# LabPi Web: A Low-Cost and Cloud-Based Measuring System

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## Challenges & Oppertunities

As digitization continues, mobile devices are becoming increasingly relevant for STEM education. However, the use of digital measurement systems remains a challenge. The acquisition of digital measuring devices is often associated with high costs for schools, but also the availability of measuring devices such as pH meters or conductometers in sufficient numbers is not possible at all learning locations and can be associated with various challenges. In order to provide learners with access to standard measurement techniques and the use of suitable measuring apparatus, a whole range of low-cost measuring devices have been developed [1-5]. Ultimately, however, simple procedures must be repeated with learners and evaluation is still mostly done manually, resulting in less active learning time. Likewise, connection to the digital infrastructure at the learning site is not always possible.

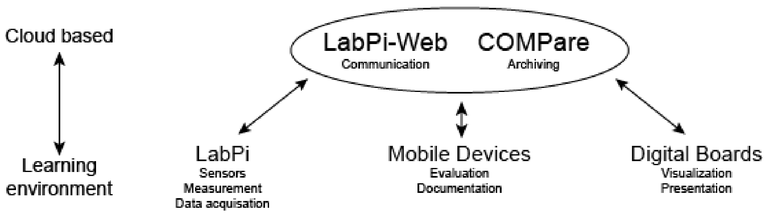


**Fig 1:** Cloud based communication and opportunities with LabPi on different devices.

In addition to the above-mentioned features, a cloud-based measurement system opens up a wide range of new possibilities and perspectives for STEM teaching. Existing mobile devices serve as an important basis, from which the operation can be carried out platform-independently via any web browser. In this way, location constraints can be removed and expanded experimental possibilities and projects open up [6]. Cloud-based solutions also offer advantages in the supervision and evaluation of experimental phases (Fig. 1).

## The Low-Cost Measuring System LabPi

To address the challenges described, the LabPi measurement platform was developed for the single-board computer Raspberry Pi [1]. This enables the use of various low-cost sensors and additionally extends the measurement value acquisition with graphical applications and operation via a touch display. With the help of a self-developed adapter board, the connection of the sensors is additionally reduced to a simple plug&play solution (Fig. 2). The LabPi software of the same name has a user interface tailored to the education and is able to record measurements at the touch of a button and display them in tabular and graphical form. The measurement data can then be exported to common formats or to the COMPare online platform (Fig. 3) [6]. COMPare enables measurement series to be merged and measurement results to be saved on a cloud, which means that the measurements can be accessed regardless of device and location. By combining several measurement series, initial comparisons can be made. For practical STEM lessons, this also provides the possibility of collaborative learning, whereby the individual partial results can be visualized on a common graph after group phases and compared with the learning group using digital boards.


**Fig. 2:** Adapter Board (left), temperature sensor (middle) and the assembled LabPi-Station on a touch display (right).

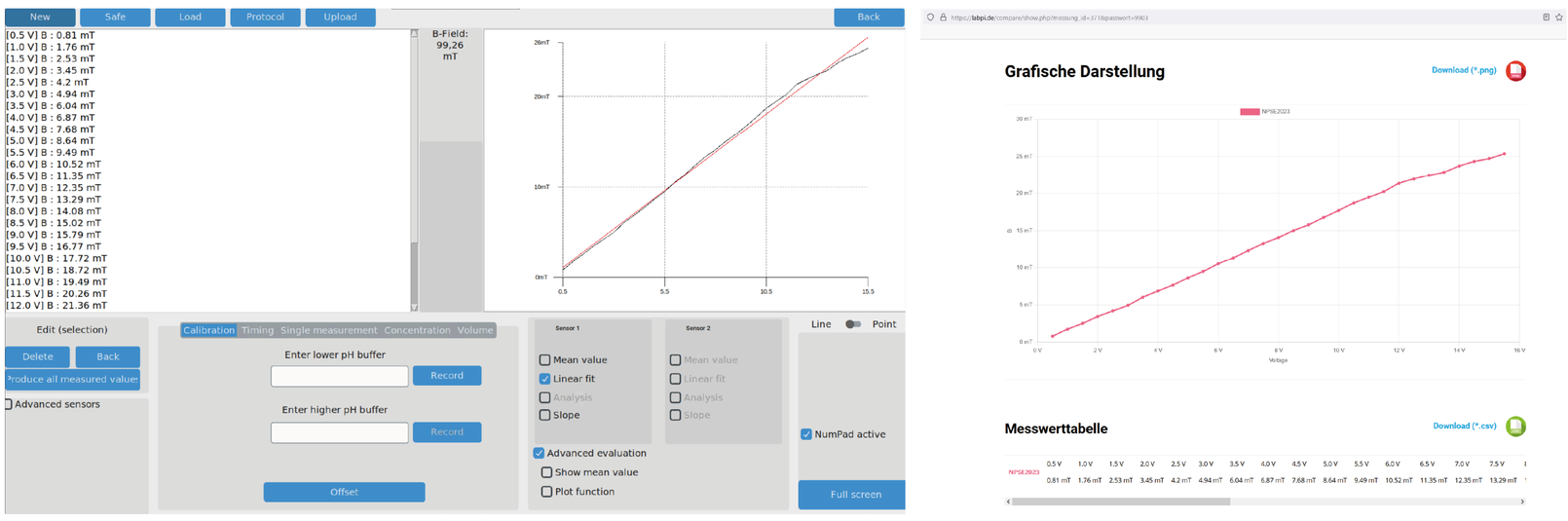


**Fig. 3:** LabPi's Graphical User Interface (left) and the online platform COMPare (right).

## LabPi Web

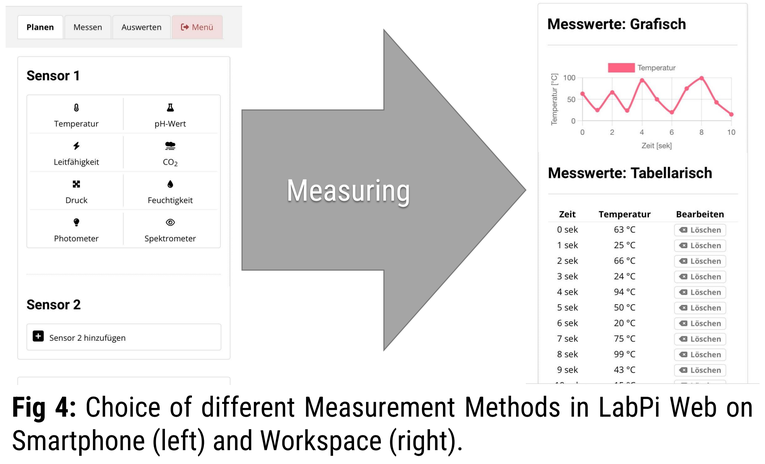


**Fig 4:** Choice of different Measurement Methods in LabPi Web on Smartphone (left) and Workspace (right).

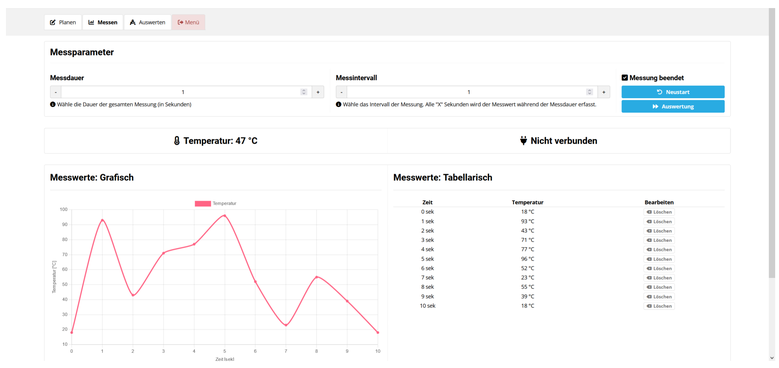


**Fig 5:** Workspace and visualization after measurement in LabPi Web.

The LabPi Web interface differs only slightly from one another depending on the type of end device in order to make recurring processes as simple as possible, just as on the conventional surface of the measuring station. The web interface is designed in such a way that it accompanies the user step by step from the selection of the sensor to the measurement. After selecting the sensors and setting the measurement parameters, LabPi-Web offers the possibility to follow the course of the measurement.

As with the base station, this is done in tabular form and by means of a graphic display (Fig. 4 & 5). The measured values can be transferred to COMPare in real time during the acquisition or later. After successful measurements LabPi Web offers the possibility to evaluate measurement data, e.g. by displaying compensation lines, intersections, slopes or concentrations with little effort and according to the requirements of the learning group.

For logging and evaluation, graphics and tables can be downloaded to the desired end device in order to be processed in other programs. In addition, LabPi-Web offers an optional, interactive protocol template to prepare and archive evaluations in a guided manner, in which the learners can describe their own observations of the experimental procedure and supplement them with their own visual material.

## Outlook

Both the LabPi software and LabPi Web are still under development. Especially for a stable and loss-free transmission of the measurement data, adjustments will be made before a final release, in order to also enable the previously widespread systems to benefit from the cloud-based interface. On the hardware level, further adjustments will be made to enable measurements to be even more precise before piloting with learning groups can take place.

## References

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