Contents lists available at ScienceDirect

HardwareX

journal homepage: www.elsevier.com/locate/ohx

Hardware Article

Open source 3D-printed 1000 μL micropump

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ARTICLE INFO

Article history:
Received 24 July 2017
Received in revised form 22 August 2017
Accepted 22 August 2017
Available online xxxx

Keywords:
Open source
3D printed micropump
3D printing
DIY labware

ABSTRACT

Scientific innovation goes hand in hand with technological innovation, so scientific work depends to a great extent on the hardware available in the laboratory. The investment in developing countries is still far below that of OECD countries, which was about 2.4% of the gross domestic product (GDP) in 2015. In stark contrast, Brazil made the highest investment of Latin American countries at just 1.2%. Today, the "open-source revolution" appears more than ever to be a powerful ally for the promotion of development and the narrowing of the economic gap between developed and developing countries. In this context, this article presents the design of a 1000 μl 3D printed micropump. It is a practical and simple design inspired by pipette pumps. The present design was printed with a 3D printer and assembled very easily with common tools. Upon comparison of the micropump's performance, it exhibits a systematic error between 1.4 and 3.8% of the volume and a random error between 0.38 and 9.5% of the volumen.

Specifications table

Hardware name	OPEN SOURCE 3D-PRINTED 1000 μL MICROPUMP
Subject area	• Chemistry and biochemistry • Medicine • Neuroscience • Biological sciences • Educational tools and open source alternatives to existing infrastructure
Hardware type	• Biological sample handling and preparation
Open source license	*CC BY*
Cost of hardware	US $43.45
Source file repository	https://3dprint.nih.gov/discover/3dpx-007460

1. Hardware in context

Developing countries have very low per-capita incomes and a small taxpayer base, and this predictably leads to low health and research spending [1]. In conjunction with minimal resources, the cost of consumables in developing countries

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http://dx.doi.org/10.1016/j.ohx.2017.08.002
2468-0672/

can be two to five times higher than developed countries depending on the distance between the manufacturer and the consumer when compared to consumables in developed [1,2]. To a large extent scientific innovation depends on scientific hardware and the lack of access to technology delays scientific progress in developing countries. The access to scientific equipment is often limited by their high cost [2]. However, the open-source movement has given hope to many; this movement is based on licenses that allow free access to hardware designs and software source code for use, and, in a spirit of collaboration, modification for purposes of improvement [3,4]. This movement began in the field of software and has expanded to other areas such as hardware development. The success of open source hardware has been further enabled by the reduced cost of 3D printing and the creation of open-source microprocessors such as Arduino [5]. 3D printing has become a low-cost alternative to manufacturing consumables and equipment. An important example is the do-it-yourself (DIY) DNA lab designed by Peter Allen and colleagues at the University of Idaho, which, by using 3D printing, generates a cost savings of 50–90% in comparison to commercial equivalents [6]. As a result, throughout these decades, a large and enthusiastic community has developed a series of low-cost scientific instruments that includes: automated sensing arrays [7], biotechnological and chemical labware [8,9], micropipettes [10], colorimeters [11], DNA nanotechnology lab tools [6], a thermocycler for PCR [12], optics and optical system components [13,14], and a sample rotator mixer and shaker [15].

In this manuscript, I present a 3D printed micropump that uses commercial micropipette tips. The development of the 3D models was done with the Fusion 360 program (Autodesk Inc., USA). The models were printed with the DaVinci 1.0 printer (XYZ Printing Inc., USA). The performance of the micropump was compared to that of commercial micropipettes (Gilson Inc., USA and Eppendorf, Germany) and while the 3D printed micropumps were less precise than their commercial analogs, they exhibit a systematic error between 1.4 and 3.8% of the volume and a random error between 0.38 and 9.5% of the volume. This accuracy and precision is well within the necessary parameters for many research applications, such as Cell culture media preparation, cell perfusion solution for electrophysiology, titration, among others.

2. Hardware description

The design was made in order to produce a light and manual micropump that would function like a pipette pump. It consists of four parts: a body, a slide, a gear, and a nozzle (Fig. 1). The body accommodates the rest of the components, and on the lower front side has a cap that provides access to the interior and is attached with two screws (M5 × 25 mm)

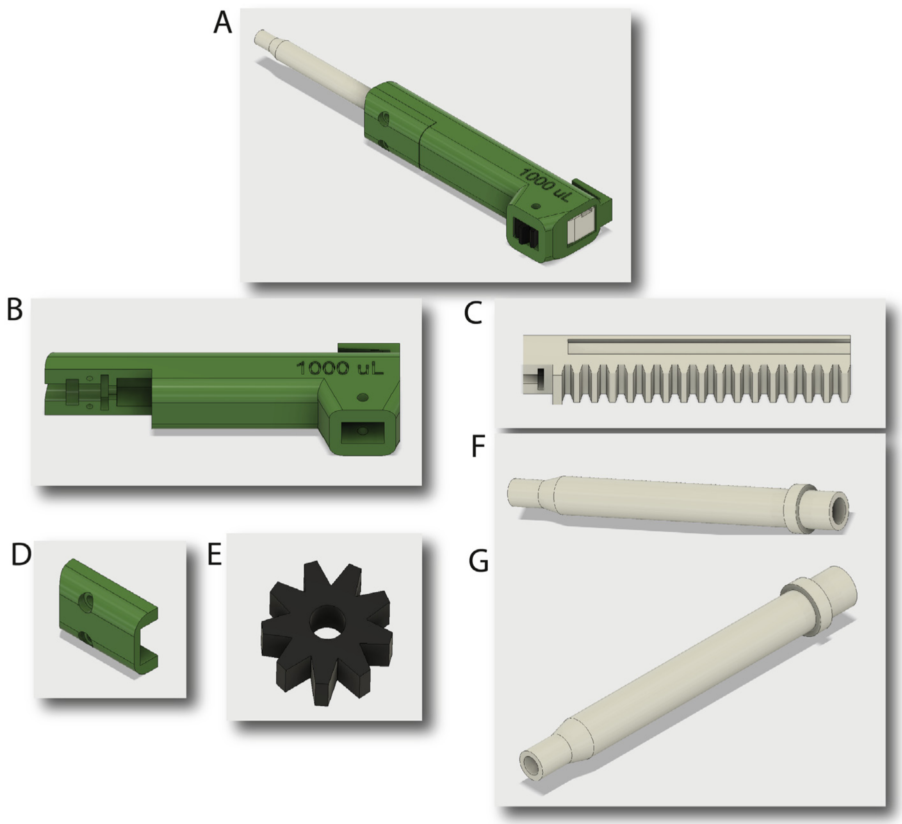

Fig. 1. Micropump components. The components of the micropump comprise five elements which are: (A) Assembled micropump, (B) Pump body, (C) Slider, (D) Body cover, (E) Gear, (G) Nozzle.