Microscope studies in Primary Science: following the footsteps of R. Hooke in *Micrographia*

Nektarios Tsagliotis
Primary Science Laboratory, Rethymnon, Crete & University of Crete
9th Primary School of Rethymno, P.O. Box 135, 74100 Rethymno, Crete, Greece
ntsag@edc.uoc.gr

Abstract[*]. *This is an inquiry conducted with 40 children of the 6th grade of a Greek primary school, divided in two classes. Initially, each child constructed a simple reflective microscope using modern materials like a plastic tube and two plastic lenses (objective and eye piece), which were extracted out of single-use disposable cameras. It is actually a modified (re)construction of a microscope (approximate magnification 20x), which has been proposed by researchers of the Istituto e Museo di Storia Della Scienza of Florence. At a later phase, an extra middle lens was added to the microscope to minimize distortion, create sharper images and enhance magnification by 3-5 times.*

The children have been briefly introduced to the historical development of the microscope, with a focus on the life and discoveries of Robert Hooke (1635-1703), from the early years at the Isle of White till the achievements of Micrographia (1665), having him portrayed as a natural philosopher and polymath who played an important role in the scientific revolution, through both experimental and theoretical work. After that, microscope studies were conducted with each child recording their observations with the constructed microscope on a notebook with text and sketches, in an approach inspired by Hooke's Micrographia. Before putting down their notes on paper, they studied a relevant extract from the classic text of Hooke, adequately transformed and adjusted for the instance. Thus, following similar steps to those of Hooke, the children initially studied the point of a needle and a small printed dot, which have also worked as focus exercises for the use of the microscope. Then they studied plant seeds (thyme and petunias) as well as parts of plants during their development in the greenhouse and the school garden. Later, they studied garden insects, conducting "insectigations" as they called them, examining ants and isopods. They concluded with a free study, on either plants or insects, since they had developed interests in various and diverse specimens they wanted to examine further. The children discussed and exchanged in class their notes and observations, within a framework of investigations about the development and functions of plants and insects. The analysis of children's notebooks is expected to reveal aspects of "doing science" in an authentic environment (inquiry-based teaching and learning approach), within a framework of learners' scientific community dealing with an intentional task and/or investigative activity.

Keywords. Simple microscope, Study of plants, Study of insects, Observation notebooks, Primary science.

1. On the early history of the microscope & microscopical studies

In the museum of *Middelburg* a very old microscope is preserved, which is reputed to be an instrument constructed by *Zacharias Janssen* himself, probably with the aid of his father *Hans,* circa 1590-1595 (Bradbury, 1967).

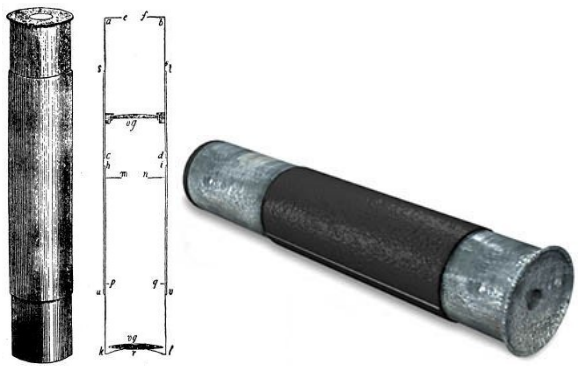

Figure 1: The Middelburg compound microscope

Despite the fact that there is no direct evidence to link this particular microscope to the *Janssens* and their craftsmanship on lenses at the

[*] This inquiry is part of the research work undertaken by the Greek group for the **HIPST project (History and Philosophy of Science in Science Teaching)**, which is funded within the 7th framework program, science in society-2007-2.2.1.2 - teaching methods (cf. URL: < http://hipst.eled.auth.gr >).

Nektarios Tsagliotis (2010). Microscope studies in Primary Science: following the footsteps of R. Hooke in *Micrographia* M. Kalogiannakis, D. Stavrou & P. Michaelidis (Eds.) *Proceedings of the 7th International Conference on Hands-on Science.* 25-31 July 2010, Rethymno-Crete, pp. 212 – 221 **http://www.clab.edc.uoc.gr/HSci2010**

time, it is still a remarkable instrument, which includes two draw tubes that could slide out of another outer casing tube, acting as a supporting sleeve. The lenses were in the ends of the draw tubes; the eyepiece lens was bi-convex and the objective lens was plano-convex. There was no stand provided for this instrument, which was apparently held in hand whilst in use. It is estimated that it was capable of magnifying images approximately three times when fully closed and up to ten times when extended to the maximum.

Galileo Galilei (1564-1642) mentioned in *Il Saggiatore* [The Assayer] (Rome, 1623) that he had probably achieved to have a *"telescope modified to see objects very close"*. It appears that in 1625 a member of the *Accademia dei Lincei* and friend of Galileo, *Johannes Faber* (1574-1629) conferred on the instrument, until then called "occhialino", "cannoncino", "perspicillo", and "occhiale", the name of "microscope". In the second half of the 17th century, remarkable results were achieved by the Italian instrument makers *Eustachio Divini* (1610-1685) and *Giuseppe Campani* (1635-1715), while in England levels of excellence were reached by *Robert Hooke* (1635-1703) or opticians and instrument makers like *Christopher Cock* (circa 1665).

Figure 2: Divini's vase-shaped microscope (left), Campani's ivory turned monocular microscope (centre) & Cock's compound microscope, manufactured in London for R. Hooke (right).

Microscope studies began during the course of the 17th century with *Federico Cesi* (1585-1630) and *Francesco Stelluti* (1577-1651) in the *Apiarium* (Rome, 1625). *Melissographia* (also appearing in Greek as "*ΜΕΛΙΣΣΟΓΡΑΦΙΑ*") is a work of *Stelluti*, covering a single folio of extraordinary size, containing detailed descriptions on bees, seen as a free inquiry into nature from the bondage of scholastics *"who have presumed to dogmatize on Nature"*, as *Bacon* criticized. Later, *Giovanni Battista Hodierna* (1597-1660) published, in *L'occhio della mosca* (Palermo, 1644), a text dedicated to the anatomy of insects, a masterly example of naturalist research conducted with the aid of the microscope.

Figure 3: The cover page of *Melissographia*, by *Francesco Stelluti*, 1625.

Robert Hooke has been undoubtedly one of the greatest personalities of English science of the 17th century. He was one of the first to realize the potentialities of the new invention of the microscope, which had been recently brought to England from the Continent. He was born in 1635 in Freshwater, Isle of White, and upon the death of his father he was apprenticed to a portrait painter in London. He soon abandoned this, however, and went to Westminster School and subsequently to Oxford. It appears that the originator of the superb microscopical illustrations later to be drawn in *Micrographia* (1665) had not only artistic talent, but also some formal training in a branch of art, which required accurate delineation and observation of detail (Bradbury, 1967).

Hooke was a scientist with a curious mind. From a very early age he worked in many scientific fields such as physics, chemistry, geology, biology, meteorology and astronomy, thus he has often been called the *Leonardo* of England (Inwood, 2003). He also knew and worked with some of the greatest scientists of the 17th century, like *John Wilkins*, *Robert Boyle*, *Christopher Wren*. He also discussed his ideas with *Isaac Newton*, *Christiaan Huygens* and *Johann Hevelius,* although he had strong disagreements and finally became rival with all three of them on different scientific issues (Burgan, 2008).

Hooke became associated with the newly formed *"Royal Society of London for Improving Natural Knowledge"*, which was initially a small group of scientists, called *fellows*, who met once a week to discuss their latest experiments and scientific ideas (Jardine, 2004). In 1662 the group decided to hire someone to do experiments and then report the results. Hooke was the first choice for the job, so he became the "Curator of Experiments". It was this time that he carried out microscopical studies, and the Royal Society recognizing the importance of this new branch of study, encouraged this endeavor. In 1663 he was solicited by the Society to prosecute his microscopical observations in order to publish them eventually and he was also instructed to *"bring in at every meeting one microscopical observation, at least"* (Bradbury, 1967). Hooke faithfully complied with this directive and showed the Society fellows the appearance under the microscope of common moss, the view of the edge of a sharp razor and of a point of a needle etc. He demonstrated various insects such as the flea, the louse, the gnat, the spider, the ant and various types of hairs. All these observations and many others besides were published in 1665 under the long title *"Micrographia: or some physiological description of minute bodies made by magnifying glasses with observations and inquiries thereon"*.

Micrographia was a huge book and was filled with descriptions of what Hooke saw under the microscope. He claimed that his goal was to use *"a sincere hand, and a faithful eye, to examine, and record the things themselves as they appear"*. Along with texts of lucid descriptions, Hooke included stunning, detailed drawings of what he saw under the microscope's lens, which often folded out of the book. For the first time ever, natural scientists as well as common people could see a new world around them which they barely knew it existed (Burgan, 2008). His lively drawings of insects made them seem *"as if they were lions or elephants seen with the naked eye"*, he commented. The book was a great success and still ranks high today as one of the great masterpieces of microscopical literature (Inwood, 2003).

Figure 4: A detailed drawing of an ant by R. Hooke with the description on page 203 of *Micrographia*.

No original painted portrait of Hooke is known to exist. It is said that any existing portrait disappeared when Newton was elected president of the Royal Society. Despite the claim that a recently discovered portrait is considered to be the one of Hooke's (Jardine, 2004), it is still not fully accredited and/or mutually accepted as such. Nevertheless, for the educational purposes of this inquiry, for the children to have a more immediate link to the scientist and his work, a visual image of Hooke has been drawn out of the paintings of the history artist *Rita Greer*. Her paintings, based on two detailed written descriptions, aim *"to put him back into history"*, in an attempt to recreate his face and appearance.

Figure 5: 'Robert Hooke, Engineer'. A memorial portrait by the history painter *Rita Greer*, 2009.

2. (Re)constructing a simple microscope

The construction of a microscope with common and readily available materials has been the first part of the twofold objective of this inquiry. The second part has been its implementation into practice, within the framework of children's laboratory work linking it with Hooke's *Micrographia* (*see section 3*).

The initial idea for the microscope construction was one that resembled to the first *Middelburg* compound microscope, in a simplified version with one tube, two lenses and a diaphragm (Vannoni *et al.*, 2006; 2007). Thus initially the children used a PVC tube (16,5 cm length and 16 cm inner diameter) and two plastic lenses (objective and eyepiece), which had been extracted out of single-use disposable cameras. A piece of black carton was rolled and inserted inside the plastic tube, to avoid light reflections. The lenses were put inside adequate metal washers and affixed with sticky tack. To reduce colour and spherical aberration, the aperture of the objective lens needed to be reduced, thus a black rubber washer was used as a diaphragm and stuck on top of the washer of the objective lens. At the other end of the microscope tube, a black film can was cut and fixed accordingly at the eye piece, providing a smooth dark base for the observer's eye. The microscope was finally fixed inside the niche of a 2-tube base glued on a third bigger supporting tube. This base was glued with a glue-gun on a piece of cardboard and the microscope was ready for observations.

Figure 6: The materials used & the first version of the constructed microscope with 2 lenses.

The microscope tube was held onto the base with two or three elastic bands and it moved up and down to focus. The children made some initial observations on small objects, like sand, salt, but also feathers, pieces of cloth etc. A small and cheap reading spotlight was used to shed light to the objects under inspection.

Rather soon, we realized that we could make an improvement to the microscope, in order to have more precise and crisp images, with less distortion. The idea was to use an extra *field lens* to achieve this. So, by extending the microscope tube with a conjunction piece we added a third lens. Thus, an extra field lens was fixed in between the end of the initial microscope tube and the new location of the eye piece, placed at the end of the attached conjunction piece (*see fig. 7*). The microscope tube was stabilized to the supporting base with a plastic cable tie fastener, which enabled the children to focus on images and remain stable for longer observation time. The friction created by the cable tie fastener, forcing the microscope tube and its base in contact, kept it firm and steady. In order to focus on the specimen, the children now had to turn the microscope gently and simultaneously move it up and down. To reach upon this cost effective, simple solution, we had spent quite some time trying out alternative ideas, always in search for the better one, dealing with a particular problem with an intentional added value in the result.

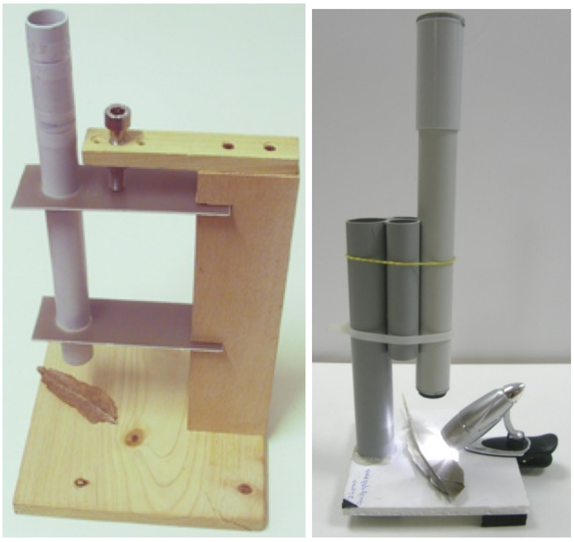

Figure 7: The improved microscope proposed by Vannoni *et al.*, 2007 (left) and the one constructed by the Primary Science Laboratory, 2009-10 (right).

These improvements have completed the construction of a simple compound microscope. In fact, we made more than 45 of them, ready to be used for microscope studies.

3. Following the footsteps of Hooke in microscope studies

The children were very curious to put their microscopes into action and investigate various specimens. In classroom discussions, after some arbitrary microscope observations, we agreed that we needed some sort of guidance to lead us along the way of microscope investigations. It was exactly at this point that the idea of linking our observations with those of a distinguished scientist came into context. Thus, Robert Hooke, in fact the first scientist to conduct systematic microscope studies in his *Micrographia*, was introduced to the children, in order to act as a scientist from the past to assist us with our studies. For this to be a successful endeavor, children had to know more about who Hooke was, starting from his early age on the Isle of White, till the writing of *Micrographia* and further on. Thus, Hooke had to be placed into a historical context, didactically transposed in an adequate manner, familiar and suitable for the children of this age. A presentation has been developed for this purpose, using many paintings of *Rita Greer*[**], the history artist, which helped a lot to visualize aspects of Hooke's life.

Figure 8: 'The Fossil Hunter'. Robert Hooke as a ten year old child on the Isle of Wight at Freshwater Bay. Oil on board by *Rita Greer*, 2005.

Robert Hooke was often sick as a child and his parents thought that he would not survive his childhood, but eventually his health improved as a teenager. His parents decided to teach him at home rather than send him to school. He developed a natural intelligence and curiosity about the world around him. Surrounded by the sea, he seams to have taken an early interest in ships and he had constructed a very detailed model toy ship (Burgan, 2008). He would have seen tall chalk cliffs on the Isle of White and worn seaside rocks. He had probably discovered fossils, remains of ancient plants and small animals preserved in the soil and rock of the island (*see fig. 8*). The young Robert also showed his artistic skills by copying paintings he saw in his family's house with impressive detail. Soon after the death of his father in 1648, Robert, at the age of 13, moved to London to begin his education as a scientist in the Westminster School, one of the oldest and best schools in England. As a teenager, he studied Euclidian geometry and learned Greek and Latin. He also developed practical skills by learning how to use the lathe, a machine used to shape wood or metal. In 1653, Hooke left Westminster and moved to Oxford University to study "natural philosophy", which included many branches of science such as physics, biology and chemistry. By the time he published *Micrographia*, in 1665, he was in his thirties, a distinguished member of the Royal Society, a polymath, a very skilful scientist and probably the first systematic microscopist.

The children were impressed by the presentation of the life story of a scientist such as Hooke and were very curious to see more closely what he had actually written and drawn in *Micrographia*. They mentioned that it would be interesting to have him alongside as a "teacher", to guide us through our own microscope studies.

Hence, for the purposes of this inquiry, seven worksheets have been designed, starting from adequately translated pieces of Hooke's text and drawings, which turned into hands-on classroom investigations and observations with similar specimens (i.e. point of needle, a printed dot, seeds of thyme, the ant). These investigations were extended to the study of other resembling specimens, which have been discussed in class and the children were curious to observe (i.e. the seeds and parts of the petunia plant, other insects like the isopods etc.). In the end, they had developed the skills and the interests to study lots of various different specimens, which were waiting for them, just outside the Science Laboratory, at the school garden. Thus, they concluded their observations with a "free study" to investigate *"something particularly of our*

[**] These paintings are available in the following URL: http://commons.wikimedia.org/wiki/Category:Paintings_by_Rita_Greer.

own", as they insisted. A brief discussion of all these studies follows in the subsequent sections.

3.1. Microscope studies on the point of a needle and a printed dot

The first two study worksheets were linked to the beginning of Hooke's studies in *Micrographia*. The worksheet on the study of *the point of the needle* is directly linked with page 1 of *Micrographia*, where Hooke comments that "we will begin these our Inquiries therefore with the Observations of Bodies of the most *simple nature* first, and so gradually proceed to those of a more *compounded* one" [emphasis in the original]. This appears to be an interesting scientific, but also didactical proposition, which we adopted with the study of the point of the needle and later with the printed dot. Both symbolise something extremely small and rather dimensionless, similar to the Euclidian "point" in geometry or the "physical point" according to Hooke, which might in fact look rather different and huge under the microscope.

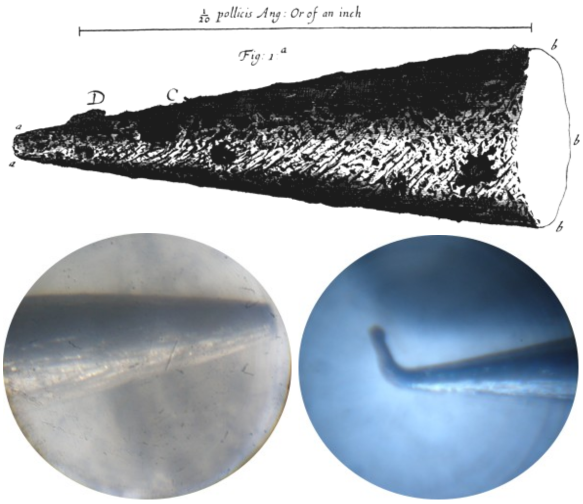

Figure 9: Hooke's drawing of the point of the needle (top) and two digital photos of needles the children observed under their microscopes.

The children read in class Hooke's description of the point of the needle, which referred to the relevant detailed drawing (*see fig. 9, top*). Then, they were invited to observe the point of a needle with their microscopes, record their own description and make their own drawings. In the beginning, they had some difficulties in finding the point of the needle and then focus on it, but rather quickly they developed skills and their own techniques, which they shared with each other. Each worksheet was kept in a plastic pocket inside a binder folder. So, at the end of children's microscope studies all of the worksheets together constituted an *observation notebook* (Klentschy, 2008; Martin, 2009).

Hooke noted that the point of the needle looked rather sharp and smooth to the naked eye, but under the microscope it *"could not hide a multitude of holes and scratches"*. A child wrote in his description that the point of a needle *"although in reality it is very straight and very sharp, under the microscope it is a bit curved and not sharp at all. It has a slight bump, probably from its bad use. At the rest part of the needle there are cracks and small bumps"*. Another child noted that *"the needle has an edge, which looks as if it is cut. It is as if it has a lot of damages on it, like long narrow bumps. It has a dark colour and a small cut. Anyhow, it is not as flat and sharp as we could imagine. At the centre the needle is more flat than at its point. Under the microscope it reminds me more of the point of a pencil"*. Although the photos of fig. 9 are not very clear, because of the inappropriate contact of the digital camera lens on the eye piece part of the microscope, it appears that the children could observe the point of the needle in a similar magnification to that of Hooke's. But, they reported a greater variety of cases, since they even found a couple of "imperfect", rather curved, needle points in each class.

Observing the printed dot, or *"a mark of full stop or period"*, Hooke mentioned that it had various irregularities and in fact it reminded him *"a great splatch (splash) of London dirt"*. One of the children wrote that *"the dots appear totally different under the microscope than with the naked eye. This one has a gray-black colour and it looks like a hairy fur ball or like a splash. It has a strange and uneven shape, which looks like the surface of the sun. At some points it appears that small sticky points are edging out of the dot"*. Another child compares a printed dot with a handwritten one and claims that the first *"has a lot of "peaks" and it appears like a big black hole"*, whereas the latter *"looks like a big cloud of smoke"* and also *"some curly pieces of hair are formed, all around the dot"*.

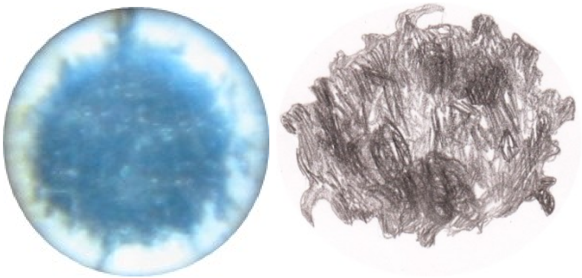

Figure 10: A digital photo of a printed dot under the microscope (left) and a child's drawing (right).

3.2. Microscope studies on the seeds of thyme and petunias

Moving on with the microscope studies, we examined *the seeds of thyme* as Hooke had also described in *Micrographia*. He noted that the seeds had a variety of shapes, whereas *"each of them exactly resembled a Lemmon or Orange dried; and this both in shape and colour"* and they were different from common seeds like beans and peas. The children used the needle, they had examined earlier, as a tool to put the small thyme seeds in place under the objective lens of the microscope and again they had to deal with some problems regarding the focus and the lighting of the specimens under inspection. Soon these were resolved with persistence and patience; virtues which children started to develop, improving their technical and methodological skills. One child wrote that some of the seeds of thyme *"have bumps and others have peaks and they look like lemons, oranges, olives and some look like "choco pop" cereals. Most of them have some small "bumps" than others which have "scratches". Most with the scratches look like nuts, whereas those with bumps look like the skin of a rotten orange and their colours are black brown or brown with black"*. Another child noted down in her worksheet that the seeds of thyme reminded her of lemons or oranges and *"they are all in a different position. There is a great variety in the volume and shape of the seeds. The seeds under the microscope have a black or a brown colour. The seeds are nosey or common like lemons. Every time we observe things they are not as we see them. The seeds look bigger and different than we see them with the naked eye. Thus, we should never say we see something unless we observe it with other methods like the microscope etc."* The latter statement appears to be an interesting epistemological note.

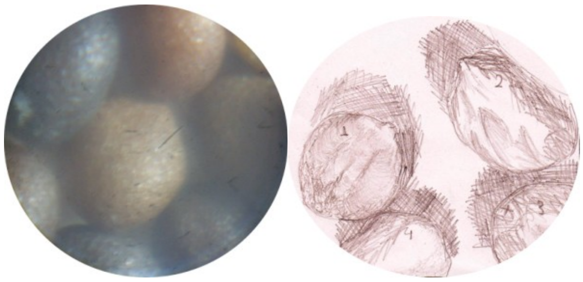

Figure 11: A digital photo of seeds of thyme under the microscope (left) and a child's drawing (right). Notice the shadows she has observed and drawn, created by the small reading spotlight lamp, which illuminated the seeds from an angle.

When the children were preparing their seed plants to be raised in the greenhouse of the organic school garden, they were impressed about the small size of some seeds. The smallest seeds they had planted were the petunia seeds. Hence, they were very interested to observe them under the microscope and this is exactly what happened as an extended investigation, following the one on the seeds of thyme. A child commented that *"the colour of the petunia seeds is dark brown. Their shape is round and they have holes and bumps. They look like small insects. In front they have something like a piece of string hanging out, whereas the back side is a bit round"*. Another child wrote that the petunia seeds *"are very small and different to those of thyme, but under the microscope they look rather big. They remind me of raisins, rotten fruits, cereals, small olives etc. They look like small bumpy marbles with brown colour"*.

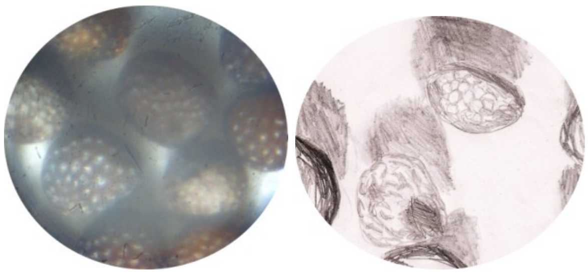

Figure 12: A digital photo of seeds of petunia (left) and a child's drawing (right).

The children went on to observe parts of the petunia plants they brought out of the greenhouse at the time of the microscope studies. One child inspecting a petunia leaf recorded that it was very strange, since *"petunias are beautiful plants, but you never know what they are hiding. Their leaves have very small white hair on their surface and they glitter as they stick out of the* *leaf, but they also look a bit transparent"*. Another child noted that *"the roots of petunias look like hands with fingers sticking out, with some soil on them and short hair. The roots are very small and thin, but I can see them clearly."*

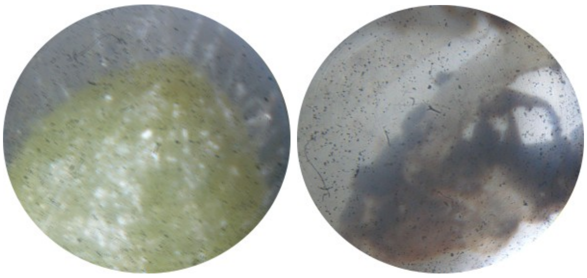

Figure 13: A digital photo of the tip of a "hairy" petunia leaf (left) and petunia roots with some soil (right).

3.3. Microscope studies on insects like ants and isopods

The next study was an investigation on insects, an *"insectigation"* in a creative term (Blobaum, 2005). Hooke had conducted several studies of insects in *Micrographia*, but one of his most descriptive and at the same time more familiar to primary school children is the one on the ant. He mentions that he had a hard time trying to keep the ant steady under the microscope for observation. Having selected some ants he *"made choice of the tallest grown among them, and separating it from the rest, gave it a Gill of Brandy, or Spirit of Wine, which after a while knocked him down dead drunk, so that he became moveless, though at first putting in he struggled for a pretty while very much, till at last, certain bubbles issuing out of its mouth, it ceased to move"*. Then he was able to take the ant under the microscope and study it (*see fig. 4*), although after an hour or so *"upon a sudden, as if it had been awaken out of a drunken sleep, it suddenly revived and ran away"*. He records that this could happen a few more times, so he could inspect the insect without killing it.

The children found this whole process rather strange at first, but fascinating later on, since they had to deal with the exactly same problem in their study of the ant. So, they went out in the school garden "hunting for ants" to be kept in small plastic pots filled with alcohol lotion. They observed that the ants were "unconscious" after 10 minutes in the alcohol lotion, ready to be put under the microscope for inspection. All of a sudden, most of them revived and started moving after 20 to 30 minutes or so. In this way most of the children managed to observe the ants in a steady position, but also in motion and they were very thrilled to be able to do so.

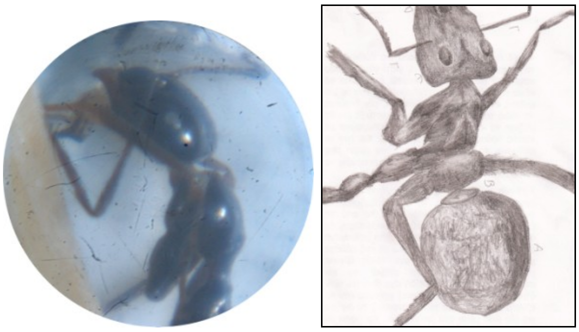

Figure 14: A digital photo of an ant held down with a tooth stick (left) and a drawing of an ant by a child, with letters in various parts of its body for text descriptions (right).

One child mentions that *"the ant was very difficult for me to draw, since it did not easily stay in its position. When I took the ant out of the alcohol lotion it was asleep and I could observe it for a while and I started drawing it, but after 15 minutes it woke up and started moving again. The shape of its head is triangular and its eyes are sticking out. It has a big mouth with bumpy sawing teeth and it also has two long horns in front. The biggest part of its body was its belly, which is connected to its legs with some sort of small waist. Over all, it is a very strange insect under the microscope and it surprised me when I saw it so big for first time"*.

The children decided to look at another very common insect of the school garden, which was the *isopod* (*Armadillidium nasatum*). They knew that they could find them in dark and wet places, under rocks or grass. So, now they went for "isopods hunting" in the garden and they also collected them in small plastic pots filled with alcohol lotion. Similarly to the ants, the isopods fell "unconscious" for a while, but then again they revived after 15 minutes or so. The children observed the isopods in whole, but also some of their parts like their legs, heads etc.

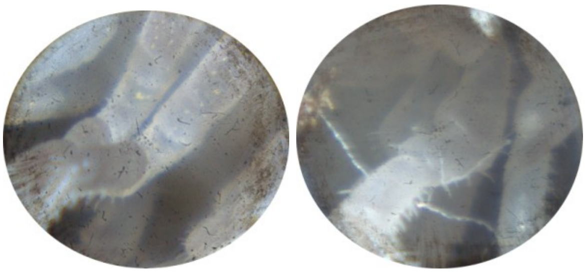

Figure 15: The legs of the isopods under study.

A child, describing the isopod, comments that *"it is like an insect with a suit of armour all over. Its body also reminds me of a stair, challenging me to climb up the steps. Its front part has two horns, which have something like joints. There is also something like a mouth in front and a sort of tail at the rear part of its body; a strange insect indeed."*

Figure 16: Drawings of an isopod & its legs.

3.4. A free microscope study

By this time, the children had performed several investigations and they had developed interests in various organisms, plants and insects, they wanted to examine more carefully. Hence, they went once again to the school garden to collect their specimens and examine them under the microscope. They brought back different kinds of leaves and flowers, but also all kinds of insects from bees to spiders etc. They observed them thoroughly and they created their own final worksheet.

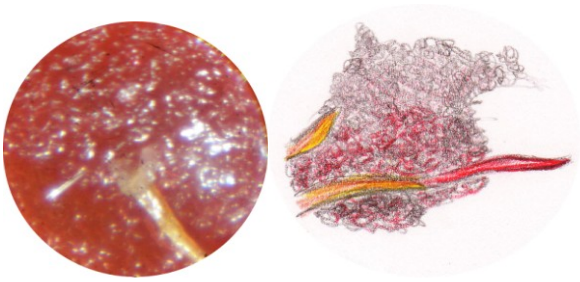

Figure 17: Photo and drawing of a raspberry with "some sort of tinny horns hanging out of it".

One child, for example, collected and observed a raspberry and was impressed by its *"bright red colour, which looks like a small red ball with some sort of tinny yellow horns hanging out of it. Observing them more carefully I found out that they look like yellow hair magnified by the microscope"* (*see fig. 17*).

4. Concluding remarks

It appears that the children have been mentally and emotionally involved in their microscope studies and they have been led with interest into their investigations and observations. The microscope studies, as approached through the texts and drawings of Hooke, appear to enroll elements of intentionality with an increased interest for the outcome and the recorded observations. During the process of recording the observations and/or descriptions, it was noticed that they came about smoothly, whereas the framework of the activity seemed to have facilitated and enhanced the text production and drawings.

The descriptions produced seem to have an initial influence from those of Hooke, whereas they are simultaneously developed and enriched within a concurrent field of language and communication. The drawings, either simple or more complex and more descriptive, appear to be created by children with interest and commitment, because they claim that they want to work in a "scientific" way as Hooke has done. Even if some children complain that they cannot make "nice drawings", they get into the endeavour of "drawing something" and attempt to comment on it verbally.

It appears that the whole framework of these microscope studies has elements of authenticity and the children get into the process of *"doing science themselves"*. The character and nature of science is being demystified as it becomes an everyday activity dealing with an instrument, the microscope, constructed by children themselves with simple and common materials. Yet, it appears to introduce them "naturally" to a framework of scientific study and investigation.

5. References

[1] Blobaum, C. (2005) *Insectigations: 40 hands-on activities to explore the insect world*. Chicago: Chicago Review Press.

[2] Bradbury, S. (1967). *The Evolution of the Microscope*. Pergamon Press Ltd, Oxford, London.

[3] Burgan, M. (2008). *Robert Hooke: Natural Philosopher and scientific explorer*. Compass Point Books: Minneapolis, Minnesota.

[4] Hooke, R. (1665). *Micrographia.* Royal Society, London.

[5] Inwood, S. (2003). *The forgotten genius: The biography of Robert Hooke 1635-1703*. MacAdam/Cage.

[6] Jardine, L. (2004). *The curious life of Robert Hooke*. HarperCollins Publishers Inc.:NY.

[7] Klentschy M. (2008). *Using Science Notebooks in elementary classrooms*. NSTA Press: Arlington, Virginia.

[8] Martin, D.J. (2009). *Elementary Science Methods: A constructivist approach*. Thomson Wadsworth.

[9] Vannoni M. & Molesini G. (2006). Constructing a microscope. Instituto e Museo di Storia della Scienza, Florence, Italy. [Available at the following URL: < http://brunelleschi.imss.fi.it/esplora/microscopio/dswmedia/risorse/erisorse.html >].

[10] Vannoni M., Buah-Bassuah P. K. & Molesini G. (2007). Making a microscope with readily available materials. *Physics Education*, 42(4): 385-390.