Rebuilding the Focusing Mechanisms of Old Microscopes Using 3D Printing

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Introduction

Microscopes have long stood as instruments of fascination and discovery, unlocking the mysteries of minuscule life forms. My initial introduction to this instrument was a delightful gift from my parents (see Figure 1), a recognition of my school achievements and passion for science. This microscope ignited my early interest in biology, evolving into a cherished possession with significant nostalgic value. I still treasure the memories and specimens from my exciting explorations during my youth with this precious microscope. The microscope, branded PAIM (PAlchetti IMport), originated from an Italian company that served as a distributor of optical instrumentation from Japan, now known as Palomar. Regrettably, I couldn't identify the Japanese company responsible for manufacturing this educational microscope. However, as depicted in Figure 1, my microscope shares a similar shape, wooden box, and accessories with the TASCO microscope, the same brand as the other microscope presented in this paper, as discussed in a recent article on Micscape [1]. Hence, it's plausible that both PAIM and Tasco imported and rebranded microscopes from the same producer.

Figure 1. The PAIM microscope: a companion of many microscopic adventures.

Unfortunately, the wear and tear of time can render the mechanics of this delicate object dysfunctional and the fine focusing mechanism of my microscope was the first to fail due to a structural issue in the metal block holding a driving sphere. I improvised a solution with a 'creative' fix using a piece of hard wood, but other parts of the focusing slider began to crumble with use, and time took its toll. Figure 3 illustrates the condition when I opened it 40 years later.

I have always aspired to restore the microscope to quasi-pristine mechanical conditions. Some years ago, with this goal in mind, I purchased two old student microscopes from the company TASCO on eBay, both similar but not identical to my original one. It turned out to be a wise investment as both sets came with a rich assortment of accessories and specimens in excellent condition. One of the two sets is showcased in Figure 2.

Figure 2. The TASCO microscope.

Unlike my PAIM microscope, Tasco microscopes feature an adjustable magnification objective lens that can be rotated for varying magnifications. In contrast, the PAIM has three interchangeable objectives with magnifications of 5x, 10x, and 20x. The TASCO microscope also includes a polarizer lens in its set. I had hoped to salvage the fine focusing slider from one of these microscopes to replace the broken one in my PAIM. Unfortunately, the slider proved to be slightly different, although it boasted a superior design compared to my old PAIM microscope. Moreover, the metallic block guide for the primary focusing slider of the TASCO microscope had suffered from cracking. Fortunately, the advent of personal manufacturing through additive fused filament manufacture (FFM) technology, commonly known as 3D printing, presented a convenient opportunity to rejuvenate both of these damaged microscopes. This allowed me to merge my passion for this new technology with a long-standing nostalgic desire to witness my old microscope in working order once again.

In this article, I will summarize the results of using a plastic 3D printing approach to reconstruct the focusing mechanisms of these two old microscopes. The entire restoration project is also documented on an Instructables project page [3], providing comprehensive details of all the steps involved.

The success of this approach is demonstrated through the repair of two distinct microscopes, each with its own mechanical issues. By sharing this experience, the paper aims to inspire others to revive their vintage microscopes and rediscover the beauty of hidden worlds.

The Fine Focusing Mechanism Slider of the PAM microscope

The fine-focusing mechanism is a slider attached to a coarse mechanism guide for sub-millimetric focusing movements. The original mechanism relied on metallic parts that broke over time, rendering it nonfunctional. As mentioned in the introduction, an initial attempt at repair was made using a naïve but functional method. However, the rest of the slider also started to crumble. Figure 3A provides an idea of the poor condition of the slider when I disassembled the microscope after 40 years. Therefore, I decided to utilize 3D printing to reconstruct the complete slider using polylactic acid (PLA)-based plastic.

Initially, the broken pieces of the slider were recomposed, as shown in Figure 3A, attempting to match them as closely as possible to the original shape. Subsequently, all relevant lengths were measured with a precise Vernier caliper. Using the open-source parametric CAD software OpenSCAD, I created an accurate 3D model of the slider (see Figure 3B), which was then 3D printed using 1.75 mm PLA filament at a 0.2 mm resolution. Due to the inaccuracy of some measurements, as some original parts were missing, I employed a trial-and-error approach to refine the model and ensure a correct fit to the guide on the microscope body.

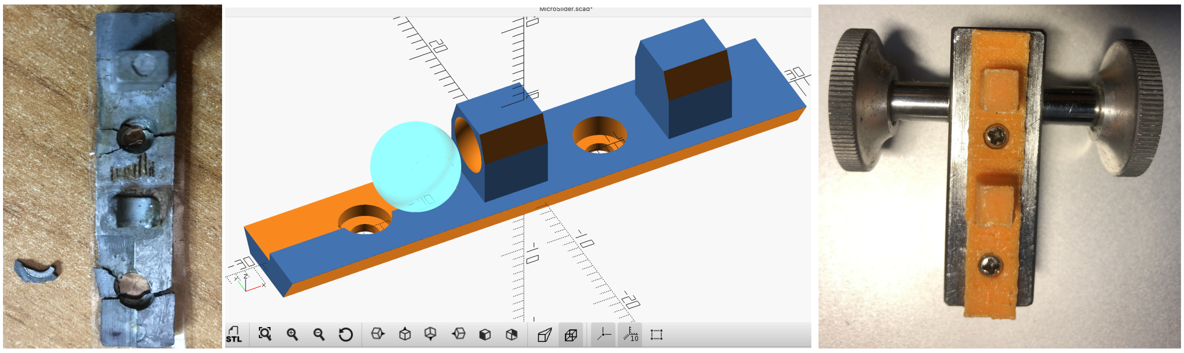

Figure 3. On the left, a top view of the meticulously reconstructed original slider of the PAIM microscope. In the center, the digital model created using OpenScad software for the replacement part. The cyan-colored sphere represents the metal sphere of the focusing mechanism. The hollow block in front of the sphere was the initial point of structural failure and was ingeniously substituted with a piece of hardwood, skillfully modeled to complement the missing part and securely glued to the slide. On the right, the 3D-printed model seamlessly integrated with the coarse focus mechanism of the microscope.

The Instructable project page [3] contains the OpenSCAD script that can be modified and adapted to other models of microscopes. It also contains all the details of 3D print parts. In Figure 3C, the final 3D-printed slider is shown. After fitting to the primary focus mechanism and greasing, the plastic replica replaced the broken slider with satisfactory functionality. While the durability of this repair is unknown, it has successfully restored the microscope's functionality, preserving a piece of the author's memories for the new generation.

The Coarse-Focusing Rack-Pinion Mechanism of the TASCO Microscope

The TASCO microscope, depicted in Figure 2 and initially acquired for repairing the PAIM microscope, also exhibited defects. The metallic block containing the guide for the primary focusing mechanism had cracked, as illustrated in Figure 4A. Similar to the PAIM microscope, the material used for the TASCO microscope did not withstand regular usage, and over time, the cracks likely compromised the overall structure.

I attempted to address the issue by gluing the broken piece back together. However, this did not provide a viable solution for restoring the microscope to a usable condition. As in the previous case, the optimal solution would involve machining or forging the damaged part, but

I lack the necessary equipment and skills for such procedures. Therefore, I opted once again for 3D printing. Initially, I created a 3D model of the damaged component. In this instance, the glued piece recomposed well, facilitating more accurate measurements for a precise replication of the part (see Figure 4B).

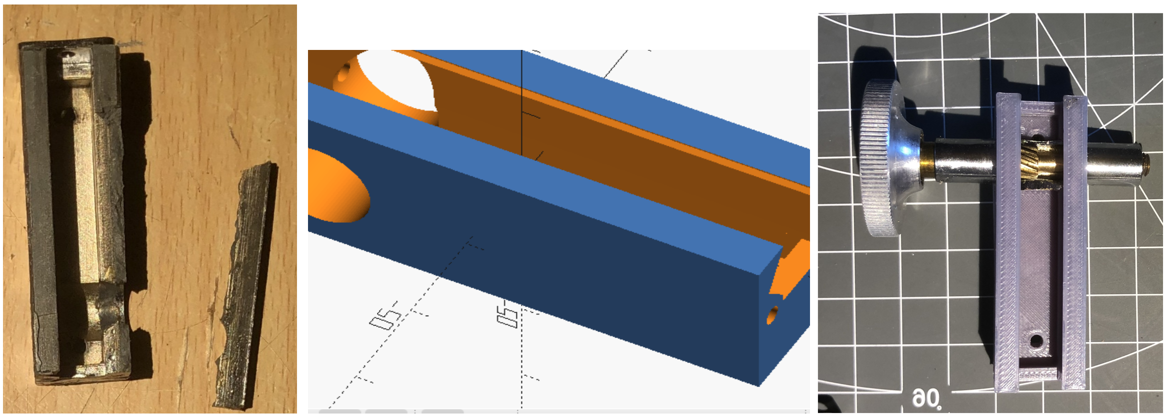

Figure 4. On the left, a top view of the original damaged guide of the Tasco microscope. In the center, the digital model designed in OpenSCAD for the replacement part. On the right, the 3D-printed model seamlessly attached to the focus wheel screw.

In Figure 4C, the 3D-printed slider guide, affixed to the focus wheel screw, is displayed. The reassembled microscope is connected to a Raspberry Pi Zero computer featuring a 5 MP camera (model V1.3), as depicted in Figure 5. The author designed and 3D printed the attachment for the camera to the ocular. The outcomes prove entirely satisfactory, enabling the use of the microscope for capturing images, albeit limited by the capabilities of this vintage instrument.

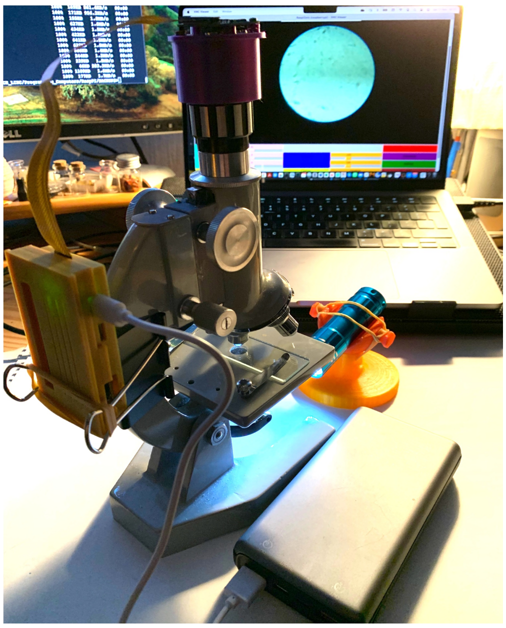

Figure 5: The 3D printed guide reassembled to the microscope. The microscope is also attached to the Raspberry PI Zero computer with a 5 MP camera (model V1.3). The attachment of the camera to the ocular was designed and 3D printed by the author.

Figure 6 presents examples of observations derived from a collection of educational prepared slides.

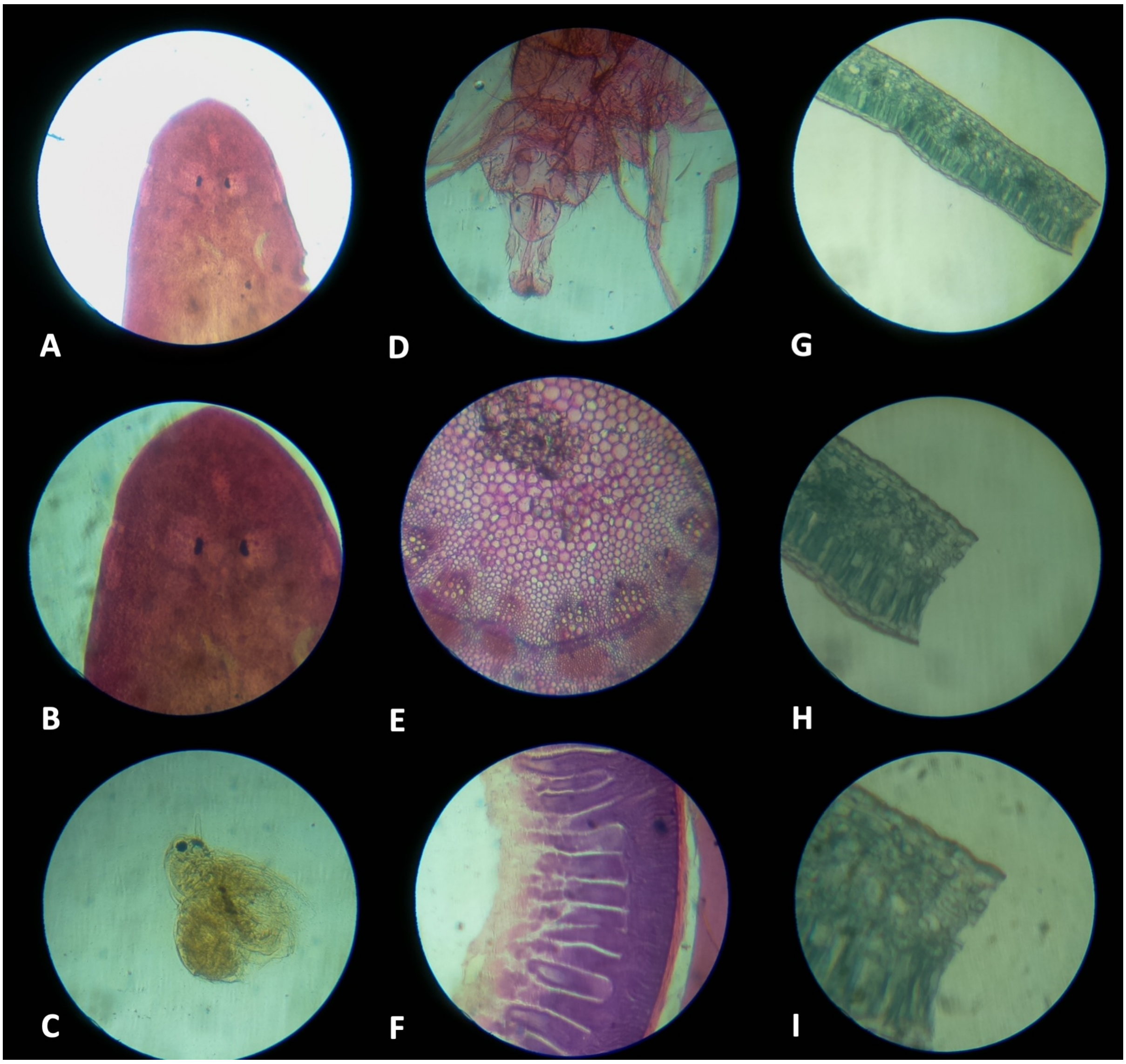

Figure 6: A, B) Planarian worm head at different magnifications. C) Water flea. D) Fruit fly head. E) Dicotyledon plant stem section. F) small intestine. G, H, I) Leaf section at different magnifications.

Conclusions

The application of modern 3D printing technology has facilitated the revival of vintage educational microscopes. I hope that the results presented herein will inspire fellow enthusiasts to embark on their restoration journey. The 3D-printed replacements not only offer a cost-effective alternative to the original materials but also prove entirely satisfactory in restoring the functionality of the microscopes. Furthermore, the versatility of materials available for FFM 3D printing technology allows for extensive experimentation. While I have utilized PLA, exploring more rigid plastics could enhance design accuracy and functionality.

For me, the primary goal was not merely to mend these old microscopes for practical use but to breathe new life into cherished companions that stirred memories and excitement from my amateur exploration of the microscopic world hidden within a droplet of pond water. In this regard, this project may serve as inspiration for rejuvenating your broken old microscope. I welcome feedback and suggestions from readers who have attempted this reparative approach or experimented with alternative materials and technologies.

References

1) M. Reese, *My First Microscope (A little nostalgia for the old folks)*. *Micscape magazine, April 2012.*
2) G. E. Santacana. *A Complete Student Microscope Set From 1965*. *Micscape magazine, March 2000.*
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