Having fun with microscopy

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Abstract This article introduces a range of ways to engage students in microscopy, from investigating water droplet lenses to using low-cost, highly adaptable instruments that can be extremely effective inside and outside the classroom.

This article explores some potential microscopy activities that do not use the microscope. Rather, alternative instruments that are cheaper, easier to handle and more adaptable are used to develop students' understanding of microscopy before they are introduced to a microscope. These activities have been used successfully with year 7 and year 8 students (ages 11–13).

An early history revealed

The history of microscopy is fascinating and spans thousands of years. It is supported by a rich tapestry of global literature and archaeological artifacts. However, saying this, there remains little consensus about who first used magnifying glasses to increase image size, or when it occurred, or indeed who was responsible for the first multi-stage microscope!

The magnifying glass

What we do know with some certainty from the literature is that eyeglasses were already in use in Italy by AD 1286 and thought to have been invented by either Friar Alessandro Spina or Friar Giordano of Pisa (Rosen, 1956). It is reported that adapted glass spheres were being used by jewellers at the same time. Also in the 13th century, philosopher and Franciscan Friar Roger Bacon used the very influential work by Ibn Al-Haytham (AD 965–1040) in his *Book of Optics*, to develop his treatise on the anatomy of the human eye and the effect of the lens on light (Sabra, 1989).

A play entitled *The Clouds*, written in the 4th century BC by the Greek dramatist Aristophanes, mentions an apothecary using a 'transparent stone' to kindle fire, and some 400 years earlier the first written account of employing magnification, to read fine print, is given by the philosopher Seneca at around AD 65 (Paasch, 1999).

Artifacts obtained from archaeological digs have revealed high-quality Viking lenses from the Gotland settlement, Sweden, dating to the 11th century (Opto and Laser Europe, 1998). Lenses used by engravers in Pompei (Rome) and Tanis (Egypt) from around AD 174 and several lens-shaped crystals discovered in Turkey dated to 2200 BC (Sines and Sakellarakis, 1987; Tomilin, Neverov and Sines, 1997) push the date of lens use further back in time. However, the oldest lenses so far discovered, dating from 2600–2400 BC, come from Egypt. These lenses were used for the eyes in funeral statues, so their use as magnification tools is unclear (Enoch and Lakshminarayanan, 2000).

The first examples of a 'modern' microscope

Zacharias Janssen is often credited with inventing the 'modern' compound microscope in 1590, yet some believe this may have been the spectacle maker Hans Lippershey (Davidson, 2015). We know that Galileo Galilei improved the simple two-lens design in 1609 and later other notable scientists such as Robert Hooke (1665), Antoine van Leeuwenhoek (1670) and Robert Koch (1882) continued to improve on the design of the microscope (Rochow and Tucker, 1994).

Developing microscopy at school

Being able to use a microscope is important and considered a key skill in the National Curriculum in England (DfE, 2013). Often the microscope and its uses are first introduced in year 7 (age 11) when students study plant and animal cells and tissues. The microscope can also be used to investigate crystals shapes, e.g. salt and sugar and the structures of interesting materials such as cotton, nylon and wool. With some confidence I believe we can say that the microscopic world revealed by microscopy is one of the most engaging activities students do at school.

The following activity ideas introduce students to the world of magnification in an interesting and highly engaging way. The order in which each activity is introduced provides a gradual progression in ideas and this supports a secure understanding of the basic principles of microscopy before students use a microscope.

Activity 1 – Water lenses

For this activity students are provided with a worksheet (Figure 1), plastic pipette, small beaker, crayon, transparency paper and access to water. Figure 2 shows the

Water lenses worksheet

Your task is to investigate whether the diameter of a water lens affects its magnification.

Before you begin, can you predict which lens will magnify the most? Will it be the smallest or largest diameter lens?

Method

1 Using a crayon, draw 3 circles of different diameters onto a transparent surface (OHP paper).

2 Carefully fill the circle with water using the plastic pipette.

3 Place the transparency over some text or a colour picture in a magazine.

What happens to the image of the text/picture?

Figure 1 Water lenses worksheet

set-up for the water lens. Figure 3 shows an example of results obtained using a water lens.

Students will often predict that the larger diameter lens magnifies most, only to find that the smaller diameter magnifies more. Some students, if they look at the water drops sideways on, will notice that the smaller diameter lens has the highest relative relief and be able to conclude that it is the relief or thickness of the lens that determines the magnification, not the diameter.

The activity introduces students to the convex shape of a lens and its ability to magnify images. It engages students by asking them to make their own lenses and compare them. In doing this they learn far more about magnification than simply using magnifying glasses and hand lenses.

The next stage in developing students' skills in microscopy might involve them using magnifying glasses and possibly hand lenses to observe a variety of objects, for example rocks, minerals, parts of insects and flowers. Magnifying glasses and hand lenses are very portable and so investigations can take place inside and outside of the classroom. Indeed, this type of activity could have occurred in upper primary school.

The next learning stage for students is often introducing the microscope. However, there are cheaper and more versatile alternatives that can be used before the microscope is introduced. Two of these instruments are the Phonescope and the Photo-lens.

Figure 2 The set-up for the water lens

Figure 3 An example of results obtained using a water lens

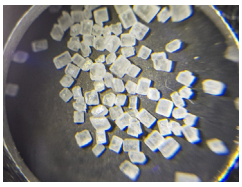
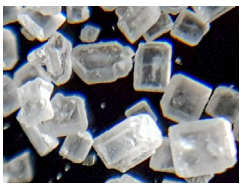
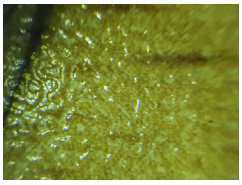
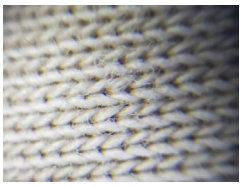
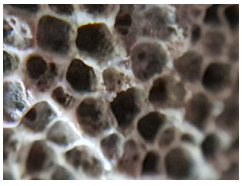
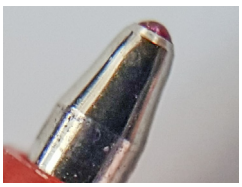
Activity 2 – Using the Phonescope and Photo-lens

Both instruments (Figure 4) can be attached to either a smartphone or an iPad. They provide good definition images up to ×30 magnification and allow students to photograph or take videos of their images. The portability of the instruments means students can use them both inside and outside the classroom.

Table 1 shows some images that were captured using these instruments in the classroom, along with some

Figure 4 Phonescope and photo-lens

Table 1 Images captured using Phonescope and Photo-lens with teaching points

Image	Teaching points
 A Phonescope image of salt crystals ×20	Salt crystals are cubic. Their shape is determined by the way sodium and chloride ions are bonded together in their lattice. Show students a model of the sodium chloride lattice?
 A Photo-lens image of sugar crystals ×30	Can students describe the shapes of sugar crystals? Do they notice how different they are from salt? The crystals are generally more rectangular (monoclinic). Could this be used to distinguish salt from sugar?
 A Phonescope image of a table top ×30	The table top appears to be smooth to the naked eye, but when magnified ×30 the surface is uneven.
 A Phonescope image of threads on a jumper ×30	To the eye the threads used to make a jumper are difficult to see, yet the magnification reveals the threads woven together.
 A Photo-lens image of a fossil sponge ×30	A fossil sponge shows where the individual organisms lived!
 A Phonescope image of a bee from a magazine ×30	The individual pixels that create the colour can easily be seen when magnified.
 Photo-lens image of the end of a red ball-point pen ×30	Magnification reveals the ball at the end of a red pen.

potential teaching points. Although students should be encouraged to take their own images and to describe these, it is interesting to present students with images and ask them to identify the images and explain why they think what they do. Students' interpretations can reveal not only how they see the images but also provide some information about prior experiences.

The possibilities for students to explore the microscopic world around them are almost endless. Parents might like to be informed about the Phonescope and Photo-lens, which are relatively inexpensive, easily obtainable and would make great gifts.

In school, students could be challenged to identify an image each week – they could be asked to contribute their own images to the challenge. Not only would this engage all students in a science task, it may also engage other teachers in the school and so raise the profile of science.

Activity 3 – Estimating the size of objects

Students can estimate the size of objects using a transparent ruler (Figure 5) and, although crude, the method provides students with a glimpse at how a graticule is used to estimate dimensions of very small objects.

Figure 5 Magnified image showing salt crystals against millimetre marks on a clear ruler

Activity 4 – Using the Phonescope and Photo-lens outdoors

The images in Table 2 were captured outdoors. Can you identify these images? The answers can be found in Table 3.

The final learning stage for microscopy at key stage 3 (ages 11–14) might be the use of a traditional microscope. This is an important skill and very necessary so that students can view images such as plant and animal cells that require greater magnification.

Table 2 Images captured using the Phonescope and Photo-lens outdoors

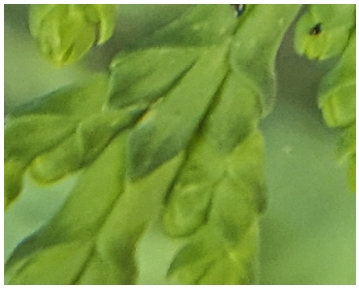
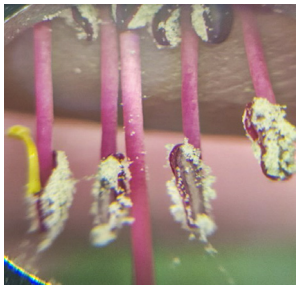
Figure	Image
A	
B	
C	
D	
E	
F	

Table 3 Answers for the images in Table 2

Figure	Image
A	Bramble thorn
B	Conifer leaves
C	Ant
D	Fennel flowerets
E	Buddleia flower
F	Fuchsia stamens with pollen

Conclusion

Microscopy and its applications engage children of all ages and abilities. The ideas presented in this article will hopefully extend the ways your students encounter magnification and encourage them to take a deeper interest in the natural world around them. Discussion about the images, what they are and why students think this, can support literacy development, enhance metacognition and ultimately an ability to engage in scientific argumentation.

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