ABSTRACT

A high-precision syringe pump has been developed for microfluidic laboratories requiring accurate control of fluid volume and flow rate. The system is designed using a NEMA17 stepper motor, TB6600 driver, and ESP32 as the control unit, supported by a physical frame model through 3D printing. The device operates wirelessly using an application on an external device, allowing users to easily adjust parameters and monitor the process in real-time. Testing revealed nonlinearity in the relationship between volume and motor step count, which was subsequently corrected using third-order polynomial regression analysis. The implementation of the polynomial equation ensures accurate fluid volume distribution, with zero error achieved in the 1–10 mL range. However, flow rate testing revealed inconsistencies at certain time intervals due to software-hardware synchronization limitations. This research provides a cost-effective syringe pump solution with high precision and offers practical wireless control features suitable for various biotechnology and chemistry laboratory applications.

Keywords **:***Syringe pump, Microfluidic, Time, Accuracy, Stepper Motor, Polynomial Regression, ESP32, TB6600, 3D Printing, Bluetooth, Fluid Volume*