

# Strengthening Technical Skills of School Children using Single Board Computers

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## ABSTRACT

Interest of school students in science subjects, nowadays, is reducing leading to their having poor technical skills, presumably due to lack of motivation, training, insufficient infrastructure in schools, resistance to adopting new technologies and high cost of training etc. So a study has been conducted to find ways to improve technical skills as well as arouse interest in science and technical subjects in school students. Survey conducted indicated that the interest in science subjects can be aroused by giving them hands-on experience with project based teaching. In this connection it is seen that pocket-sized, single board computers which have flooded the market in the last one decade could be very effectively used at the school level for giving hands-on experience to students. Project based teaching always attracts students, arouse interest in them to learn basic science subjects thus attaining technical skills which are required for making them practical hands. So in this paper, capabilities of various single board computers have been studied and suitable projects, are suggested which school children can undertake easily to promote creativity, inculcate technological skills and arouse interest in science and technical subjects in them.

## 1. Introduction

The children, nowadays, are found to be lacking in technical skills, presumably because of its high cost, insufficient infrastructure in schools, various barriers for adopting new technologies and students' perception of science as a tough subject. It is a cause of concern for the nation and must be addressed to. As an example, For the last five years in Punjab, the number of students opting for science subjects has been reducing considerably. In the current year 2018-19, in Class 11 out of 1,56,979 students took admission in government schools under Punjab State Education Board, only 14,546 students (just 9%) opted for science both in medical and non-medical streams. One of the reasons attributed to it is the perception of students that science is a difficult subject. Reduction in science students will affect in technical skills in them, affecting their employability and technical innovations in the country.

So a study has been implemented interest in science and technical subjects in students and improve technical skills as well. Survey conducted indicated that use of low cost single board computers would be very effective in achieving this aim for school children. A Single Board Computer in the present era is a pocket-sized computer on which school children can easily make a variety of projects by adding simple hardware to it. It can be connected to the internet and programmed for carrying out functions like controlling a camera, television, speaker and playing games etc. It can also bring more quality of life in the classroom by using the ability of SBCs to support plug in devices, to start streaming education material, or to pull power point material from the cloud thus helping students understand the technology for the use by the society. An SBC is an extremely powerful, portable, and cost effective tool. Commonly available SBCs, currently used by the students are Raspberry pi, Banana pi, Arduino etc. Capabilities of these SBCs have been studied and suitable SBC selected for use by

school students. So in this paper, capabilities of various single board computers available and used by the students have been studied and suitable projects based on these computers, which school children can easily undertake, are suggested to engage their interest towards science and promote creativity, besides inculcating technical skills in them.

## 2. Objective

Objective of this research paper is to explore capabilities of various types of single board computers used by the students and suggest interesting projects which could be undertaken by the school students so as to have interest in science subjects and inculcate technical skills in them.

## 3. Survey of Literature

Technology is changing and developing at fast pace, migrating from simple mobile phones and computers to smart phones, tablets, introducing miniature devices with tremendous computing power. Latest communication techniques have connected the whole world turning it a global village. Thus for carrying out the current study, literature survey of various technologies and the hardware devices present in market was done. Literature surveyed include the following:-

- News items giving details of students taking science subjects at school level
- Single Board Computers offered by various companies.
- Capabilities of various models of SBCs.
- Study of electronic devices in the common houses like televisions, music systems, speakers, lights, fans, air conditioners etc. for suggesting projects to the students using items available in the houses.
- Literature on home automation.
- Books on electronic designs.

Besides above, survey was conducted in various schools to gather opinion of students and teachers to understand the skill gap in students and reasons for the same. Also views were ascertained to understand the techniques to be used for inspiring children to take interest in science subjects.

#### 4. Introduction to Single Board Computer

A Single Board Computer in the present era is a pocket-sized, low-cost board with a microcontroller and other components fitted on it which was developed to help for understanding, learning and study of computing in schools and colleges. Initially these were made as model /development systems, for purpose such as education, computing, computer microcontroller etc. These are open source programmable boards, similar to motherboards of computers, with suitable software which could be used to develop variety of projects. Following components are generally mounted on these:-

- Microcontroller
- General Purpose input/output pins for connecting variety of hardware devices
- Flash storage
- AV ports/HDMI
- Voltage regulator
- USB ports
- LAN ports

Now adays these devices are generally used across the world for developing IoT (Internet of Things) projects.

An SBC is also a very simple system to learn coding. Not only amongst children but these are also in demand with adults who are desiring to be good in coding and perusing for their existing projects. SBCs are the latest addition in the most promising and increasing market for the microcomputers. SBCs may be used as tools for learning programming, supporting knowledge construction, designing projects using common house hold equipment , helping children learn to code and improve technical skills. To make the school students skill oriented, it is desired to promote science and technical subjects among them and asking them to do projects using single-board computers which create their interest towards creativity. The main aim of this paper is to engage students by increasing their interest about single board computers, and programming environment.

##### 4.1. Features of Single Board Computer

Features of each SBC are different from one another. Some of these have the following or any of the following features:-

- Use of microcontroller ATmega328 or ARM11 etc. which functions on RISC.
- Input voltage between 7-12 Volt, and conserved power levels.
- Powerful and performing with forced cooling low profile.
- On-board Flash Disk..
- Provision for wireless LAN, Ethernet etc.
- LVDS connector used for direct TFT interfacing.
- USB ports for video and HDMI

#### 4.2. Commonly Available SBCs

A large number of companies have come up with the SBCs, however, the common type of SBCs present in the market and their main characteristics are described in succeeding paragraphs.

1. **Arduino Series:** A project named Arduino was started in Italy in 2003 to make a simple and cheap board using microcontroller to be used by non-engineers for making simple projects. Initially, it used 8-bit microcontroller ATmega 168 to make their own projects, but later on it started using ATmega328, ATmega1280, ATmega 2560 etc. to build complex and smart projects. Arduino provides easy connectivity hardware and software. Currently with the improvements there are different types of Arduino boards present in the market such as Arduino Esplora, Arduino Micro, Arduino Genuino 101, Arduino Genuino MKR1000 etc. An The Arduino Uno is the widely used board which having 14 digital input/output pins, six analog inputs a USB connection, , a power jack, an in circuit serial programming header, and a reset button. It support the microcontroller; simply connect it to a computer. Popularity of this board can be tracked from the fact that till 2017, 10 million of Arduino boards had been sold. Figure 1 shows a typical Arduino board.

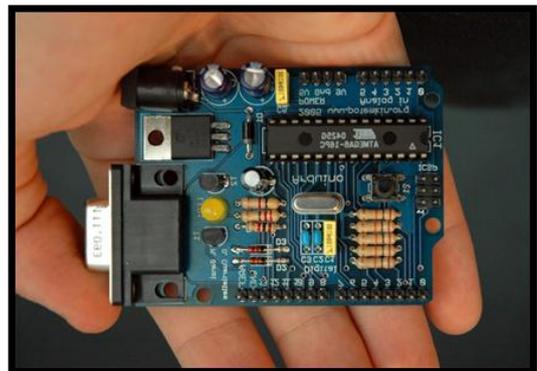


Figure 1: A Typical Arduino Board

2. **BeagleBoard series:** Along with Texas instruments, the BeagleBoard.org developed a low-power, open-source, single-board computer, with Digi-Key and Newark element14. One of its boards was launched on July 28, 2008, primarily for education purpose using the open source hardware and software with microcontroller ARM Cortex-A8 CPU. It also uses OMAP3530 system-on-a-chip configuration. It has Android ports, AV decoding system, an PowerVR etc. S-Video and HDMI connections are used for the video out and single SD/MMC card slot, a USB port. The board is powered with 2 W using USB connector or separate 5 V power supply along with in-built storage and memory (256 MB RAM). Various models of this board are as BeagleBone, BeagleBone Black, BeagleBoard-X15 etc. Figure 2 shows a typical Beagle Board.

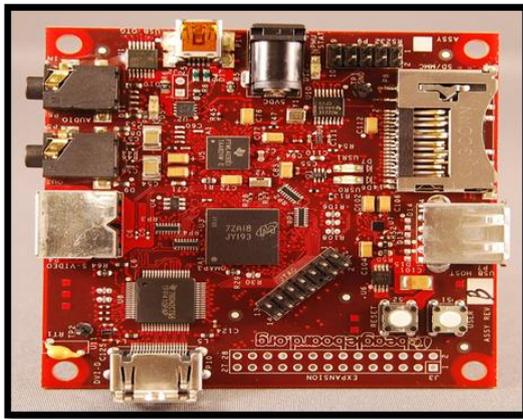


Figure2: A typical BeagleBoard

3. **Banana Pi Series:** With the increase in popularity of SBCs, a Chinese company Shenzhen SINOVOIP Co. Ltd decided to develop boards better than the existing Raspberry boards. It then developed a board and called it Banana Pi which is a cheaper board and as small as a credit card. It was released during April 2015 and copied the hardware features of Raspberry Pi. It uses ARM CORTEX A-7 microcontroller with dual core CPU. To connect additional hardware, it has 26 pins and uses memory of 1 GB RAM. It can run on various OS like Linux, Ubuntu, Android etc. It is a complete system on computer and is called Allwinner SoC. Common models present in the market are Banana Pi M1, Banana Pi M1+, Banana Pi M2, Banana Pi M2 Magic, Banana Pi M3, Banana Pi M64, Banana Pi BPI-S64 core, Banana Pi BPI-R1, Banana Pi BPI-R2, Banana Pi BPI-W2 etc.

Figure 4 shows typical BANANA Pi board:

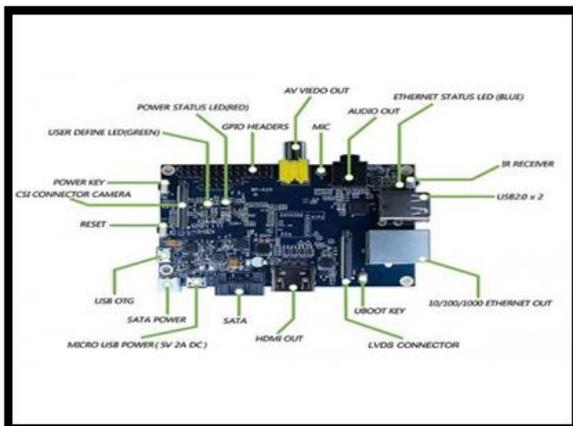


Figure4: BANANA PI Board

4. **Raspberry Pi series:** It is another cheap, readily available and most popular single board computer which was developed in United Kingdom in 2009 by Raspberry Pi Foundation. Aim was to produce an affordable SoC(system on Chip), education-oriented which school children could buy (with cost in UK as less than \$ 35 or so) so as to promotion of basic computer science subjects in schools and in developing countries. It should also demonstrate improving the programming skills & hardware programming of school and college children providing

a good path for performing various Raspberry projects. It got tremendous acceptability with the society because of its compatibility and ease of interfacing with the other objects i.e. sensors, actuators etc. All models feature a system embedded on chip manufactured by Broadcom, with CPU and GPU which are ARM compatible. One version of Raspberry Pi was introduced in 2012 after which many versions have been introduced, latest one being Raspberry Pi3+ introduced on 27 June 2018. They plan to bring a better version Raspberry Pi4 during 2019.

According to the Foundation, over 5 million Raspberry Pi boards were sold by February 2015. This sale kept on increasing and became 19 million by March 2018. Its demand is still increasing day by day in the market. Various models are as Raspberry Pi Zero, Raspberry Pi Model A, Raspberry Pi Model B. Figure 3 show typical Raspberry Pi board:

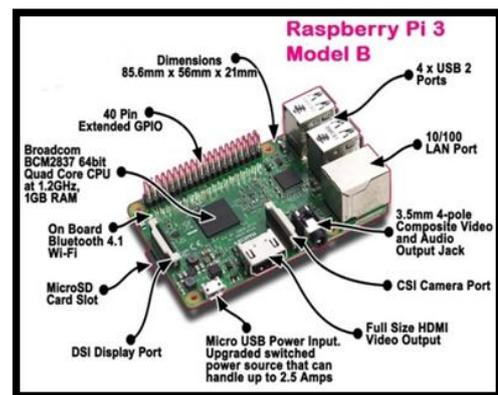


Figure 3: Raspberry Pi Board

4.1. Essential components used in Raspberry Pi hardware are:

- SD card having Linux Operating system.
- USB keyboard.
- TV or monitor having HDMI.
- Power supply.
- Video cable suited with the TV or monitor used.

4.2. Installation of Operating system(OS) on Raspberry Pi

Before using any single board computer for developing projects, its booting process must be completed. As it does not work on Windows OS, so the installation of Linux OS must be done first. Steps involved in installation of Linux OS and the booting process as under:-

- Downloading the NOOBS operating system.
- Burning the NOOBS image onto a micro SDcard.
- Inserting the card into the microSD card slot on the RaspberryPi board.
- Plugging all the peripherals such as keyboard, mouse and monitor cable onto the board and to the monitor.
- Plugging the USB power cable.
- The boot process will begin and a configuration window appears and setting the date and time.

- username: pi, password: raspberry are Default username and passwords. After the booting process the board can be used for any project.

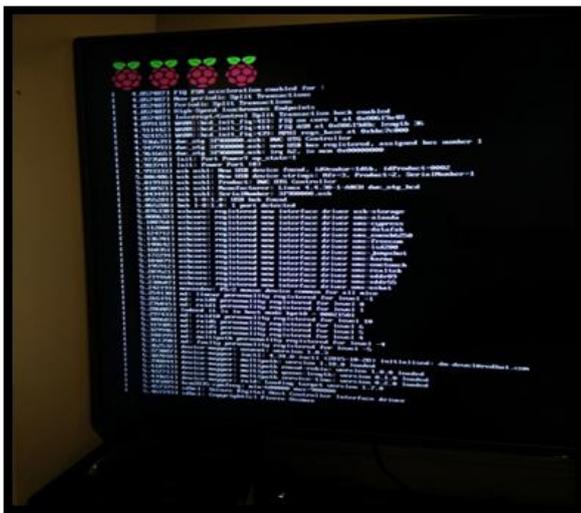


Figure shows the booting process

Wifi	Yes	No	Yes	No
Bluetooth	Yes	No	Yes	No
RTC	Optional	No	No	No
Released	29 Feb 2016	1 March 2014	July 28, 2008	2005

### 5. Selection of SBC for Projects for School Children

After studying the comparative features of all the single board computers, it has been suggested to use Raspberry Pi for the school projects which are recommended in this paper. Main reasons for preferring Raspberry are:

- It provides beginners a good platform to perform and implement various project ideas
- Its versatility and compatibility with, retro gaming, media centre, Linuxdistros OS etc.
- The boards have in-built wifi and Bluetooth connectivity along with the Ethernet port.
- It has faster processor i.e. (Quad core running at speed of 1.2GHZ) with 1GB of RAM.
- Peripheral hardware of own make can be used.
- No need to use desktop computer for downloading data as Raspberry Pi could be used easily for the same purpose with less power and remote control
- Provision to play high-definition video through HDMI port is available.
- To help beginners understand programming concepts, it provides drag and drop coding tool Scratch.
- Easy to interface hardware for teaching purpose.
- In case advance learners want to create and handle small servers, it is possible with Raspberry Pi.

### 6. Projects Suggested for School Children

In general, intelligence comprises of two fundamental parts – learning and adapting. After learning basic concepts through single board computers, one can move to its advanced applications such as Internet of Things, cloud computing and coding.

The projects suggested will help improve the following skills for the school children:

- Practical knowledge of the sensors, actuators and microcontrollers.
- Knowing the system as to how these components interact with each other.
- Practical implementation of the theoretical knowledge.
- Learning basic programming concepts
- Learning the interfacing between variety of hardware
- Designing projects helping Innovative Learning
- Inculcating adaptive and critical thinking and creativity
- Develop problem solving skills with innovative approach
- Learning from failures; remaining calm in stressful situations and then quickly moving ahead.

**Project No. 1: Learn to Program Games:** As children love playing games, but later they assume that these games

### 4.3. Comparison of various SBCs

All the four types of SBCs discussed above are used for arousing interest in science and technical subjects in school children. Tabulated below are the comparative features of typical SBCs in each of the above series.

Specificati on	Raspberr y Pi 3 Board	Banana Pi Board	Beagal Board	Arduino Uno Rev 3 Board
CPU	1.2 Ghz 64 Bit Quad Core ARMA8	1 GhzARM CorteX A7- Dual Core	1 GhzA RM Cort ex-A8	16 MhzATM EGA328P
GPU	Broardco mVideo Core Iv @ 300 Mhz	ARM MALI 400-MP2 GPU DUAL Core	PowerV R SGX5 30	-
RAM	1 GB DDR2	1 GB	512 MB DDR3	SRAM: (2 KB) EEPROM : (1 KB)
Onboard Storage	SD, MMC, SDIO card slot	SD/MMC card up to 64GB; &up to 4TB on a SATA disk	MicroSD Card Slot	32 KB ( 0.5 KB for bootloade r)
Ethernet(LA N,RJ45)	Yes	Yes	No	(Hardwar e Attached on Top) and Shields are required
USB	Yes	Yes	Yes	No
SATA Ports	No	Yes	No	No
HDMI Port	Yes	Yes	Yes	No

are too complicated to make for themselves. But, Raspberry Pi 3 will give them the opportunity for creating the games very easily and the skills, mentioned earlier, will automatically be imbibed. The children can have own mini-computer using Raspberry Pi which is portable and can be carried easily. Moreover, it helps them in understanding both the hardware and software. The setup of this board with visual programming languages, (Scratch), can open the door for children enabling them to create and play videogames. Figure 5 shows program games using Raspberry Pi.

Children can use their power of coding / logic of their game by simply setting up different elements together. This not only offers a lot of educational benefit but is fun for the children.



Figure 5: Sample program for video game

**Project No. 2: Build Weather Station:** A great project for children is making a weather station with your Raspberry Pi. By interfacing the sensors for measurement of temperature, pressure, wind speed, humidity, and wind direction etc. of your location and coding your device with the Linux operating system, the students can make a weather station in the school laboratory. Students can also access data from established weather stations, if they want, and collate data for the week.

Students will get interested in this project and they can compare the data collected by them with the information they see every day on their televisions. This will help students learn about the sensors, the hardware and electronic chips. Such projects engage the children; keep them connected with the environmental parameters besides promoting computational thinking. Due to the availability of the wifi module in Raspberry Pi 3, it becomes easier for the students to send the information to other users to access online. Fig 6 shows weather station using Pi.



Figure 6: Weather Station on Raspberry Pi

**Project No. 3: Make Web-based Home Automation System:** With great advancement of the technology, the home automation is in great demand. In modern Era single board computers are usually used by the children for making projects based on the home automation. Basically, home automation is defined as control over various appliances at home such as for home security. The whole system is made of two parts: server and client. Here, the server is the user interface that will allow us to turn a device on or off. The client side generally has Raspberry Pi (SBC) with circuit connected to its general input/output pins. The Raspberry Pi uses Python language which provides a path to post i.e. sharing the client and server. Hence the single board computers provide children a convenient way to design such projects which will help in understanding the various concepts of programming such as JSON, Cloud computing, SCRIPTS, PHP etc. It includes the following steps:

- Preparing the HTML and PHP Files.
- Setting up the Circuit to the general input and output pins of the Raspberry Pi Home Automation System.

Figure 7 shows a glimpse of home automation.

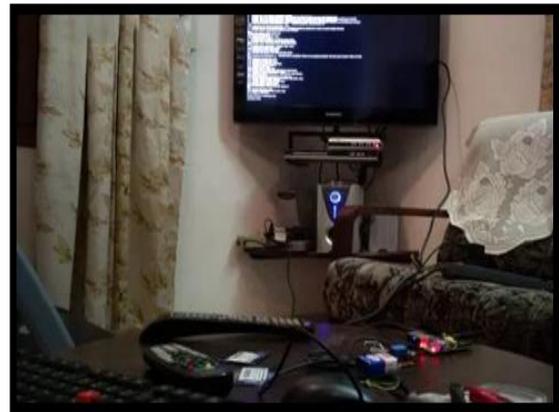


Figure 7: Home Automation

**Project No. 4: To Build A Multi-room Audio System:** Instead of having the expensive audio system available in the market, the children can make such a system themselves just by using Raspberry Pi. It has in-built Pi-Music Box software, a USB, A-D converter and receivers can stream (digital music service) tunes to the speakers around his home providing children a good platform to create a small sound system at home and many children have made it and retained their interest in further modification. Fig 8 shows the Audio system using Raspberry Pi.



Figure 8: Multi-room Audio system

**Project No. 5: Creation of own Cloud Storage:** With further advancement of technology Raspberry Pi introduces children the idea of cloud (online storage) which is used as key component for the modern computers, so it's important to consider whether data is on the local device or accessed online. Figure 9 shows cloud storage using Raspberry Pi. First the student have to add storage capacity to their Raspberry Pi device through SD or microSD card. When the devices have been formatted, it can be used to store files ( don't overwrite), and finally a student using the Linux operating system can remotely access the drives through SSH command available on the device and using network sharing protocol, the student can setup access and users for the cloud storage.

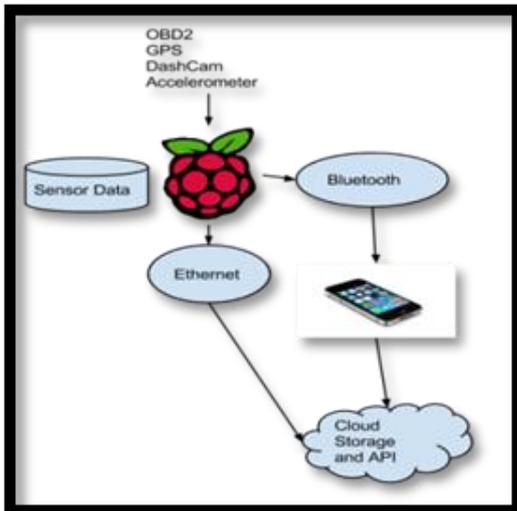


Figure 9: Creating Cloud Storage

**Project No. 6: Making of Arcade Game:** One of the Single board computer's greatest benefits is its versatility and ability which support many of different types of softwares. Arcade games are defined in various types of programs as many are compatible with the Raspberry Pi (SBCs). By just using USB and free imaging software on a separate computer, the children can easily download and install free arcade game softwares such as Retro Pie on their Raspberry Pi. Once installed and loaded, Retro Pie will allow kids to load arcade games which can be paired with controls to simulate a custom arcade. This idea promotes mini-construction project among the kids and also helps in developing the skills such as coding, practical implementation and innovative learning. Figure 10 shows the glimpse of Arcade Game



Figure 10: Arcade Game Using Raspberry Pi

**Project No. 7: Creation of Race Cars:** The most exciting Raspberry projects for younger generation is the Formula Pi which makes kids to have race between their Raspberry Pi against each other by showing their power of coding. As the name depicts, it creates the interest among the children with code designed by them to control their Raspberry Pi's movements make them to participate in various Pi races. These projects develop the coding skills among the children to the great extent which increase their interest towards the computational thinking. Figure 11 shows the glimpse of the raced cars

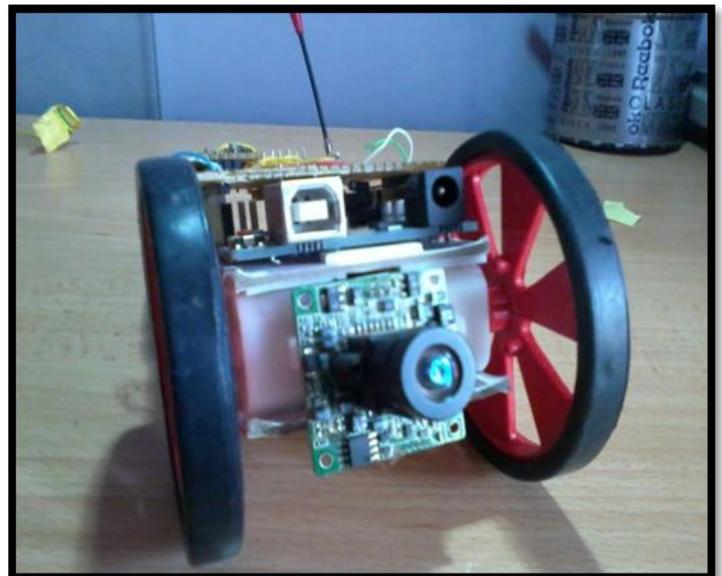
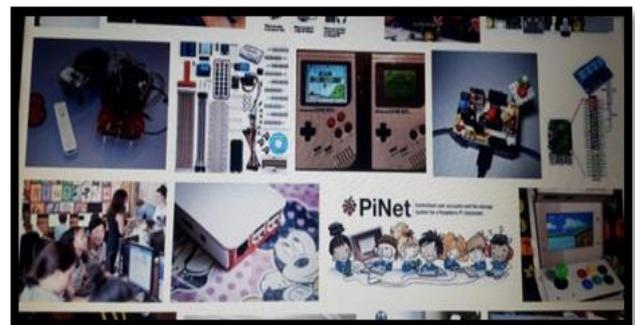


Figure 11: Race Cars Using Raspberry Pi



7. Conclusion

To generate the declining interest in the school children in the subjects of science and develop technical skills in them, it

is found that single board computers are very useful, portable devices and easy to use. In this paper, various types of popular single board computers have been compared and a suitable board named Raspberry Pi has been suggested. It provides good platform for students with technical, project-based environment for learning and experimentation. It is commonly used by the children who really need to learn electronics and computers as the scope in these fields is increasing day by

day. It also gets children interest towards science subjects such as computing, coding etc. Suitable interesting projects using Raspberry Pi have been suggested in this report which provide ambience which interests the school children. Once they work on these projects, they will get interested in science subjects besides getting practical skills which is the need of the hour.

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