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LabPi Web – A low-cost and cloud-based Measuring System

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Abstract

The digitization of STEM teaching presents teachers with several challenges and decisions. Starting with the choice of basic digital equipment suitable for their lessons through digital whiteboards, tablets or laptops, the acquisition costs of various digital measuring devices, such as pH meters, photometers or conductometers further complicate the use of digital measurement technology in STEM lessons. In order to meet the requirements of contemporary and digital teaching, it is equally desirable for teachers to ensure that the digital infrastructure and measurement technology are as compatible as possible in order to teach digital skills in a targeted manner. At the same time, the measuring devices should ideally remain affordable enough to ensure that student-centered instruction remains possible.
The LabPi measurement station, which is based on the Raspberry Pi minicomputer, offers a cost-effective solution for digital data acquisition and combines various measurement instruments into a uniform low-cost measurement station with the aid of a large number of miniature sensors [1]. It is didactically tailored to teaching and, with the help of the associated cloud platform COMPare, provides the space for collaborative teaching-learning opportunities.
In this article, we will show how the new LabPi-Web interface extends the existing measurement system with novel and cloud-based functions. It will be shown in which areas of teaching the use of a cloud-based measurement system can offer advantages and create new learning opportunities.

Keywords: *Measurement Systems, LabPi, Digitalization, STEM Education 4.0*

1 Measured data acquisition in STEM lessons

The ongoing digitalization of everyday life ensures that smartphones, tablets and laptops are becoming increasingly relevant for contemporary STEM teaching. However, the use of digital measurement systems remains a challenge. Acquiring digital measuring devices such as spectrometers, gas chromatographs or polarimeters is often associated with high costs for schools, but even the availability of smaller measuring devices such as pH-meters or conductometers in sufficient quantities is not possible at all learning sites. Once purchased, they are therefore often only available to the teachers, which means that the devices are mainly used in demonstration experiments.
In order to provide students with modern access to current measurement techniques and the use of suitable measuring equipment, a whole range of low-cost measuring devices have been developed. These range from melodic conductivity testers to homemade LED photometers [2,3]. Digital, arduino-based solutions can also be found in the low-cost range [4,5]. In the end, however, the evaluation is still often done manually and a connection to the digital infrastructure at the learning site is still missing.
In this article, the further development of the digital measuring station LabPi will be presented. It will be shown how LabPi can be integrated into the existing digital infrastructure at the learning site and what opportunities thus arise through a cloud-based measurement platform for STEM teaching.

2 LabPi – A low-cost Measurement System

To address the challenges described above, the LabPi measurement platform was developed for the single-board computer Raspberry Pi [1]. This computer allows the use of different sensors, which are also available for the Arduino in a wide selection and extends the measurement value acquisition additionally with a Linux OS, whereby also larger, graphical applications and an operation over a touch display are made possible. With the help of a self-developed adapter board, the connection of the sensors is additionally reduced to a simple plug&play solution (Fig. 1).

Fig. 1: Adapter Board (left), temperature sensor (middle) and the assembled LabPi-Station on a touch display (right).

The LabPi software of the same name was developed to operate the sensors. This enables the acquisition of measured variables without having to perform further programming on the device. It has a user interface tailored to teaching, which was developed specifically for the Raspberry Pi, and is able to record processes (such as time measurements) at the touch of a button or automatically, while being displayed in tabular and graphical form. The curve progressions and measurement data can then be compared directly in the software, exported to a USB stick for calculation programs or to the online platform COMPare (Fig. 2) [6].

Fig. 2: LabPi's Graphical User Interface (left) and the online platform COMPare (right).

Uploading measurement series to the COMPare online platform enables measurement series to be combined and, at the same time, measurement results to be saved on a cloud, which means that previously recorded measurements can be retrieved 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.

3 Opportunities in Cloud Based Measurement Systems

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 devices such as smartphones, tablets and laptops serve as an important basis, which can be operated platform-independently via any web browser. Since a suitable measuring station remains as the basis for controlling the sensors and recording measured variables, the expensive display for operating the measuring station is no longer required. On the one hand, this makes the use of digital measuring devices more affordable for the place of learning, and on the other hand, it eliminates the location-bound nature of fixed power sources - thus, operating the measuring station via a power bank opens up expanded experimental possibilities for novel environmental and citizen science projects [6].

A cloud-based solution offers advantages not only for experiments, but especially for the supervision and evaluation of experimental phases (Fig. 3).

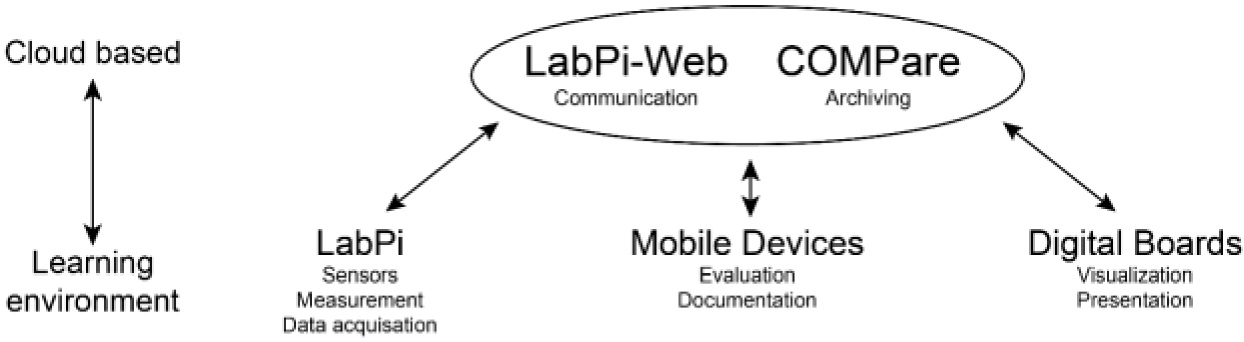

Fig. 3: Cloud based communication and opportunities with LabPi on different devices.

By transferring the measurement data in real time to the cloud, learners are able to view progress without being tied to a specific location and are able to document and discuss it on their own devices. In addition, teachers gain an immediate insight into the progress of the experimentation phase of their subgroups and can thus react individually and adapted to difficulties in the implementation, as well as ensure a more student-centered teaching. The logging and evaluation of the respective experiments can ultimately also be carried out via the cloud, which increases the accessibility of the results, or conventionally via all common calculation and text programs.

4 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.

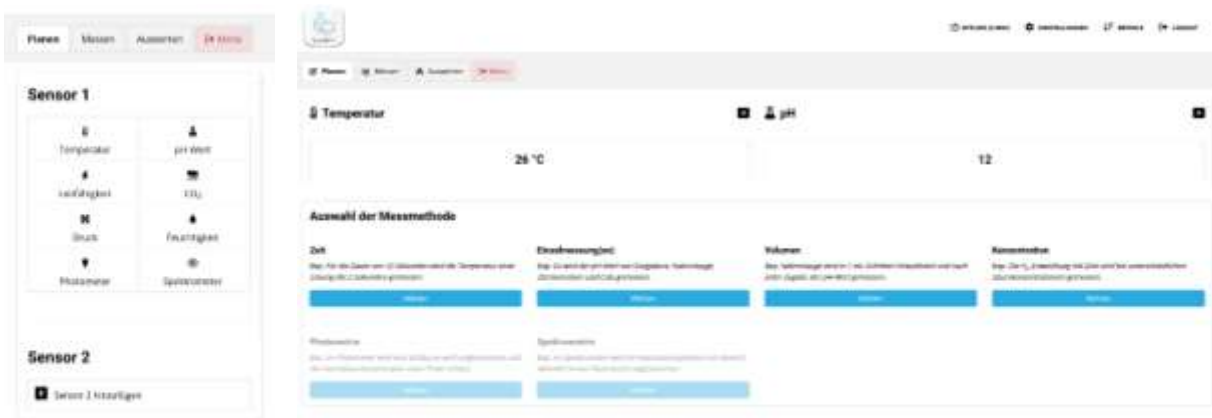

Fig. 4: Choice of different Measurement Methods in LabPi Web on Smartphone (left) and Desktop (right).

After all sensors and measurement parameters have been set, LabPi Web offers the user 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. 5). Here it is up to the experimenters whether an automatic real-time transmission to COMPare should take place or only afterwards.

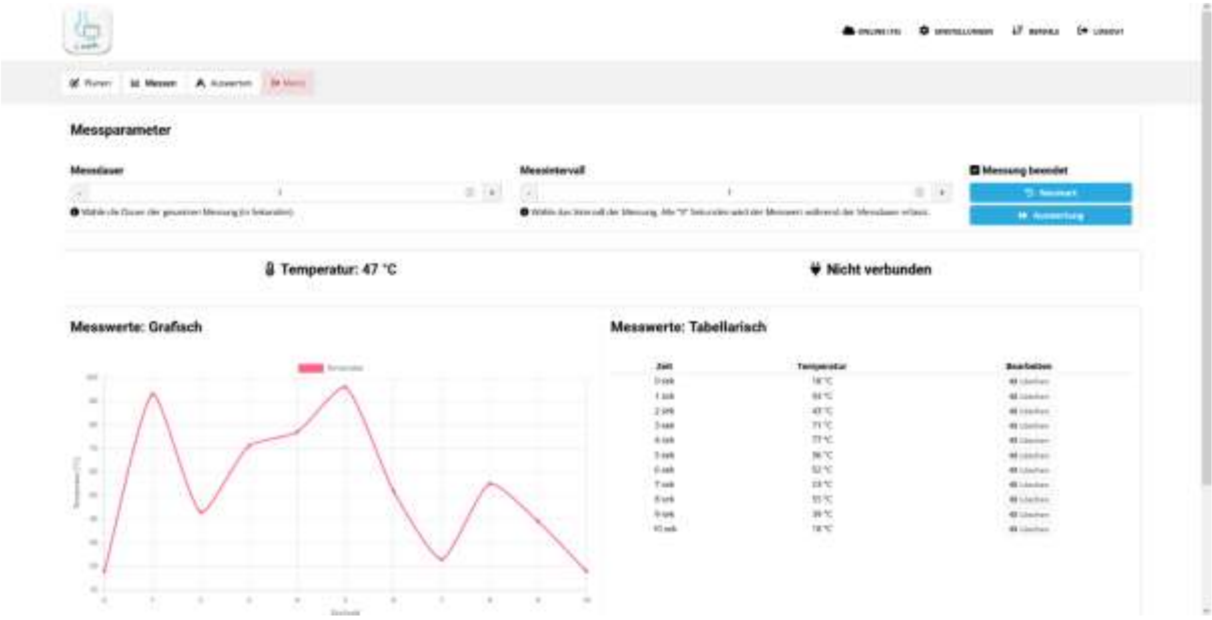

Fig. 5: Workspace and visualization after measurement in LabPi Web.

After a completed measurement, LabPi Web makes it possible to further evaluate the measurement data by displaying, for example, compensation lines, intersections, slopes, or concentrations with little effort and depending on the requirements of the learning group.

For logging and evaluation, graphics and tables can be downloaded directly to the desired device and integrated into calculation programs. In addition, LabPi-Web offers an optional, interactive protocol template as support for preparing evaluations and protocols in a guided manner, in which the learners can describe their own observations of the experimental procedure or enhance them with visual material.

4 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.

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