4.3 Case study 3 (CS3 Greece)

Concept Focus	White light and primary colours
Activities implemented	Activity D, Activity E
Inquiry skills	Planning investigations Forming coherent arguments
Scientific reasoning and literacy	Scientific reasoning (drawing conclusions, making comparisons)
Assessment methods	Classroom dialogue Teacher observation Worksheets
Student group	**Grade:** lower second level **Age:** 12-13 years **Group composition:** mixed gender and ability; 24 students **Prior experience with inquiry:** None

This case study looked at two activities – exploring white light and filters and exploring primary colours. In addition to prisms, the teacher utilised some online resources to aid student learning and encouraged students to observe pixels in their mobile using a magnifying glass. Classroom dialogue was a key method for assessment of skill in *forming coherent arguments* and *planning investigations*, while the teacher also evaluated students' worksheets using the rubrics proposed in the unit.

(i) How was the learning sequence adapted?

The **Light** SAILS unit was implemented in a single 120-minute lesson. Activities investigated were Activity D: Exploring white light and filters and Activity E: Exploring primary colours. The learning sequence followed the steps described in the unit without significant modifications.

The teacher started the lesson by announcing to the students the problem of the investigation. The teacher divided the students into groups of 3-4 members and then described the steps of the research process. Each group tried to carry out the first activity, i.e. to project light through a prism onto a white sheet of paper. The teacher asked all the students to carry out the experiment. All the students completed the task, some students with the help of the teacher or the help of their group schoolmates.

Then, the teacher presented the two alternative explanations for this phenomenon (either the prism "converts" white light into coloured light or white light is a mixture of colours that are subsequently "separated" by the prism through different angles) and asked from students to plan an investigation in order to resolve this issue. The teacher raised the following questions:

- What would you look for?
- Do you need any other equipment?
- What can you do in order to get as trustworthy results as possible?

There were a lot of discussions between the groups. At the end each student wrote his/her own suggestions in the worksheet. The answers showed that students did not find the ideal solution, however there were students who suggested the use of two prisms. Others suggested formation of rainbows as another experiment. Many students were lost in finding what they had to do.

Then the teacher introduced the coloured filters. He showed the suggested experiment to students and he also used the recommended resources from freezeray.com:

- http://freezeray.com/flashFiles/prism.htm
- http://freezeray.com/flashFiles/colouredFilters.htm

The teacher asked students to play with these applets in order to investigate the effect of different coloured filters. The students liked this activity very much. Then, they completed the next two activities of the worksheet. After the completion of the activities the teacher returned to the previous issue of the two alternative explanations for the phenomenon and asked students now to explain which of the two possibilities is supported by their observations through the use of filters (*forming coherent arguments*). Most of the students reported justified answers.

In the next hour the teacher focused on Activity E: Exploring primary colours (understanding that white light can be produced by mixing red, green and blue light). The teacher announced to the students that they would play with colours, and then raised the following questions (*planning investigations*):

- Is it possible to create white light without using the seven colours of the rainbow?
- Can you suggest an experiment that might be able to answer this question?
- What kind of equipment would you need?
- What can you do in order to get as trustworthy results as possible?

After discussions in groups, the students wrote their answers on a worksheet. Almost all the groups suggested combining the coloured lights. However, there were some students that mentioned this would be a hard process because there will be a lot of combinations and it would be better to find something faster. Two students wrote that they could use a computer to make the experiment but they don't know how to program this. In general, this activity engaged a lot the students and they actually faced with the scientific methodology when they study a phenomenon.

After that, the teacher proceeded to the suggested experiment using the red, green and blue filters. After various combinations and discussions the students realised that these three colours can produce a large amount of different colours as well as white light. Then the teacher asked from students to play an online game provided by the Centre for Applied Research in Educational Technologies (CARET) at the University of Cambridge. The game includes two modes (a) the mode of mixing light colours and (b) the mode of mixing paints. The teacher asked from students to observe and write their findings in the related activities of the worksheet.

Finally, the teacher asked from students to examine the pixels of their mobile phone screen using a magnifying glass in order to verify the usage of red, green and blue light mixing. Students were really impressed.

(ii) Which skills were to be assessed?

In this case study, the inquiry skills assessed were *planning investigations* and *forming coherent arguments*. The teacher used the suggested rubrics from the original unit. For the skill *forming coherent arguments* he used the rubric named “interpreting results and drawing conclusions.” The teacher observed the students during the activities by giving feedback. The suggested rubrics were used on the written artefacts.

(iii) Criteria for judging assessment data

Planning investigations

For the assessment of this skill the teacher used the following criteria:

1. The student suggests how an investigation might be designed, but not in detail (very poor design).
2. The student suggests how an investigation might be designed, but where the design is incomplete in respect to (a), (b), (c) of the next criterion.

3. The student suggests an investigation, where the design includes: (a) Which variables to change and which to be held constant, (b) In which order to perform different parts of the investigation, (c) Which equipment to be used.

Forming coherent arguments (interpreting results and drawing conclusions)

For the assessment of this skill the teacher used the following criteria:

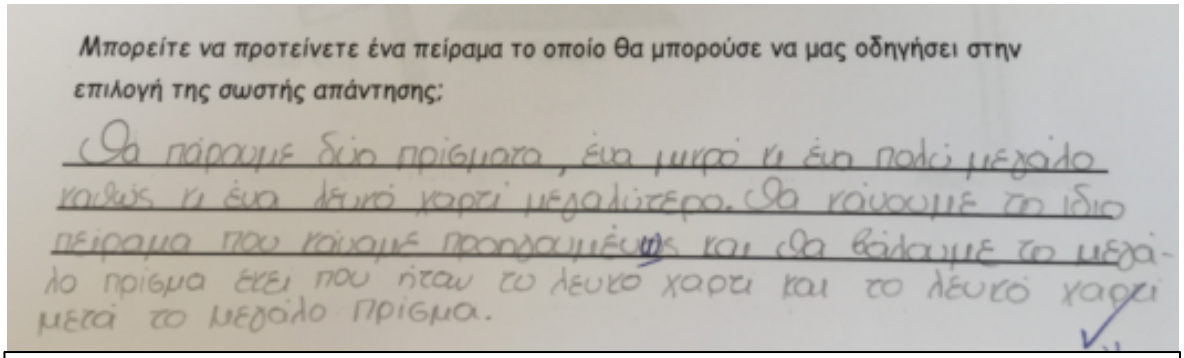
1. The student...
   ...draws conclusions, but only uses a limited amount of the results from the investigation
   …compares the results from the investigation with the hypothesis.
2. The student...
   ...draws conclusions based on the results from the investigation
   ...compares the results from the investigation with the hypothesis.
3. The student...
   ...draws conclusions based on the results from the investigation.
   ...relates the conclusions to scientific concepts (or possibly models and theories)
   ...compares the results from the investigation with the hypothesis.
   ...reasons about different interpretation of the results.

(iv) Evidence collected

Teacher opinion

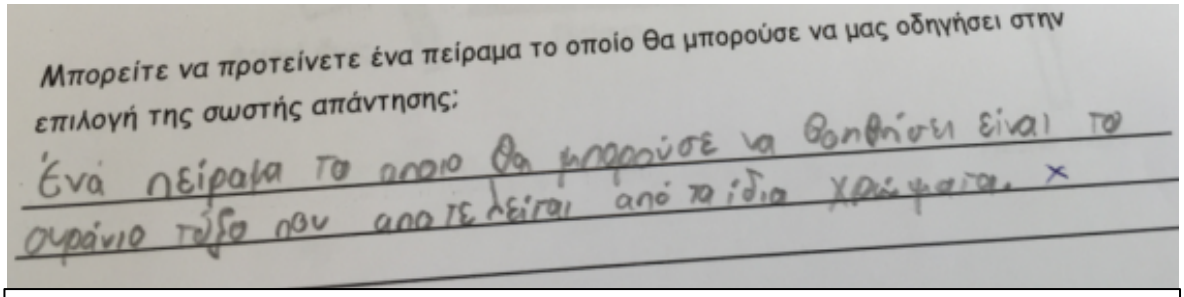
The students were motivated and enjoyed the activities, especially the activities with the coloured filters, the game activity and the examination of mobile screens' pixels. The teacher tried to use the suggested rubric sheets for assessing the skills.

Sample student artefacts

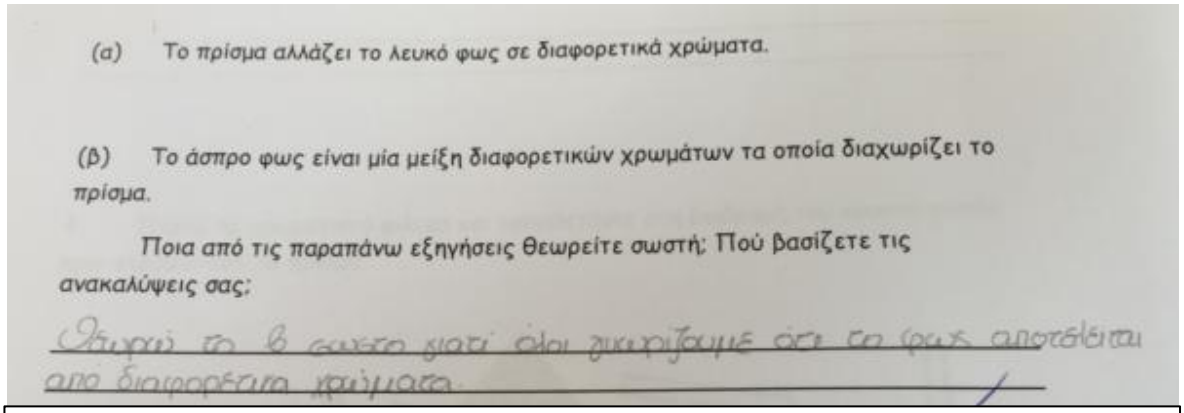

Μπορείτε να προτείνετε ένα πείραμα το οποίο θα μπορούσε να μας οδηγήσει στην επιλογή της σωστής απάντησης;

Θα παίρναμε δύο πρίσματα, ένα μικρό κι ένα πολύ μεγάλο καθώς κι ένα λευκό χαρτί μεγαλύτερο. Θα κάναμε το ίδιο πείραμα που κάναμε προηγουμένως και θα βάζαμε το μεγάλο πρίσμα έτσι που ήταν το λευκό χαρτί και το λευκό χαρτί μετά το μεγάλο πρίσμα.

The above group suggests an experiment that will involve the use of ***"two prisms a small and a big one; one after the other, the big one should be put at the same position where it was the white sheet of paper before."*** When the teacher asked why do you need a bigger prism they said in order to have enough space to fit all the colors.

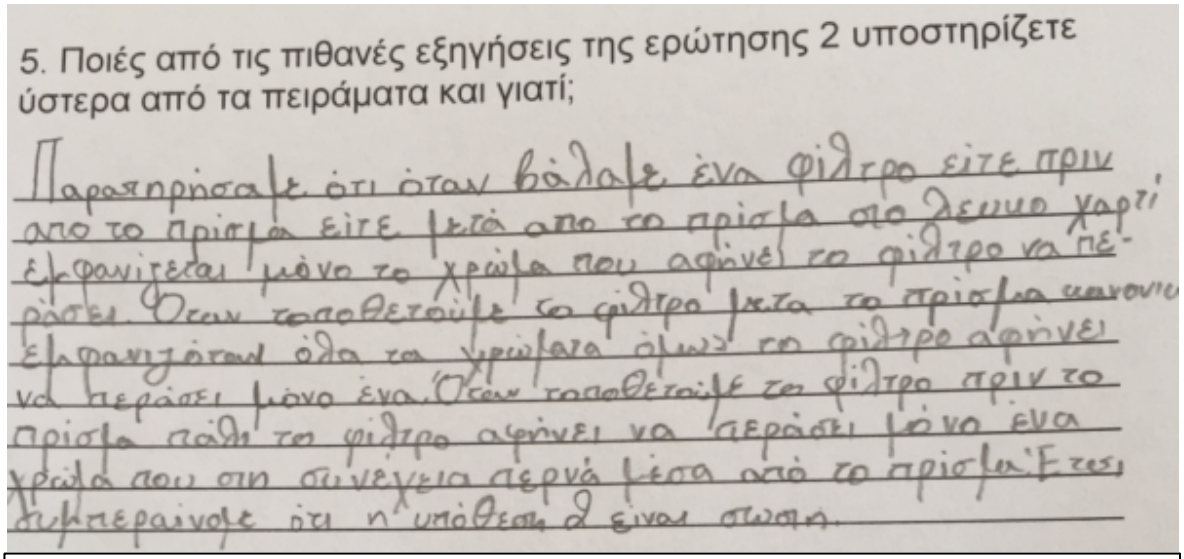


This group suggests the phenomenon of rainbow formation as an evidence that white light is a mixture of different colours. According to the teacher, the underlying group just recalled material from previous class.



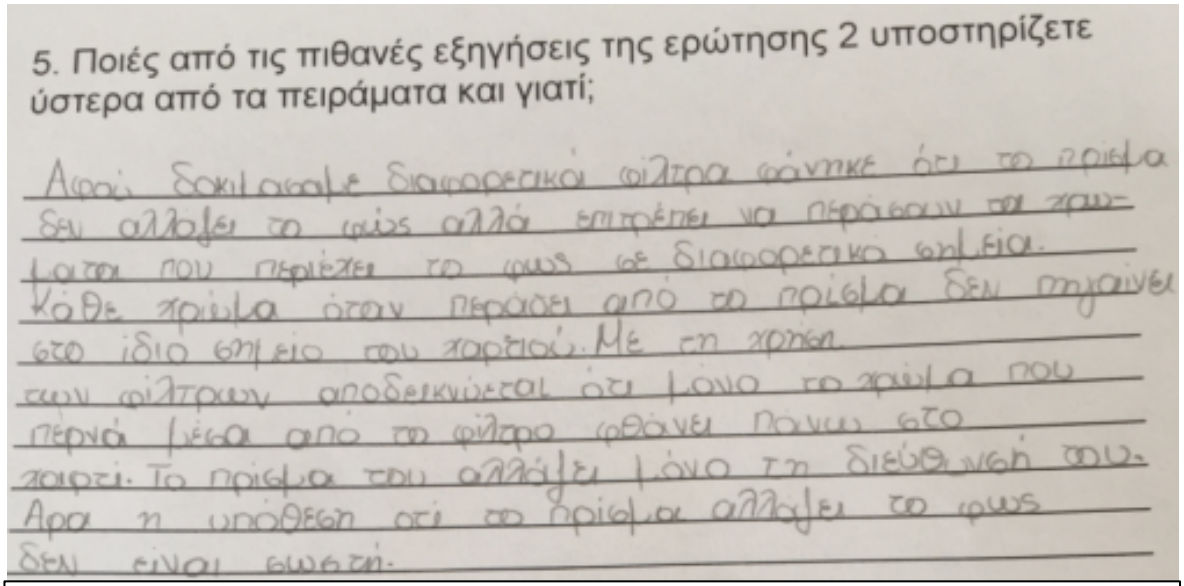
There are two possible explanations for the colours you have observed on the screen. These are:
(a) The prism changes white light into different colours
(b) White light is a mixture of different colours to begin with and the prism separates them
Which of these explanations is correct? How do you know based on your observations?

Most student know that the second option is the correct but they can't formulate an acceptable argument (in relation to the experiment with the prism). This group just wrote that "***we know it from previous class***."


5. Ποιές από τις πιθανές εξηγήσεις της ερώτησης 2 υποστηρίζετε ύστερα από τα πειράματα και γιατί;

Παρατηρήσαμε ότι όταν βάλαμε ένα φίλτρο είτε πριν από το πρίσμα είτε μετά από το πρίσμα στο λευκό χαρτί εμφανίζεται μόνο το χρώμα που αφήνει το φίλτρο να περάσει. Όταν τοποθετούμε το φίλτρο μετά το πρίσμα εμφανιζόταν όλα τα χρώματα αλλά το φίλτρο αφήνει να περάσει μόνο ένα. Όταν τοποθετούμε το φίλτρο πριν το πρίσμα πάλι το φίλτρο αφήνει να περάσει μόνο ένα χρώμα που στη συνέχεια περνά μέσα από το πρίσμα. Έτσι συμπεραίνουμε ότι η υπόθεση 2 είναι σωστή.

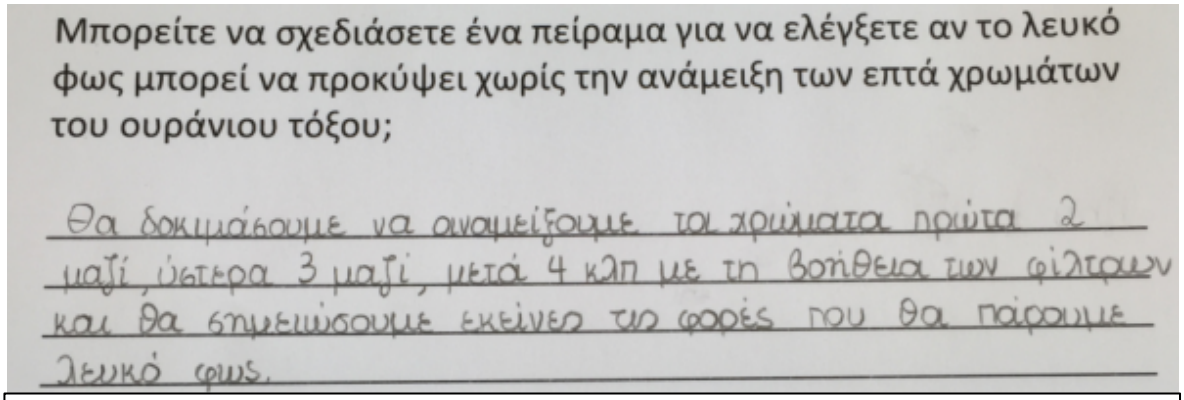
"We noticed that when we put a filter either before or after the prism in the white paper appears only the color that permits the filter to pass through. When we place the filter after the prism it is clear that from all colors that came out of the prism the filter leaves to pass just one. When we put the filter before the prism again the filter lets pass only one colour, which then passes through the prism. Thus we conclude that the 2nd hypothesis is the correct one." The group shows that it can draw conclusions based on the results from the investigation as well as it can compare the results from the investigation with the hypothesis.


5. Ποιές από τις πιθανές εξηγήσεις της ερώτησης 2 υποστηρίζετε ύστερα από τα πειράματα και γιατί;

Αφού δοκιμάσαμε διαφορετικά φίλτρα φάνηκε ότι το πρίσμα δεν αλλάζει το φως αλλά επιτρέπει να περάσουν τα χρώματα που περιέχει το φως σε διαφορετικά σημεία. Κάθε χρώμα όταν περάσει από το πρίσμα δεν πηγαίνει στο ίδιο σημείο του χαρτιού. Με τη χρήση των φίλτρων αποδεικνύεται ότι μόνο το χρώμα που περνά μέσα από το φίλτρο φθάνει πάνω στο χαρτί. Το πρίσμα του αλλάζει μόνο τη διεύθυνσή του. Άρα η υπόθεση ότι το πρίσμα αλλάζει το φως δεν είναι σωστή.

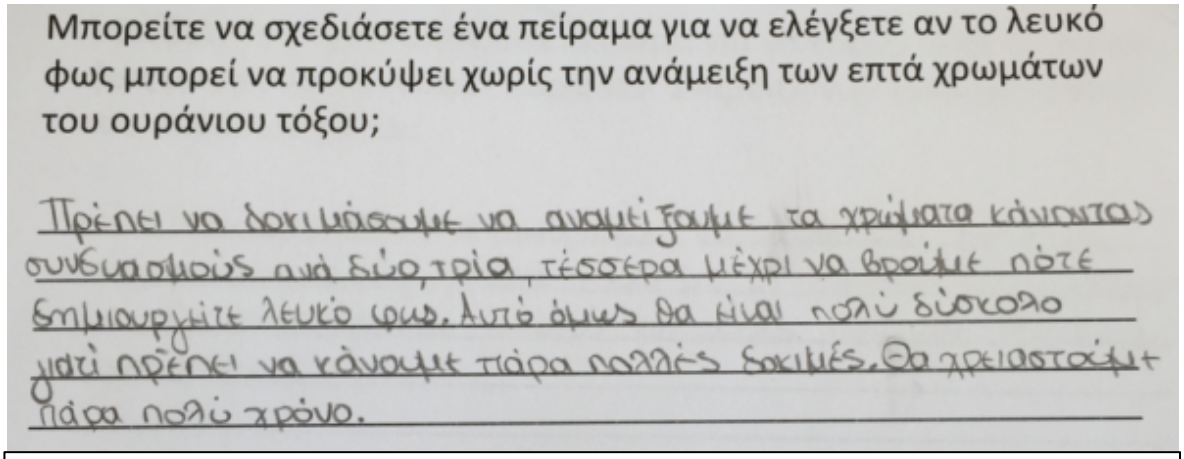
Moreover, the next group shows more deep understanding that scores the best because it says ***"After trying different filters we observed that the prism does not change the light but allows to pass the colors included in the white light at different points on the white paper. Each color when passes through the prism does not go to the same point of the white paper. By use of the filters proved that only the color passing through the filter reaches the white paper at the same spot. The prism only changes the direction. So the assumption that the prism converts white light into colored light is not correct."***

As it concerns the question ***"Is it possible to create white light without using the seven colours of the rainbow? Can you suggest an experiment that might be able to answer this question?"*** all the groups answered that they had to try all the colours.


Μπορείτε να σχεδιάσετε ένα πείραμα για να ελέγξετε αν το λευκό φως μπορεί να προκύψει χωρίς την ανάμειξη των επτά χρωμάτων του ουράνιου τόξου;

Θα δοκιμάσουμε να αναμείξουμε τα χρώματα πρώτα 2 μαζί, ύστερα 3 μαζί, μετά 4 κλπ με τη βοήθεια των φίλτρων και θα σημειώσουμε εκείνες τις φορές που θα πάρουμε λευκό φως.

This group suggests to ***"mix first 2 colours, then 3 colours, etc. with the use of filters and we'll see when white light is produced."***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Πρέπει να δοκιμάσουμε να αναμείξουμε τα χρώματα κάνοντας συνδυασμούς ανά δύο, τρία, τέσσερα μέχρι να βρούμε πότε δημιουργείτε λευκό φως. Αυτό όμως θα είναι πολύ δύσκολο γιατί πρέπει να κάνουμε πάρα πολλές δοκιμές. Θα χρειαστούμε πάρα πολύ χρόνο.

This group makes the same suggestion as above, but with a qualitative difference. The students go further because they identify some variables. They will need a huge number of combinations and time is a problem.

(v) Use of assessment data

The teacher reported that he had a successful experience. For the first time he tried to assess certain inquiry skills and he believes that it was successful. He thinks that it is possible to be done in classroom but it must be very well prepared. Also, he appreciated the material of the unit and the suggested rubrics.

(vi) Advice for teachers implementing the unit

It must be a well-prepared task.