacity than smart TVs as regards the media support and capacity of interaction. Despite the resolution limitation in this device, it is possible to execute videos, images and presentations in a satisfying way using Aulacast.

The application used on the smartphone demands a greater interaction with the user, since it is through the user that the tasks are performed, either the activities related to management or related to the content and interaction with the SBC. It was shown, during the presentation, how to perform each one of the functionalities available in the application and also the connection provided by the SBC. It is important to highlight that the application developed did not pass through a use validation process because the purpose of this study is related to the capacity of performing tasks so that the validation of a proposal can be done, in which the use possibilities from this hardware can be considered.

3.2 Comparison with Other Tools

The Aulacast architecture has proved to be useful in several aspects in educational use when compared to other solutions capable of performing the tasks performed by Aulacast. The 1 table presents a comparison between the Aulacast solution, laptops, and two popular multimedia presentation devices Chromecast and EZCast.

Most programs written for Linux can be compiled for ARM processors, allowing SBCs to be used in a way that is similar to personal computers. The main difference between SBCs and laptops as a tool to support the teaching and learning process is related to the processing and memory capacity that is usu-

Table 1: Comparision among devices.

Resource	Aulacast	Laptop	Chromecast	EZcast
Video Interfaces	HDMI, Video Composite, GPIO (as LVDS)	HDMI and LVDS	HDMI	HDMI
Sensor Integration	USB, GPIO	USB and serial port	None	None
Application Support	Documents Files, Vídeo, Sound, etc	Documents Files	Images, Audio, Vídeo, Sound, etc	Images, Audio, Vídeo
OS Choices	Linux basead	Windows, Linux, Unix like	No	No
Provider independent	Yes	Yes	No	No
Network independent	Yes	Yes	No	No
Data persistent	USB, SD, Network	HD, USB, SD, Network	256Mb flash storage	256Mb flash storage
Ease transport	fit on pocket	fit on bagpack	fit on pocket	fit on pocket
Average Weight	45 g	More than 500 g	59 g	68 g

ally higher in devices based on traditional computer architectures. However, this study used as Raspberry Pi as prototype but there are SBC projects with performance close to those of laptops that can be used instead of Raspberry.

Unlike the multimedia devices used in the comparison, Aulacast allows the development of a collaborative ecosystem for the construction of solutions. This architecture model favors the development of products suited to educational needs independent of suppliers. Unlike the other products analyzed, Aulacast was conceived as an educational tool focused on the best use of educational objects in the classroom.

It is possible to adapt an operating system to promote facilities in the use of computers as an educational tool, but the smartphones popularization shows a better acceptance of this type of computers by teachers and students. Aulacast offers an integrative tool in which you can use the skills in the use of new mobile technologies interacting with the facilities of laptops using a tool of low energy consumption and of reduced size and weight.

4 SBC POSSIBILITIES IN AN EDUCATIONAL ENVIRONMENT

Data given by Brazilian basic education census, in 2016, discuss the access to communication technology and computing in Brazilian schools (INEP/MEC, 2017). Although the number of schools without internet access is reduced, there is no information related to the wireless network infrastructure availability. Due to the large population in Brazil and to the great quantity of learning institutions, the low percentage of people without access to technology, although it is low, it still represents a great number.

An educational ecosystem that uses SBC has not a great dependence on great device producers. It also offers equipment with longer life, since they can be designed in a modular way, offering the replacement of some parts instead of having to replace the whole equipment. This external devices' capacity of use allow the existence of a suitable tool for both the consumption and the content production, giving mobility and flexibility to the equipment's use. School management activities can also be answered using this kind of computers, since they are capable of executing those systems that are developed to personal computers, besides being capable of supporting integration to sensors that allow the automation of several processes related to management activities, such as access control, environmental aspects control, integration to printers, among others.

In order to make SBC based technologies use hypothesis authentic, the construction of a foundation capable of providing a tool to assist the teacher in the content delivery was proposed, reducing new equipment acquisition cost by reusing apparatus such as monitors and old or new televisions. The prototype was built with a web base, but it did not depend on internet connection or any available local web, something common in low development (Moreira et al., 2013) index regions. It also allows the use of files persistence in Android devices and of SBC as content exhibitor.

In the school environment, specially in classrooms, the teacher has a key role as a promoter of technologies that encourage innovative solutions (Venancio et al., 2013). Accordingly, the resistance towards innovations can be teared down if the teacher presents solutions obtained through certain tool with adequate functionalities.

This device offers an environment which allows simplification in additional content delivery, supplementary to the traditional instruments used by teachers, according to the pronouncements of cognitive learning theories. However, it is the teacher's duty to select and organize the content so there is not an unproductive cognitive load. In an educational ecosystem model, the integration between the device and the educational web portals, which offer specialists content, grants reduced risks of information overload.

5 CONCLUSION AND FUTURE RESEARCH

Single Board Computers (SBC) provides a model with devices that support the teaching process. It enables to replace general purpose computers adequacy to a process in which the devices are adapted to their use as an educational tool. These devices are proposed uphold the majority of the tasks accomplished by tablets and personal computers and may be easily adjusted to suit distinct age ranges specific needs.

The implementation and use of a prototype allowed to identify a great potential of use of technology based on the interaction between the SBC and an Android smartphone. It was possible to identify the importance of an ecosystem with access to the content, but with no dependence on the internet connection. This is especially important in classrooms in countries with low development rates. In the particular case of schools in the state of Paraná, where there is a reuse of equipment such as flash drive compatible televisions purchased in 2008, the use of SBC represents a greater longevity for the equipment, promoting a smarter use of public resources.

During the development of the prototype, some weaknesses were identified. One of them was the necessity of security mechanisms, which should be implemented in the device. Because it was not predicted in the beginning of this study, these mechanisms were not considered until this moment. Also, the video uploading from the smartphone to the SBC happened via http server. Although it was not a problem, a UTP socket would probably look nicer.

This work indicates the availability of ICT's implementation on the scholar environment, as an integrated, low cost, innovative model, which would increase the use of new technologies as supporting tools for teaching and learning. As shown by the conception of equipment adequacy to the users needs, specially the users who play important roles in educational settings, it is possible to obtain available technology at low cost. These conceptions also present opportunities to insert an interactive use of computers, not being necessary for the teachers to be in a specific place, breaking up with the traditional teaching practice, which only occurs in the formal school space.

This work provides concepts and information to propose the use of SBC as a meaningful tool in the construction of an educational ecosystem. In order to continue this process, new research concerning an integrated informational environment should be started, allowing bigger accessibility to content. A new step in the implementation of data transfer to students' smartphones is recommended.

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