Science & Technology Equipment News

Number 23
Autumn 2001

For Primary Schools and Teachers of S1/S2 courses

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STS National Support Services in
Science, Technology, Safety

 ISSN 1369-9962

One major function of SSERC is to offer advice as to safe and suitable equipment for use in the curriculum. In the past, most of this work was carried out for post-primary teachers and FE lecturers. We first opened up the service formally to the primary sector in early 1994. Educational wheels always did grind slow but we have been suprised at how long it has taken us to win the trust of primary practitioners and build up a regular clientele. Nowadays we are receiving more and more calls and E-mails from primary teachers and advisers. Some of you, at least, do read this Newsletter and visit our website. Which is nice. So, keep those calls coming.

The 5-14 documentation refers, at levels D and E, to the use of lenses and prisms. It states how a lens can change the direction of a light path, but makes no direct mention of ray boxes or light boxes. Nor does it offer clues on how the investigations are to be carried out. Nonetheless, we have had recent requests for advice on ray boxes suitable for primary school usage. Our knee jerk reaction was to ask why they were needed. The other question was how were they to be powered? One response was with commercially available power supplies. Others said "with batteries". Our experience with battery powered ray boxes was that they were pretty ineffective. Perhaps our prejudices were showing. We would be pleased to hear from anyone with a whole class lesson plan that makes use of a ray box. And, then we'll be happy to eat our metaphorical hat. Meantime, this Newsletter reports on the results of what, we trust, were "fair tests" of three popular models of ray box.

Rays - a curtain?

Investigations into light phenomena usually bring a need to reduce normal (ambient) lighting. Ideally we would have access to a darkroom, or have blackout in a classroom. Primary schools of our acquaintance don't have a darkroom at all, never mind one capable of holding 30+ pupils. A substantial number may have curtains that can be drawn to dim the room. With this in mind we carried out a series of evaluations on each of the ray box samples. Firstly, we set up a DIY 'light laboratory' using a large cardboard box, inside which a number of pupils could get their heads. This is a solution advocated in several books. Secondly we set up tests in a darkened room and thirdly we used a daylit classroom. The photographs in this issue were taken in a classroom, under ambient light, on a normal Scottish Summer's day, i.e. dreich wi' a wee smirr.

Testing

Our tests on ray boxes were carried out using a biconvex lens, (fat in the middle), and a biconcave lens, (thin in the middle). A biconvex lens makes parallel rays of light initially come together (converge - see Figure 1 opposite). This can be demonstrated with a hand held magnifying glass, which is a biconvex lens. Most children will know that light from the Sun can be concentrated in a very hot spot on paper or, more usually, their own or a neighbour's wrist (not recommended - see *Be safe!*).

A more user-friendly method is to hold the magnifying glass near a window and project the astragals on to a sheet or screen. A biconcave lens has the opposite effect as it makes the light rays diverge (see Figure 2).

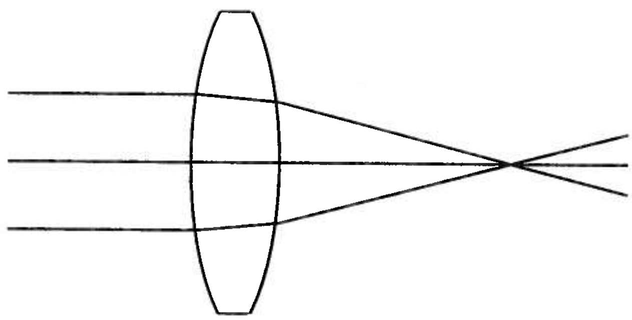

Figure 1 Sketch of a biconxex lens bringing parallel rays of light together (converging them) to a focal point.

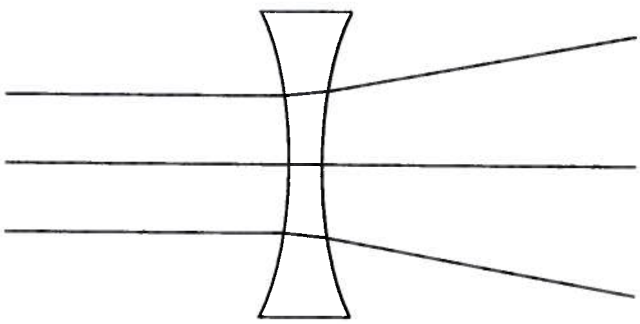

Figure 2 Sketch of a biconcave lens spreading out parallel rays of light (diverging them).

The challengers

Three commercially available devices were evaluated: *Raymond the Raybox* (TTS); an *Economy Ray Box* from Commotion and a ray box from Hope Education's *Light Box Set*. See the end of the article for supply details and prices. Under the same conditions we also tried out a DIY device using a battery powered torch in a cardboard box fitted with a comb.

Raymond

Our first contender was *Raymond the Raybox*, a reasonably priced item which can be powered by batteries or a low voltage power supply. We tried both. Setting up this ray box is simple but, with battery power, the source is too weak for the rays to be seen readily in an undimmed room. Even inside our cardboard 'light laboratory' box the lines were faint and the general stramash caused by working in an confined area wasn't ideal for children. With a 6V 500 mA power supply the light rays were more obvious but the results again were not ideal. The box comes complete with 2 mirrors and a set of coloured filters.

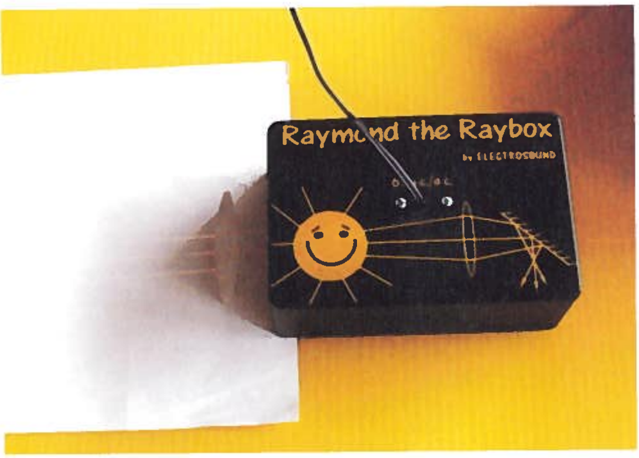

Figure 3 'Raymond' in use with a biconxex lens. No dim-out.

The instructions, which were minimal, intimate that the filters, as supplied, can be used to mix blue, green and red light. The result is to be projected onto a screen. In theory we then show colour mixing, that a combination of the primary colours can give white light. This demonstration was unsuccessful no matter how we powered the raybox or arranged the ambient lighting. We concluded that the light source simply just isn't powerful enough to carry out this demonstration.

Light Box Set

Next into the ring was a light box sold by several different suppliers although it was originally designed, we believe, for Osmiroid. We got ours from Hope Education. After "Raymond" it inevitably got knick-named "Ossie". This is a circular design (see Figures 4 and 5, opposite column).

It comes with 2 mirrors, 2 rubber rings (to hold the filters in place), 3 coloured filters and an opaque plastic mask. This is a battery only device, and for this reason the light lines were barely visible in the cardboard 'light laboratory' box or in a darkened room. There were no teacher notes but only a simple written set-up procedure with a fault-finding page. Perhaps readers should be left to draw their own conclusions?

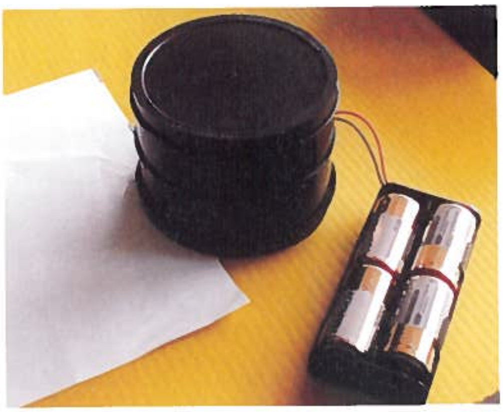

Figure 4 Economy light box (Ossie) in use with batteries. No dim-out.

Figure 5 'Ossie' in use with a biconcave lens. No dim-out.

Economy Ray Box

To continue the boxing theme, now we come to the heavyweight of the class, and not only because it is made of metal. The STE-made Light Box is compact, and has a simple, clean design. But, it can only be powered by a 12 volt, 800 milliamp, power supply. This particular pack comes with a spare bulb, colour filters, a selection of combs, collimating lens (helps to keep the rays of light coming from the box parallel) and lens holder. An instruction leaflet for setting up and faultfinding is included. No ideas on investigations, however, are provided with the equipment supplied by Commotion. Both they and Griffin, however, also sell it in another package with a well written book of experiments, albeit at a much higher price.

This device, with its more powerful light source, worked quite well in a darkened room, and in a cardboard box with a huddle of pupils. In ambient light it was undoubtedly the best of the three devices, yet not quite good enough for routine use in daylight conditions.

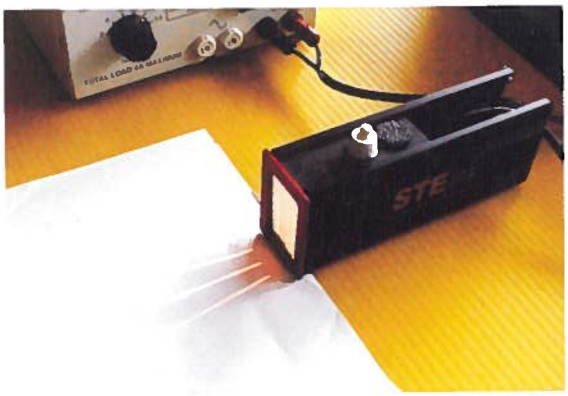

Figure 6 The STE Light Box in use with power supply. No dim-out.

To set against that superior performance it has the problem for primary of a separate mains to low voltage power supply. We also judge that the slide carrier may be difficult to operate by young children, and the lamp, not surprisingly, gets hot. The lamp also has a particular type of 'festoon' filament and is difficult to refit in the proper position.

The raybox can be used to show colour mixing so long as it's done in a darkroom. The red beam tends to dominate. When blue, red and green are mixed the result is pink, rather than white, light.

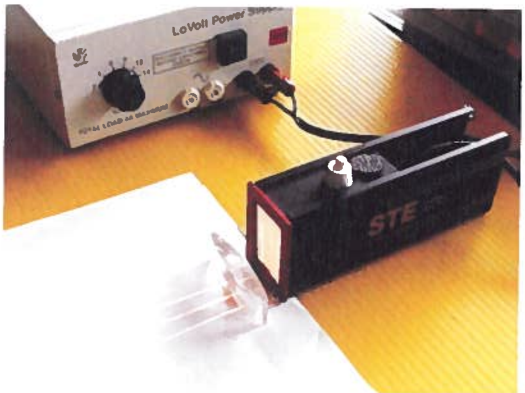

Figure 7 Light Box in use with a biconvex lens. No dim-out.

DIY solutions

Now for a hand knitted solution, one likely to be frowned upon by purists. In our own trials a home-made raybox worked quite well. What's needed are: a small cardboard box; a pocket comb; a torch, and - in true Blue Peter tradition - the ubiquitous sticky tape. The sketch below should be fairly self-explanatory.

Use a cardboard box of about 19 x 19 x 15 cm or if need be to suit the size of the torch which you have to hand. Cut a slot, slightly smaller than the comb, in the leading edge of the box. Then tape the comb across the slot, teeth pointing downwards. Place a sheet of A4 white paper under the comb, switch on the torch to shine through the comb. *Et voila!* You should now have a series of streaks of light on the paper.

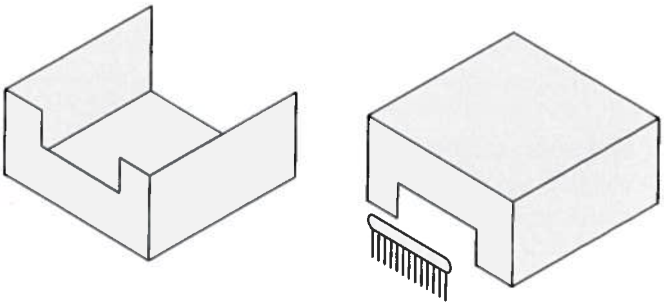

Figure 8 DIY cardboard ray box

Place the fat biconvex lens in front of the comb then, try the thin biconcave lens. With luck, and a certain continuity in the laws of physics, you should note how the direction of light rays (or ray-streaks more like) is altered - see the sequence of photographs opposite (Figures 9-11 inclusive).

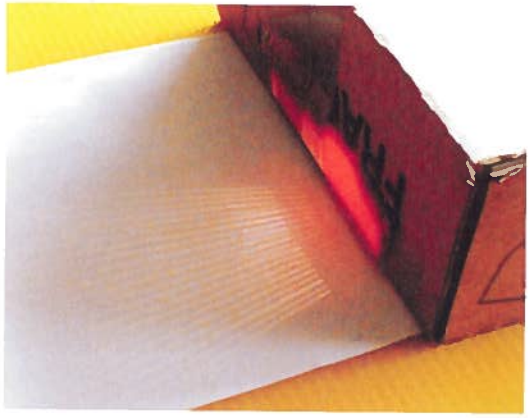

Figure 9 DIY Light Box. No lens in use. No dim-out. Note that a torch and the teeth of a pocket comb produce slightly diverging, rather than parallel, streaks of light. These streaks are also quite coarse. What do you want for next to nothing?

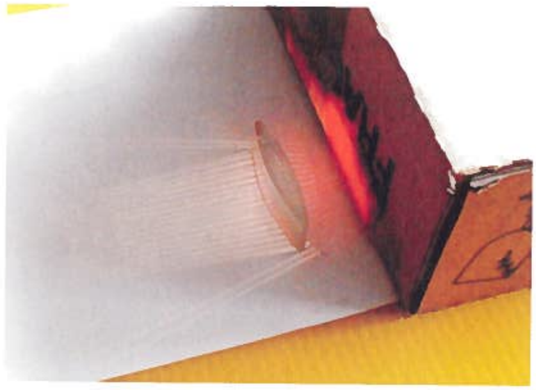

Figure 10 DIY Light Box with a biconvex lens. No dim-out. Note that the streaks which pass through the lens now come together (converge).

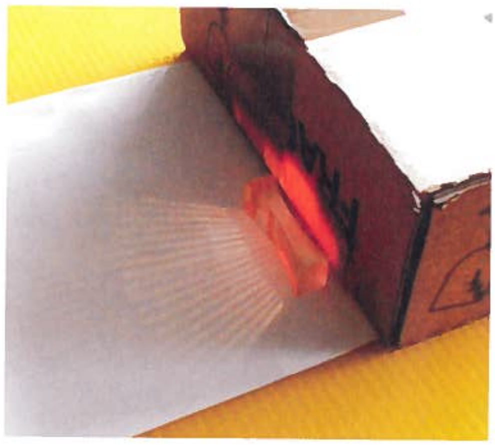

Figure 11 DIY Light Box with a biconcave lens. No dim-out. Note that the streaks which pass through the lens now spread out (diverge) more than before with no lens in use.

continued/over

Summary

From our simple investigations, with this selection of commercially available light boxes, and our knowledge of other inexpensive models, we judge that none of them are suited to use in primary schools. This is particularly so with those models powered by batteries. To ensure a reasonable light output, a mains to low voltage power supply is needed (eg as for the STE equipment from Commotion - see Figures 6 and 7).

Apart from the capital outlay of £50 - £70 for such a supply, there are the problems of safely managing trailing mains leads. In primary schools, the number of mains sockets in each classroom can be severely limited. In many cases there may be only one electrical socket in the classroom. Any need for a darkroom or darkened area could also be a problem[1]. This is so whether this activity is to be a demonstration with whole class teaching, or an investigation by a group of 10 year olds huddling with heads inside a big cardboard box.

A further concern was the lack of teacher's notes in any of the packs actually evaluated (but, see note on page 2 on the more expensive versions from both Commotion and Griffin). Hurrah! We have a light box! What now? As we understand the references in the 5-14 Environmental Studies documents [1], all that needs to be investigated up to Levels D and E is the change in direction of light rays as they pass through lenses or a prism.

Our *comb and torch in a box* set-up seems to demonstrate these aspects adequately. Further work on colour and colour mixing is only suggested at Level F. Any such further investigations could be carried out at S1/S2 or Standard Grade, where schools already have the necessary equipment.

Conclusions

It is our usual practice to give equipment a score against each of a number of aspects of performance with an overall summative assessment on a three point scale (A - most satisfactory; B - satisfactory and C - unsatisfactory).

The trials we carried out here, however, were mainly intended to discover how well each piece of apparatus worked under various lighting conditions. We did not consider their use in any detailed investigations into the nature and behaviour of light. For example, we only experimented with simple lenses. Because of the simplicity of our evaluation, and the fact that we remain unconvinced of the value of using ray boxes in primary science, we do not consider we can rank the devices in any meaningful way. The best we can find to say is that all of the commercial devices were inexpensive.

Reference 1*. See LT Scotland 5-14 Micro-site at: www.ngflscotland.gov.uk/5-14/guidelines/htmlguidelines/index.htm*

[1]Footnote *Although some primary classes have been known to build their own planetarium inside a classroom!*

Supplier Details

Device	Supplier	Ref. No.	Price (£)
Economy Ray Box (STE Model)	Commotion	48086-7	14.99
Raymond the Raybox	TTS	RAYBOX	14.95
Light Box Set	Hope Education	05152/006	14.95

TABLE 1 Light box models evaluated

Lens	Supplier	Ref. No.	Price (£)
Economy Acrylic Prism Set	Commotion	48052-7(7)	19.99
Biconvex Lens	Scientific and Chemical	XOP370020	4.90
Biconcave Lens	Scientific and Chemical	XOP370040	5.30

TABLE 2 Sources and prices of lenses used in the evaluation.

Address List

SSERC

St Mary's Building, 23 Holyrood Road, Edinburgh, EH8 8AE Tel. 0131 558 8180 Fax 0131 558 8191 E:sts@sserc.org.uk W: www.sserc.org.uk

Commotion

Unit 11, Tannery Road, Tonbridge, Kent TN9 1RF Tel. 01732 773399 Fax: 01732 773390

Hope Education

Hyde Buildings, Ashton Road, Hyde, Cheshire SK14 4SH Tel. 08702 433400 Fax: 0800 929139 E:enquiries@hope-education.co.uk W: www.hope-education.co.uk

Scientific and Chemicals Supplies Ltd (Sci-Chem)

Carlton House, Livingstone Road Bilston West Midlands WV14 0QZ Tel. 01236 449669 W: www.sci-chem.co.uk

Sci-Chem in Scotland:

Woodburn Road, Blackburn Industrial Estate Kinellar, Aberdeen AB21 0RX Tel: 01224 790190 Fax: 01224 790990 E: elaine.henderson@scichem.co.uk

TTS Ltd

Monk Road, Alfreton, Derbyshire DE55 7RI Tel. 01773 830255 Fax: 01773 830325 E: kate@tts-group.co.uk W: www.tts-group.co.uk