A New Sampler Invention

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ABSTRACT

The unit of volume in a micropipette is microliter, so the slightest error causes the largest variations in the test results. Most of the time, the researcher does not notice the error that changes the overall result of the experiment. At best, the researcher realizes the error and has to repeat the experiment, resulting in a waste of materials and time. Accordingly, this error became the basis for this project and an attempt was made to solve this problem by providing a simple, creative and low-cost model that is available to all laboratories. We made a counter sampler using a magnet B/sensor and an electrical counter, which were installed in the piston and body of micropipette.

Key words: *Micropipette, Laboratories, Errors, Creative model*

1 Introduction

If you are a researcher in biology laboratories, you are definitely familiar with micropipette as one of the most important equipment. Human error is an inseparable part of an experiment. One of the most common human errors that occurs when working with a micropipette is that the sampled well is lost in a 96-well plate due to the proximity of the wells, low transfer volumes (<1000μl), adding a colorless solution (which prevents visual control of the sampling process), environmental factors (such as noisy devices and overcrowded rooms), and mental states of the operator (work stress, fatigue, and lack of concentration). The unit of volume in a micropipette is microliter, so the slightest error causes the largest variations in the test results. Most of the time, the researcher does not notice the error that changes the overall result of the experiment. At best, the researcher realizes the error and has to repeat the experiment, resulting in a waste of materials and time. Accordingly, this error became the basis for this project and an attempt was made to solve this problem by providing a simple, creative and low-cost model that is available to all laboratories. We made a counter sampler using a magnet B/sensor and an electrical counter, which were installed in the piston and body of micropipette. Installation of the sensor into the body has caused the counter can count the number of sampling only when piston button was pressed to the second step. So, drawing up liquid is not included in the count. Low price, portability, and being user friendly are the advantages of our plan.

1-1 Pipette

Working in laboratories and doing experiments is one of the most important parts of a research. Among the various instruments which are used to perform laboratory test, some equipment such as pipettes and samplers are very useful. Pipettes are mostly used in a few fields like genetics, chemistry, microbiology and pharmacology. A range of pipettes with different accuracy is manufactured and designed based on their applications. They can be a non-standard piece of glass or plastic designed to transfer a single volume of liquid or can be precious instruments with more complex structures for transferring a couple of volumes (Fig. 1).

Fig. 1: Pipettes

1-2 Micropipettes

Micropipettes, also called samplers, are the most accurate pipettes which are widely used to collect and transfer a very little amount of volumes in microliters. They are favourable instruments for many researchers working on some precious researches, especially in the field of cell-molecular biology, chemistry and pharmacy. Moreover, lab technicians are likely to learn to use it in the first steps of their experiments and to spend most of their time on using it. Accordingly, samplers can be classed based on their different characteristics, some of which are mentioned below.

1-2-1 Adjustable and Fixed Micropipette

Adjustable pipettes are those that can be adjusted to a range of specific volumes. These pipettes usually have such labels as "10-100 microliters" that indicate the desired volumes by which can be transferred. In fact, this type of samplers can only draw the adjusted volumes; However, the pipetting system will be disrupted if users use sampler out of the defined ranges.

On the other hand, fixed volume micropipettes are those whose volume is unchangeable. Compared to adjusted samplers, there are fewer moving parts in the structure of fixed micropipettes, therefore, their mechanism of action is simpler, which makes them enable to transfer a specific volume more accurately. These kinds of samplers are mostly used in laboratories with routine daily works with a need of transferring some specific volumes (Fig. 2).

Fig. 2: Variable (A) and fixed (B) samplers

1-2-2 Single-Channel Samplers and Multi-Channel Samplers

There is a difference between single-channel and multi-channel samplers depending on the number of channels attached to their pistons. Most researchers sometimes prefer a multi-channel pipette to a single one, e.g. filling some wells of a 96-well plate at the same time, so that one-by-one filling in using a single-channel sampler will take a long time during an experiment.

Fig. 3: Single-channel samplers and multi-channel samplers

1-2-3 Electronic Samplers

The electronic micropipettes were designee by reducing the required force to improve the ergonomics of the micropipettes. Manually moving the piston is replaced by a small electric motor powered by a battery. The work steps are set and displayed on a small screen. In addition, electronic pipettes can reduce the risk of RSI-type injuries (Fig. 4).

Fig. 4: Electronic samplers

The main components of a sampler and mechanism of its action are as shown in figures (5 and 6).

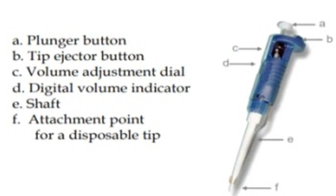

Fig. 5: Components of a sampler

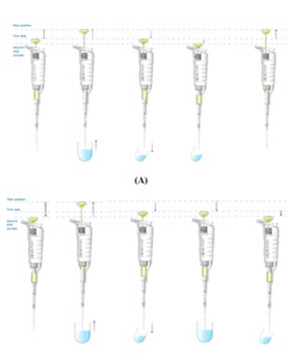

Fig. 6: The schemes of (A) the direct and (B) the reverse pipetting methods.

2 A problem Statement

Since laboratories are complex systems consisting of different people and devices, the presence of errors in there is undeniable. Basically, laboratory errors are classified as pre-analytical, analytical and post-analytical errors. On the one side, pre-analytical errors may occur in the procedure of requesting a test, collecting a sample, and transferring it to the laboratory. On the other side, analytical errors may occur during a test in response to either uncalibrated equipment or tired, careless technician with high workload. Besides, post-analytical errors are present after a test during data collection, analysis and reporting.

Since the samplers are usually used for doing an experiment, driven errors are analytical. As mentioned, poor calibration and quality controls along with technical errors of users can be the main sources of this errors. Due to the calibration program for most laboratory devices is scheduled, some researchers believe that the role of technicians in occurring this error might be greater. As a result, the awareness of the technicians is the most important factor to prevent the occurrence of this type of error, which is usually less noticed.

3 The Main Aims

The error related to a sampler can be caused by various factors, including using an uncalibrated sampler, contaminated sampler, unsuitable tips, a broken sampler and so on. These errors can be largely eliminated by properly training staff and creating a regular program to calibrate. However, error is always an integral part of human action; as a result, efforts should be made to identify drastic errors that have been overlooked in the testing process and to take actions to correct them.

The error in counting sampling number is one of the most common human errors which can be occurred during a work set with sampler. Some environmental factors, such as working in a noisy workplace with high workload or having a bad working day and getting exhausted, can disrupt the focus of technicians, which let them to make mistake. In addition, running a test into 96-well plates might be another source of analytical errors. That's why their wells are too small and close to each other, resulting in missampling especially when the transferred volume is very small and its visually tracking is practically impossible. For example, the researcher forgets in which well he has sampled or in which step of adding a solution to a mixture s/he has been. On the other hand, the sampler transfer volumes in the microliter range, so any error in transferring equals more deviation in results. In fact, researchers usually do not pay attention to these errors, which lead to erroneous results and reports. Occasionally, a researcher recognizes the error and has to repeat the experiment, resulting in a waste of material and time. Sometimes it is practically impossible to repeat the experiment due to a limitation of budget, time and materials. For example, the ELISA test is usually one of the final stages of a test series; thus, if for any reason the researcher makes a mistake in pouring the sample into the ELISA plate wells, all the cost and time spent on the series of experiments will be wasted.

As a result, in this study, an attempt was made to design a sample with the ability to count the number of sampling in order to increase the efficiency, accuracy, precision and reproducibility of the results by reducing user errors, so that it could save materials and time in the laboratory.

4 Methods

4-1 Solution 1:
Installing the Counter on the Piston Button of a Sampler

The first scheme was to install the counter on the plunger button. Thus, when the experimenter wanted to do sampling, he/she had to push the counter which led the number on counter to increase by one unit.

There were some disadvantages in this idea; the major problem was that it counted each sampling twice because the button was pushed one time for filling the disposable tip and the other time for discharging the solution. Moreover, the other problem was that the surface of the counter's button is slippery and non-user friendly (Fig. 7).

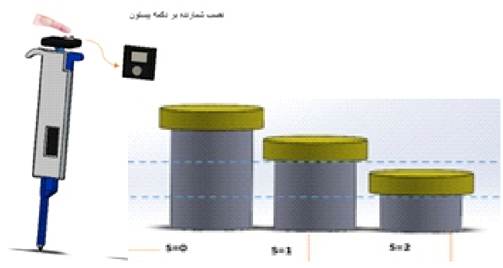

Fig. 7: Solution 1

4-2 Solution 2:
Installing of the (Diode-Receiver-Transmitter) on Piston Base and Piston Button

In this idea, two diodes were used that one of them was attached on the plunger rod and the other was placed in front of the tip ejector. While the experimenter pushed the plunger button, the plunger rod went towards other diode. Consequently, an electrical current was triggered and the number on counter increase by one unit (Fig. 8).

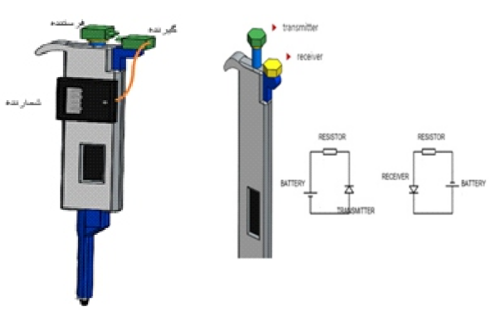

Fig. 8: Solution 2

To be honest, this idea was practically impossible so that it would not be user-friendly.

4-3 Solution 3:
Installing both Receiver and Transmitter on Piston Base and Piston Button, Respectively, Along with Adding a Shiny Reflective Ring to the Piston Rod

In this idea, both receiver and transmitter were placed on the same place (i.e. in the front of the tip ejector) and a shiny ring was attached on the plunger rod. The mechanism was that the transmitter sent a beam of light as soon as the technician pushed the plunger, then these beams got reflected by the shiny ring and the receiver received them. Consequently, an electrical current added a number to the counter. This idea was easier than our 2nd solution but still there were some problems. The diodes were expensive and needed more energy sources. In addition, the shiny ring was able to be destroyed after several uses (Fig. 9).

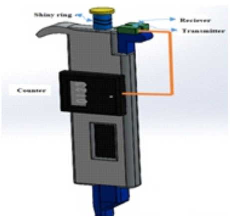

Fig. 9: Solution 3

4-4 Solution 4:
Micro-Switch

In this idea, when the experimenter is doing the samplings and pushes the plunger button until the second step(the step of sampling, which should be count),the plunger button hits the micro switch , the counter counts.

The mechanical touch, between the plunger button and the switch makes the device not to be able to Work for a long time. Also, a switch as small as needed wasn't found (Fig. 10).

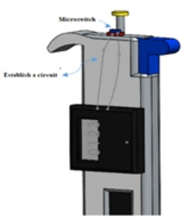

Fig. 10: Solution 4

4-5 Solution 5:
Copper Wire and Ring

In this solution, a ring was attached under the plunger button, and 2 wires were attached from the counter to the sampler body. When the experimenter pushed the plunger button for sampling, the wires reached the ring and the counter counted.

The disadvantages of this solution was that the copper wires and the ring had mechanical connection which let to make damage to them after several sampling (Fig. 11).

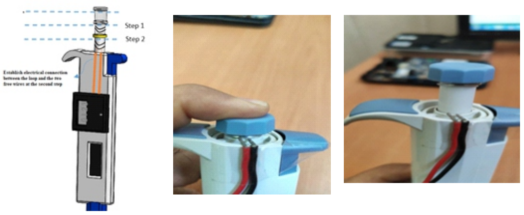

Fig. 11: Solution 5

4-6 Final Solution
Magnet/ Magnet key

In this idea, a magnet was put in the plunger rod hole and a magnet bee sensor was put on the sampler body, attaching by 2 wires to the counter which is also put on the sampler body, with a short distance of the sensor. The mechanism was that when the experimenter pushed the plunger button till the second step of sampling, the magnet became close to the sensor; Consequently, an electrical pulse was induced which led to adding a number to the counter.

This idea had the most advantages. It was user-friendly and easy to use. Moreover, it was simply placed on the other hand, the battery of counter consumed the least amount of energy, so it was not able to be destroyed even for several years. Furthermore, there was no mechanical connection between its component and it could work for years (Fig. 12).

Fig. 12: Final Solution

We also did a 3D print for covering the counter in order to look better (Fig. 13).

Fig. 13: Final Design

5 Suggestion

There are some suggestions to expand this work. A program could be designed in order the counter be able to save the data. It may also be applied in other samplers by the sampler companies.