Comparative study : Raspberry Pi Pico vs Zero

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Abstract: in this work, we made a comparison study with examples on two main low-cost Raspberry Pis. Finding a Raspberry Pi in stock is currently a challenge, but you want to make sure you pick a model that fits your needs. With that in mind, the Raspberry Pi Pico and Zero have a few things in common that could make you think it's the same thing. But they are not at all built for the same projects, which is why I'm writing this article. The main difference between the Raspberry Pi Pico and Zero is that the Pico is a controller while the Zero is a computer, like the other models in the Raspberry Pi family. The Pico is great to run a specific task in an electronic circuit, but it can't run a full operating system like the Zero can.

1. **RPI Pico.**

The launch of the Raspberry Pi Pico and the RP2040 processor it's based on injected new energy and interest into the world of microcontroller development boards. Until the Pico, Raspberry Pis were fully fledged single-board computers capable of running an operating system.

The diminutive Pico is designed to interface with and control physical, real-world projects. It's a modern take on an established class of devices – including the venerable Arduino – and it's at a price point of less than $5 (subject to change with availability).

The specifications of the Pico are impressive. It has a fast dual-core processor, 2 MB of onboard flash memory, 26 I/O pins (3 of which are analog inputs), 2 each of UART, SPI, and I2C controllers, 16 PMW channels, and an impressive 8 PIO (programmable input/output) "state machines". In other words, it supports a huge variety of peripheral sensors and devices.

Expert users can squeeze a lot of performance out of this device, but it's also ideally suited to beginners. Newbies can program their Pico in the easily accessible CircuitPython or MicroPython, while coding rockstars can still use C or C++.

2. PRI Zero

It doesn't mean that one is better than the other, you just need to have this difference (and a few other ones) in mind before making your choice. I explain everything you need to know in this article.

If you need help getting started on Raspberry Pi, I have an entire course to guide you through your first steps. I'll help you use the perfect hardware, plug everything in and install your first system. You'll also do your first project with me, just to make sure you are ready for the next level. Get all the information on this page if you are interested.

3. Raspberry Pi Pico vs Zero: Technical differences

Let's start by listing the main differences between the Raspberry Pi Pico and Zero. Even if, in pictures, they look very similar see figure 1, their features and purpose are very different.

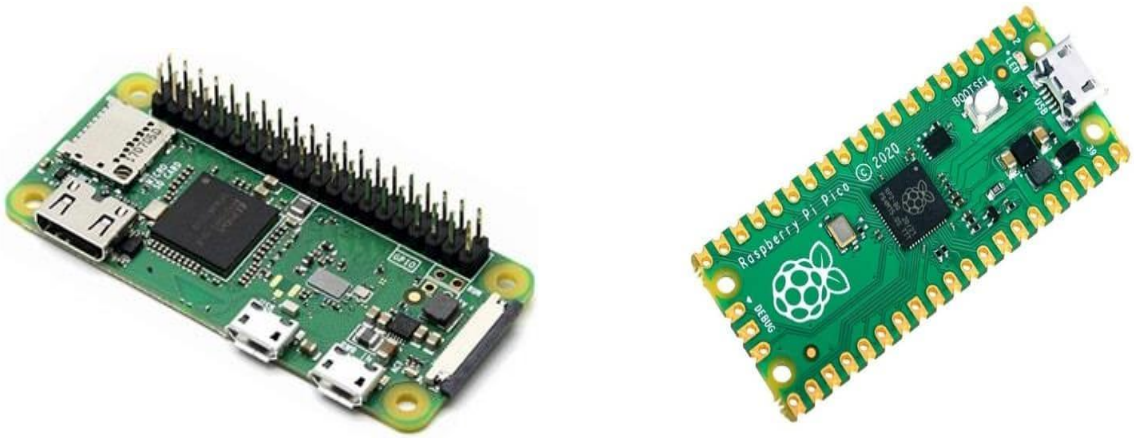

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Fig 1. Left Raspberry Pi Zero W , right Rasoppberry Pi Pico

A. Computer vs Controller

As explained in the introduction, the main difference to keep in mind is that the Raspberry Pi Zero is a single-board computer, while the Raspberry Pi Pico is a microcontroller.

A single-board computer can basically do everything as traditional computer does, with limitations because it's not as powerful, and Raspberry Pi generally uses a Linux system (and not Windows or macOS).

A microcontroller has generally one main task in an electronic circuit (get data from sensors, run a motor if a button is pressed, compute data sensors and activate a lEd ormotor or transmite results using RFcircuits etc.). That's why the Raspberry Pi Pico has little storage space available. It will only store a few lines of code on it. There is no SD card slot on it.

If we take a look at the main specifications, it's obvious they are not built for the same things as shown it table 1:

	Raspberry Pi Zero W	**Raspberry Pi Pico**
CPU	Minimum of 1GHz on the oldest version	RP2040, 2x 133 MHz
RAM	512 MB	264 KB
Storage	Up to 1 TB with an SD card	2 MB max
RF Com	Bluetooth and WIFI	None

If this difference is not clear enough for us, we might need to read the article in reference 2 entitled " What's the Difference Between a Raspberry Pi and a Computer?."

B. Size: different form factors

The Raspberry Pico and Zero are the smallest Raspberry Pi models available, and at first glance, we might think they are the same size, but it's not the case.

The Raspberry Pi Pico is 51 mm long and 21 mm wide, making it the smallest model currently (hence the name). There are input/output pins (GPIO) on both sides, and only one USB port to power it or transfer code from or to a computer.

The Raspberry Pi Zero is 65 mm long and 30 mm wide, so it's slightly bigger. All GPIO pins are on the same side (like on other Raspberry Pi models), and there are more connectors available (I'll tell you more about this later).

I guess the size of the device won't make a big difference in your decision, but I had to list it as one of the main differences between these models.

C.Features: GPIO pins

One thing we may have noticed in the previous pictures is the GPIO pins. Not only does the Raspberry Pi Pico have them on both sides of the main board, but there are also fewer pins than on the Raspberry Pi Zero (as the Pico is smaller).

All Raspberry models (including the Zero) come with 40 GPIO pins, except the Raspberry Pi Pico which has only 26 pins available. It should be enough for most projects, but it's something to keep in mind when deciding which model will be appropriate for our application.

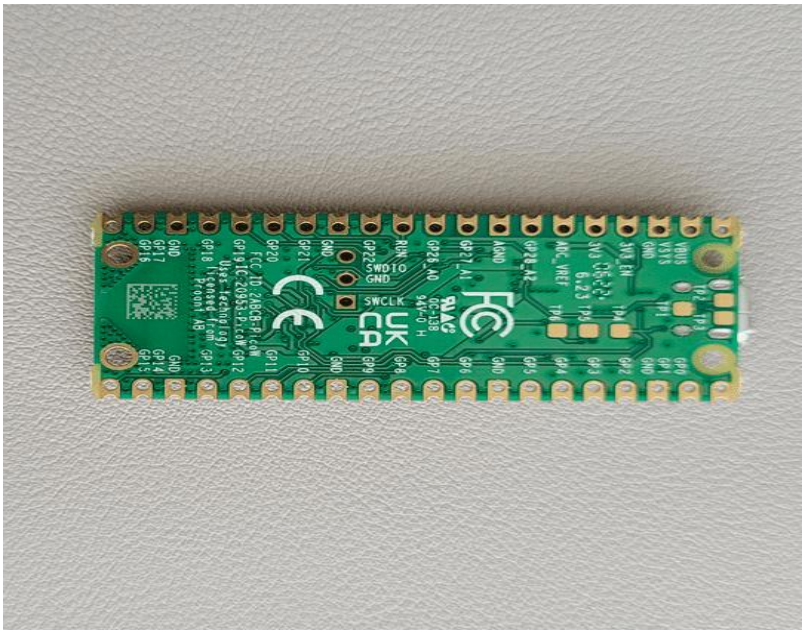

Fig 2.GPIO pins of Raspberry Pi PICO

We can find more technical details about the GPIO pins on the Raspberry Pi Pico, you can click on this link to find my dedicated article on this topic (including a GPIO pinout schema and code examples).

C. Connectivity differences

If we compare a photo of both models, there is something else you'll notice at first glance: they don't have the same connectors available at all:

The Raspberry Pi Pico has only one USB port (micro-USB) that can be used to power it or transfer data. On the other hand, the Raspberry Pi Zero comes with a mini HDMI port (display), 2 micro-USB ports (power + accessories), an SD card slot and a camera connector.

So, even if it's still pretty limited, the Raspberry Pi Zero W can be used as a standard computer (we can plug in a screen, an SD card and a keyboard and mouse for example), while the Pico can't be used like that.

We notice that there is no traditional USB port (USB-A) on these models and no Ethernet port, unlike bigger models like the Raspberry Pi 4. But both come with built-in Wi-Fi and Bluetooth on the latest versions.

D. Various models available

By the way, now that we are starting to get an idea of the main differences between the Raspberry Pi Zero W and Pico, I need to explain that both have a series of models. They both exist in several versions.

It's not that complicated, as they share the same nomenclature, but it's something to have in mind before buying one:

Concerning Raspberry Pi Zero:

- The **W** version has built-in wireless features.
- The **H** version has a pre-soldered GPIO header.
- The WH version has both.

If you still find a Raspberry Pi Zero W or Pico without these letters in the model name, it's generally that there is no Wi-Fi and no GPIO header.

A GPIO header looks like this (instead of the holes you saw in the previous pictures):

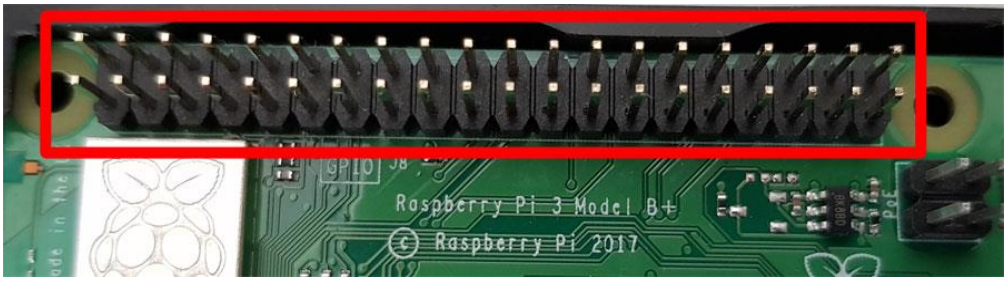

Fig. 3. GPIO pins of Raspberry Pi Zero

If we can afford it, I would recommend buying at least the W version, and maybe the WH if the height of the pins is not an issue (it's easier to use pluggable wires instead of soldering them on your circuit).

Also, we should know that the Raspberry Pi is available in two main versions, as it has been updated recently:

- **Raspberry Pi Zero W**: Released in 2017, mono-core CPU at 1Ghz (32-bit only).
- **Raspberry Pi Zero 2W**: Release in 2021, quad-core CPU at 1Ghz (64-bit support).

There were also earlier versions, available before 2017, but they lack some key features.

E. Pricing of the Pico and Zero

The Raspberry Pi Pico and Zero are the most affordable Raspberry Pi models. A Raspberry Pi Pico costs around $5 while a Raspberry Pi Zero is around $10.

The price can be slightly different based on the version we choose (original, W, H or WH) and also the Raspberry Pi Zero 2 is a bit more expensive ($15 instead of $10).

In most cases, the price won't be the main criterion, as both a really affordable if we can find them on official resellers.

F. Raspberry Pi Pico vs Zero: Different use cases

We have seen the main differences between the Raspberry Pi Pico and Zero, and if there is one thing to remember is that, they are not built for the same uses. We will now list a few concrete projects to make this even clearer.

G.Raspberry Pi Zero projects examples

The Raspberry Pi Zero is basically a low-end computer. Even if it's not as powerful as your main computer, it can basically do the same things.

We can run a full operating systemon it.

A Raspberry Pi Zero (and especially the Zero 2) can absolutely run a full operating system like Raspberry Pi OS, even with a desktop environment. It won't be great for desktop usage (a Raspberry Pi 4 or 400 is recommended in this case), but it can easily be used to browse the web, write code on it, or host small servers.

As soon as you need a specific app running on the Raspberry Pi, the Zero is your only option. You can't install traditional applications on a Pico, as there is no operating system.

we can use the GPIO pins in Python

Like all the other Raspberry Pi models, the Raspberry Pi Zero has 40 GPIO pins available and comes with Python and many useful libraries pre-installed (if you use Raspberry Pi OS).

It means that you can plug external accessories into these pins (LEDs, sensors, etc.) and interact with them via Python.

That's where the Pico and the Zero share the most common points. we can do almost the same thing with a Pico (if you don't need any app). For GPIO projects, where the Raspberry Pi has a pretty specific and limited task to accomplish, you can often use any of them.

Zero 2W: you can basically do any Raspberry Pi project

In short, the Raspberry Pi Zero can run any Raspberry Pi project you'll find online. As long as you keep in mind the hardware limitations, everything is possible with this model (especially if you get the more powerful Zero 2W).

Raspberry Pi Pico projects examples

On the other hand, the Raspberry Pi Pico will be limited to smaller electronic projects. It's a cheap device, that runs MicroPython and can be used to interact with sensors, motors or LEDs.

For example, if you build a temperature monitor, you'll only need a Raspberry Pi Pico and a temperature sensor. You'll then write a few lines of code to get the temperature on a GPIO pin, and send it to a main server that will store the database and probably display the data for the end user (or you can also have a tiny screen plugged into the Pico to show the data in real-time).

For some people, the Raspberry Pico might be easier to use, as there is no need to learn Linux to use it. You can plug it into your current computer to write the code, and that's it. You still need to know Python (or MicroPython), but it's a smaller challenge for beginners

Even in bigger circuits, you may save money by having several Raspberry Pi Pico connected to a master Raspberry Pi (Zero, or any other model) that will be the brain of your project. Instead of buying 10 Raspberry Pi 4, you can save a lot by having only one + 9 Raspberry Pi Pico.

By the way, if you get overwhelmed as soon as Python is required for a project, I recommend checking out my e-book "Master Python on Raspberry Pi". It will guide you step-by-step to learn the essential concepts (and only the essential concepts) required to achieve any project in the future. Raspberry Pi without Python is like a car without an engine, you miss all the fun parts.

4. Example of Applications

A. Pico Apps here is 3 applications using Raspberry Pi as examples.

Interfacing LCD Display

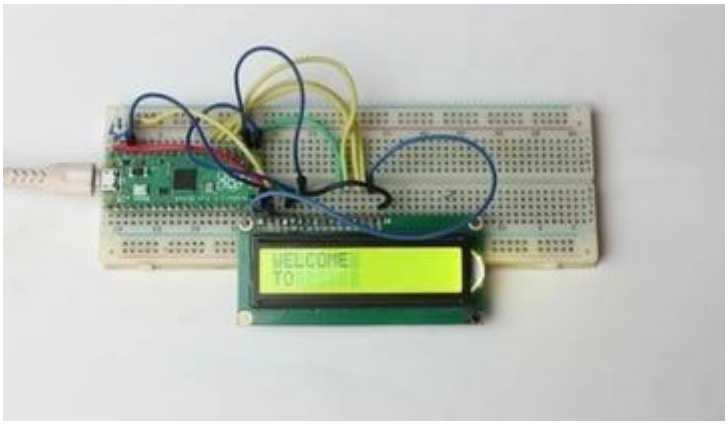

Fig 4.1 : LCD connected to Raspberry Pi Pico

In this practical upgrade, you'll use MicroPython programming to interface an LCD display with your Raspberry Pi Pico. It's a pretty useful addition to your microcontroller since you can use LCD displays for any number of projects.

While this isn't a Raspberry Pi Pico project per se, it's an LCD interfacing upgrade that can lead to even more projects. There are clear descriptions of the pins and circuit diagram with lots of color photos as demonstrations[7].

LoRaWAN (Long-Range WAN)

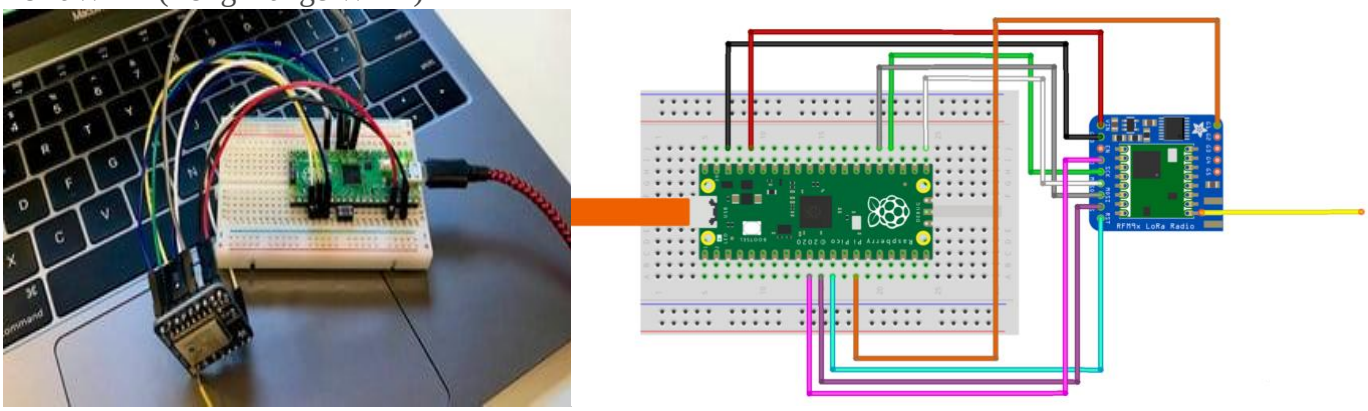

Fig 4.2 LoRaWan connected to Raspberry Pi Pico

LoRaWAN is a low-powered, low-bandwidth, and long-range protocol. Intended to connect battery-powered remote sensors back to the internet via a gateway, on a good day, with a reasonable antenna, you might well get 15km of range from an off-the-shelf LoRa radio. The downside is that the available bandwidth will be measured in bytes, not megabytes, or even kilobytes.

In order to keep the basic package low-powered and focused on interfacing with real-world sensors, the Pico doesn't include any native wireless capability. With that in mind, what better wireless technology to use than LoRa?[8]

According to the creator of this project, LoRa has "won the standards war for wide-area networking for the internet of things". It's made it possible to connect very low-power devices over previously impossible distances. This project opens the doors to an exciting new wave of LoRa applications that bring the IoT to rural and urban spaces. Welcome to the future!

SMARS Robot

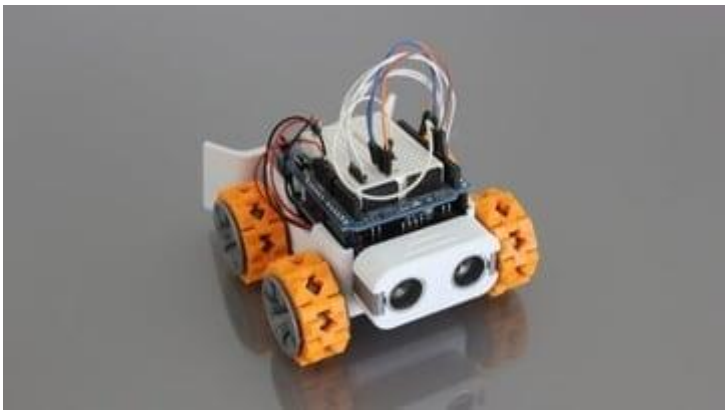

Fig 4.3 Project Robot based on Raspberry Pi Pico

Robotics is a big area for microcontrollers. The Pico's extensive I/O and processing capabilities make it ideal for this, and there are already many Pico-compatible add-ons, so the building is even easier.

The enormously popular modular SMARS robot series has embraced the Pico wholeheartedly, and this is a great example of how to build a robot from scratch.[9]

B. PRI Zero w Apps: There's a reason suppliers often limit the number of Raspberry Pi Zeros that any one person can purchase. Even in the price-plummeting world of mass-produced electronics, what else can you buy for $10 that offers so much? Demand for these little boards can easily outstrip production.

Here, we present 3 favorits projects that show exactly why this tiny computer running high-level software is so popular. Along the way, see how it can work in combination with microcontrollers and a host of other hardware to build brilliant projects.

Here is 3 applications using Raspberry Pi zero.

Projection Mapper
This is a project with lots of opportunities to learn new things. It combines projection mapping with touch-sensitive artwork to create an interactive installation.

The Pi Zero transmits touch data to software running on a computer connected to a projector. If you don't have access to a projector, then you could adapt this project to play sounds or perhaps control smart devices.

You'll need basic crafting skills to build the touch surface. Be ready to learn a little about the free graphics-development tool Processing and the video-mapping tool MadMapper.

In conjunction with a Pi Cap (~$30), you can create conductive surfaces using Bare Conductive's electric paint (~$10 a tube). We found some very well-reviewed projectors for under $100, assuming your budget can stretch that far. Of course, you can use a projector for home cinema when not projection mapping![10]

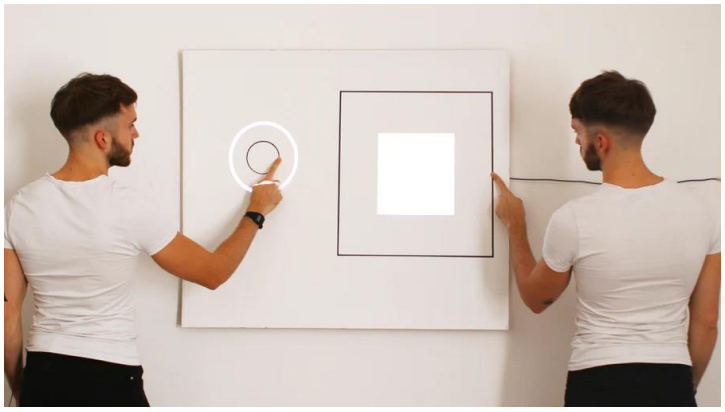

Fig 4.4: Projection Mapper with Raspberry Pi Zero W

Wi-Fi Repeater

Fig 4.5 : Wi-Fi Repeater project based RPI Zero

Extend the reach of your Wi-Fi with this low-budget project. Using a second Wi-Fi adapter gives the Pi Zero the capability to relay network traffic beyond the reach of your router. The creator explains how to set this up and even offers a web interface for configuring connections.

You'll find full instructions and links to helpful videos on the Hackaday project page. Most of the work involves setting up network services and configuring interfaces. You'll need a Raspberry Pi Zero W board, a USB Wi-Fi adapter, and probably a USB to OTG adapter.[11]

FPV Robot

Fig 4.6 FPV Robot Controlled by RPI Zero W

You can control the ZeroBot Pro with a phone or computer (Source: Max.K via Hackaday)

The ZeroBot is a remote-controlled robot that transmits a live video stream from a forward-facing camera. The original model from 2017 was very popular, encouraging the designer to develop an updated model, the ZeroBot Pro.

A web-based interface makes it easy to view the low-latency video stream on a wide range of devices. Using a joystick and multi-touch devices makes the analog control of this robot simple and convenient.

This is a well-documented project that's been refined and improved in its second iteration. The robot should be fun to build, without too many surprises. The author provides CAD (STL) files to allow the whole design to be 3D printed. We think that it already looks great, but this means you're free to tinker as much as you want.

The required components are widely available, so keeping within a budget of $50 should be achievable with some savvy shopping. We assume that you already have a Raspberry Pi Zero W awaiting its destiny.

Conclusion Raspberry Pi Pico or Zero: Which one to choose?

To summarize, the Raspberry Pi Zero can be used for any Raspberry Pi project**.** It can run a full operating system (Linux), host servers, run scripts and be used in electronic circuits. The Raspberry Pi Pico only runs MicroPython code and is limited to electronic projects.

If you want to experience the full range of projects that Raspberry Pi fans like, a Raspberry Pi Zero 2W is probably your best option. For around $15, you won't be limited and can try everything (even if some projects will be a bit slow, it should work).

If your only goal is to put a Raspberry Pi in cheap and easy-to-manage electronic circuits, the Raspberry Pi Pico is a great option. You don't need to learn Linux to use it, and it will be up and running faster than the other models.

References

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