Setlhare
science curriculum trust

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Report on the *Planet Earth and Beyond* courses, dealing with CAPS content for primary and secondary schools

Contents

Dates and participants

The course was held on 30 September and 1 October 2014. The people who attended were

Edgar Mupfumira

Estelle Jonker

Ruth-Anne Holm

Martha Sibanyoni

Lindiwe Maleta

Sakepi Mlobane

Margie Chinn

The intended outcomes of the course

The intended outcome of Setlhare courses is that participants will have personal satisfaction in teaching challenging lessons. We think that in lessons like this, teachers generally ask the students questions that call for creative thinking and, over time, students begin to ask questions about nature, and look for real equipment to try to answer those questions.

Good questions that call for creative thinking are based on **process skills**; when children are using process skills they are doing these kinds of mental activities:

Observing, comparing, making measurements, recording observations and measurements, looking for patterns in those records, predicting from a pattern, making hypotheses about why the pattern exists, thinking of ways to test hypotheses, finding suitable language to express relationships between variables, using models to communicate their understanding or using models to see whether an hypothesis makes sense.

Each of these skills came up at least once during the course's practical or paper-based activities. These activities are shown in the course hand-outs.

The activities and content in the course address each of the Learning Outcomes, now known in the CAPS as "Specific Aims".

Specific Aim 1: 'Doing Science and Technology'

Learners should be able to complete investigations, analyse problems and use practical processes and skills in designing and evaluating solutions. This means that learners plan and do simple investigations and solve problems that need some practical ability.

Specific Aim 2: 'Understanding and connecting ideas'

Learners should have a grasp of scientific, technological and environmental knowledge and be able to apply it in new contexts. The main task of teaching is to build a framework of knowledge for learners and to help them make connections between the ideas and concepts in their minds – this is different to learners just knowing a lot of facts. Learners must make connections between new ideas and previous experiences and knowledge.

Specific Aim 3: 'Science, Technology and Society'

Learners should understand the practical uses of Natural Sciences and Technology in society and the environment and have values that make them caring and creative citizens. Issues such as improving water quality, growing food without damaging the land, and building energy-efficient houses are examples of everyday applications. Similarly, Science and Technology can lead learners to a range of career and job possibilities. An appreciation of the history of scientific discoveries and technological solutions, and their relationship to indigenous knowledge and different world views, enriches our understanding of the connections between Science, Technology and Society.

The key knowledge areas in the course

The course was advertised for Grade 4 - 9 teachers, but since everyone who took part was from primary schools, we touched only lightly on topics that are done in Grade 9.

1. A little history of ancient astronomy and why people wanted to record changes in the sky; developments since the time of Copernicus in the 16th century through to the modern astronomy and the study of the cosmos.
2. Locating oneself on a ball-shaped Earth; why there are the cardinal points north, south, east and west. The relationship of the cardinal points to the directions of magnetic compasses.
3. Changes in the sky over the course on one day or one night; apparent motions of the Sun, Moon and stars. How we measure time and why clock times are different in different countries
4. Changes in the sky over the course of a year: the changing positions of the Sun, the seasons, the annual shift in constellations of stars.

5. Planets' orbits and the solar system
6. The motions of the Moon around the Earth, and the Earth around the Sun
7. Universal gravitation and how it holds the planets in their orbits around the Sun, the Moon in its orbit around the Earth, man-made satellites in their orbits around the Earth and the stars in their motions around the centre of a galaxy
8. Gravity force between the Moon and the Earth, and the tides in the oceans

The course methodology

It would be possible to cover the knowledge areas above by means of slides, demonstrations, videos and printed notes. This could be done quite quickly, but this approach would not address the intended outcomes and Specific Aims and it's very unlikely that this approach would promote process skills and practical work in lessons. The significance of practical work lessons is that pupils experience real matter and materials, and can talk about them and develop the language they need for thinking scientifically.

We all tend to teach in the way we were taught, so it's very important for a course leader to model the approach practically, with real equipment.

During the courses I give files with notes and internet references and refer teachers to them but seldom teach directly from those notes. Teachers are able to read for themselves, so it is better to use the time for interacting with the equipment and each other.

Some reflections on the course

On the first day everyone wrote a personal baseline test, which was a set of 10 questions on aspects of the astronomy curriculum; the questions were more like the kind of difficult questions pupils sometimes ask, rather than factual stuff from the official curriculum. In other words, the questions were mostly not about the things one can learn from a textbook. Naturally, there were a number of questions people could not answer – if they could answer them all, they would not need to come on the course!

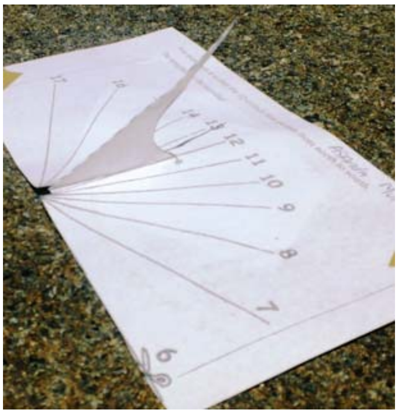
Usually on these courses, people get to write the same test (called the post-test) at the end and then they can compare their before-and-after knowledge. We ran out of time on the last day and so I had to simply give out the answers for people to mark their own pre-test.

Figure 1: *A shadow stick – checking yesterday's record of times.*

One of the basic problems to overcome in the this part of the curriculum is that most people are simply not aware of what is happening and changing in the sky above us. Many children now have a new reality that happens on iPad and smartphone screens. How do we widen their awareness from a manufactured electronic world to the great big reality of the heavenly bodies and the universe?

Well, perhaps the simple shadow-stick activities are more important than they look. The shifting position of the shadow makes children aware of something moving, unstoppable but predictable. Unlike a video game, we can do nothing to manipulate this reality of the angle and speed of the shadow – this is truly The Real Thing. The sundials capture their attention, I think, because the little sundials connect them to this unstoppable movement.

An example of the paper sundials we used on the course, now taped to the playground at McCauley House school. The time on the sundial is about 12:50.



The girls have lined up the gnomons of their sundials in the north-south direction and the sundials are showing a time of about 12:30. (We have permission to show the girls' faces.)

Observing the shape and position of the Moon every night

Observing the shape and position of the Moon every night for a week is another simple activity that raises awareness that the Earth is in Space with other huge, moving bodies.

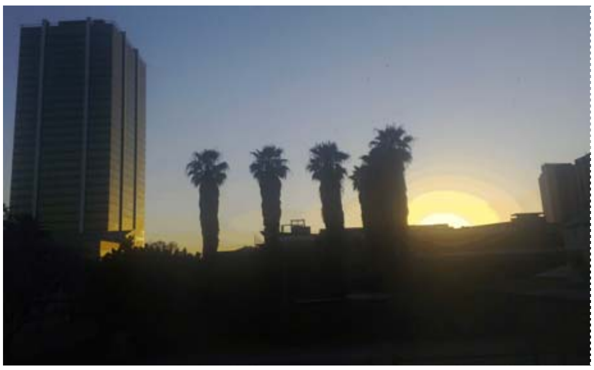
Of course the other thing that the shadow-stick activity does is to show the meaning of "east" and "west", and from those two directions we get the directions north and south. North and south are not places but directions; wherever we are, we can identify north and south direction if we know where the Sun comes up, or if we can find the Southern Cross. So each child can identify a north-marker and a south-marker at the place where they live.

Observing the shift in sunrise time and position as the year advances

Edgar has taken some photos that brilliantly show the changing time and position of the sunrise as the year goes by. Look at these:

Figure 4: *Sunrise was between trees 3 and 4 on 27 September 2014 at 6:04.*

Figure 5: *But sunrise was more to the south, to the right of Tree 4, on 19 October 2014 at 5:40.*



These two photos illustrate just why the ancients erected standing stones in Africa, Scotland, Ireland, England and Europe. Any observatory needs some fixed points – you measure changes by measuring from those fixed points – and the trees act as those fixed points in Edgar's photos.

The Earth globes were important and necessary for understanding seasons

The small globes turned out to be very necessary learning tools, and it was important to have so many. For a class, I would suggest that you need about one small globe for every 3 children. They don't have to be top-quality globes; one must just be able to find South Africa and other countries on them, the equator must be clear, and the stand must hold them at an angle of about 23.5° from the vertical. Try looking in places like China Mall.

We had to have the globes, with the axis at 23.5° from the vertical, to understand the seasons (Grade 7 in the CAPS). I think the 100 watt or 200 watt bright bulb in the middle of the room was also essential, to model the Sun that radiates light in all directions. The seasons change because the Earth moves in a near-circle around the Sun. So a torch just won't show that.

The activity is a modelling activity. It has 2 requirements (a) that the children move the globes in the right way and (b) that they predict from the model.

The axis through the Earth – that is, the top point of the stand – has to point at the same spot on the ceiling all the time. Paste a paper star on the ceiling in one **corner** of the room, to give them an aiming point. The north end of the real Earth axis points at the Pole Star (which you can see only in the northern hemisphere). So when the children are walking with their globes, you have to watch carefully that they keep the axis pointing at that star up in the corner.

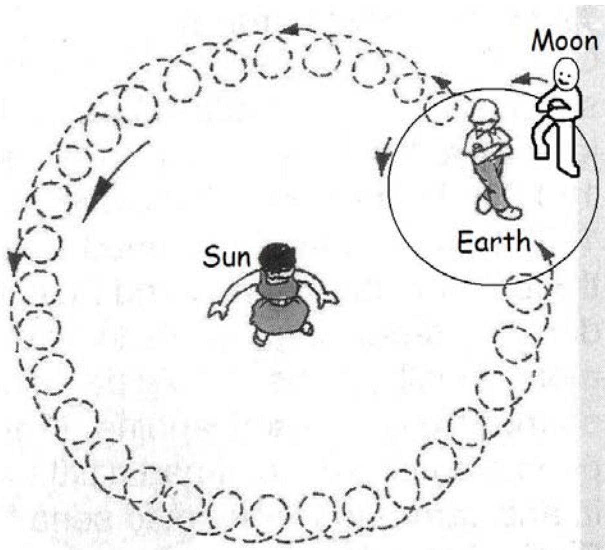
Questions to ask **individual** pupils are:

- Look at your globe and how the light is falling on South Africa. Now work out if it's winter or summer in South Africa. (The answer will depend on where the pupil is standing on the orbit around the "Sun")
- Walk around the orbit until it's winter in South Africa. Show me why you say it's winter.
- How long will it take for the season to be summer? Also show me where you will stand on the orbit so that it's summer in South Africa.

Modelling the motions of Earth and Moon around the Sun

Something good came up by accident when we were doing the drama model of the motions of the Earth-Moon-Sun system. Estelle was in the middle as the Sun, Martha was modelling the Earth (spins around and also moves in a circle around the Sun) and Edgar was modelling the Moon (moves around the Earth while Earth spins and moves around the Sun). We realised that though the Moon does spin, we don't see that spin from Earth, because **the same side of the Moon always faces the Earth**. So, in our model, Edgar had to orbit slowly around the Earth in such a way that he was always facing Martha. However, the rest of us were looking at him from far away (as though we were somewhere out in Space). To us it was clear that he **did** spin: he began facing us, and then he faced the one wall, and then another wall, and finally

Figure 6: *The Earth spins about 365 times as it orbits the Sun once, and the Moon orbits roughly 12 times around the Earth in the same time.*



he came back to facing us. That's one spin (called a rotation). [1]

This sort of model is called a drama model; we need to prepare a group of children beforehand to act it out, because it's complicated the first time you do it. Then the model group is like a demonstration – we can tell the class to watch carefully and then answer questions like,

- When Martha ("Earth") spins and faces away from Estelle ("Sun"), is this like day or night on Earth?
- How many times does this facing-away really happen on Earth in a year?
- Edgar ("Moon") moves slowly around Martha ("Earth"); how long does it really take for the real Moon to go once around the Earth? (The answer, by the way, is 27.3 days but the Earth has moved on in the meantime, so the Moon needs 29.5 days to get back to the same position relative to the Earth, so that it's 29.5 days from full Moon to the next full Moon.)
- Is there a way to find out what the far side of the Moon looks like?
- Is the far side of the Moon always dark? Why not? How long between each sunrise, if you were at any spot on the Moon? (Answer is about two weeks)

The solar system model

We did not have time to act out this model, but if my memory is good, Estelle said she has done it with one of her classes. Choose a soccer ball to represent the Sun; then Jupiter is 123 m away (about the diagonal of a soccer field) and Saturn is 225 m away. Neptune is somewhere

Figure 7: *Pupils are surprised to find how far apart the planets are.*

outside the school at 707 m. The small sizes of the planets and the great distances between them is quite a surprise to the children, who are used to illustrations of the solar system that fit onto one page. Earth is the size of half a grain of rice, and Saturn the size of a marble. (You'll find this info in the handout I gave you.)

No wonder spacecraft take so many years to reach planets like Saturn. Use Google to find Voyager 1 on Wikipaedia. Launched in 1977, and travelling at 17 kilometres **per second**, it has taken 37 years to reach the outer limits of the solar system.

What I find fascinating is this: the force of gravity between, for example, the Sun and Neptune, acts over those 4 488 million kilometres, to hold Neptune in its orbit.

1 Most of the hand-drawn illustrations are from the Setlhare textbooks, titled *Science for All*, and are used by permission of the publisher Macmillan SA

A mnemonic for remembering the name of the planets in order

We forgot to make up one! Have you got some good ones? If so, please share them. Find some at http://www.teachingideas.co.uk/science/orderingplanets.htm By the way, the planet Venus is also known as *Ikhwezi* or *Naledi ya masa* in several other South African languages.

The model of the phases of the Moon

I realised from this activity how important it is for each pupil to have his or her own Moon model (orange, or ping-pong ball, or some light-coloured ball). They have to do it themselves – they have to **be** the Earth – to see the phases of the Moon. We can't demonstrate it because they won't see what we see.

By the way, for this activity you don't have to have a bright lamp in the middle of the room. You can shine real brilliant sunlight into the room. Arrange a large mirror outside, prop it up on a chair, and angle it so that the Sun shines in through the door or window.

Figure 8: *Each pupil must do it for herself.*

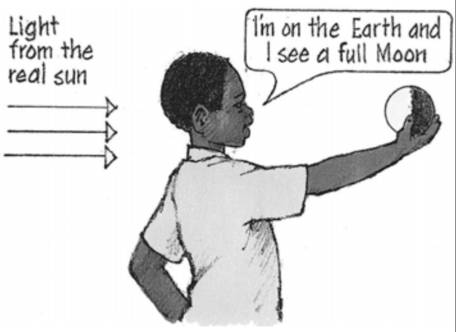


Figure 9: *You can get bright light into the room this way. In this picture, they are working out why some countries have day at the same time other countries have night. But it works for Moon phases also.*

Making the phone call at sunset and sunrise

Thanks to Margie and Lindiwe for calling the subject adviser in Calvinia. We should have found and marked the position of Calvinia on the globes. It is about 600 km to the west of Johannesburg, and not far from the sea. We found that the Sun went down about 36 minutes later in Calvinia, than in Jo'burg. That could only happen if the Earth is round like a ball. It could not happen if the Earth were flat.

I think it's interesting to see how much we could do in a practical way. Some people think that because astronomy is about far-away objects teachers can only talk about the planets, etc. But we were out of our seats and doing activities about half the time.

Evaluation comments from teachers

Teachers wrote comments along with rating the sessions and activities. The ratings were generally good. I have extracted some of the comments below. If they seem a bit glowing, it is because there were no negative remarks among them for me to quote.

. . . It was very informative and an eye-opener on most areas of the course. Thank you very much for explaining things so well.

Course was excellent [will] *you come in schools to demonstrate this to our learners?*

Thanks! This course was VERY helpful!!!

The course was very informative and useful to my teaching. I am going away with more confidence to teach the work covered in the course.

I thoroughly enjoyed the course. It cleared up a lot of misconceptions for me personally. It was done in a way that we could grasp the concepts and use in our teaching. I am feeling very inspired. It held my attention at all times. Thank you. ☺

Then there were emails afterwards which were really the best kind of evaluation comment, because they show that the children also did course activities. For example, Edgar wrote

I did the sundial with Grade 5s and the whole school loved the concept....the grades 8 and 9 said how come you didn't teach us this? Will also send the pics that I took. (He did send the pictures, you saw some of them above)