The Use of Science Kits in the Professional Development of Rural Elementary School Teachers

Ann Sherman[1] and A. Leo MacDonald[2]
[1]*University of Calgary, Calgary, Alberta, Canada*
[2]*St. Francis Xavier University, Antigonish, Nova Scotia, Canada*
lasherma@ucalgary.ca, lxmacdon@stfx.ca

Abstract

This study reports on a science professional development initiative with elementary school teachers in Canada. Grades 4 and 5 teachers were involved in the implementation and modification of science kits, together with corresponding professional development activities. Each kit was aligned to specific outcomes in the curriculum and provided a complete set of materials and guidelines for classroom use. Teachers describe, through surveys and interviews, the benefits of using the kits and share a new confidence for teaching science.

This study reports on a science professional development initiative with elementary school teachers in Canada. Many elementary teachers, particularly at the upper grades, feel challenged with science teaching (MacDonald & Sherman, 2007). Professional development can have a positive impact on teachers' pedagogical content knowledge (MacDonald & Sherman, 2006), especially when it occurs on a continuous basis (Koch & Appleton, 2007). In this study, rural Grades 4 and 5 teachers were involved in the implementation and modification of science kits, as well as corresponding professional development activities.

Challenges for elementary science teaching. Research has identified challenges involved in teaching elementary science. One challenge for many elementary teachers is a lack of previous experience with hands-on science (MacDonald & Sherman, 2007). Furthermore, many tend to make limited use of hands-on or inquiry activities in their classroom teaching (Goodrum, Hackling, & Rennie, 2001). Many pre-service teachers enter teacher education without much confidence about science teaching, believing they lack the content knowledge needed to teach even lower elementary grades (King, Shumow, & Lietz, 2001). Guillame (1995) and Bryan (2003) noted that poor experiences with science and/or a general lack of engaging science experiences affects the belief system each teacher has about her/his own science teaching. Harlen (1995) identified a lack of background knowledge as a challenge for elementary teachers. Even when teachers have a successful teacher education experience with science, and meet governmental teacher licensing requirements, many feel they lack the science content needed to teach science (Sherman & MacDonald, 2008).

Many teachers indicate science is the subject area they least enjoy teaching, in part because they hold little confidence in their science content knowledge and are afraid their classroom teaching/learning activities will yield results they do not understand and cannot explain to students (MacDonald & Sherman, 2007). In addition, teachers feel challenged to acquire the resources needed to create the kind of science learning environments they consider appropriate. When teachers are able to find resources, they are challenged when asked to set up the equipment in ways accessible to the students. Many are exasperated and claim they don't even know where to start (MacDonald & Sherman, 2006). Murphy, Neil, and Beggs (2007) found that approximately one half of the teachers in their study identified lack of confidence and ability to teach science as the major challenges they faced in their classrooms.

Professional development for elementary science teaching. In light of these challenges, it seems important to examine how professional development can support elementary teachers' capacity to teach science. Several professional development (PD) approaches with science teachers have been reported (Loucks-Horsley & Matsumoto, 1999). In some research, the focus has been on the teaching of elementary teachers (Craft, 1996; Garet, Porter, Desimone, Birman, & Suk Yoon, 2001). Harris (2001) examined face-to-face professional development in rural settings, while Falvo (2003) explored distance approaches with rural teachers. The PD needed to make the transition from pre-service to in-service teaching in science was described by Mulholland, Dorman, and Odgen (2004). Stein, Ginns, and McRobbie (2003) argued that PD in the first year of teaching is critical. Annetta and Shymansky (2006) recommended a blended approach to PD in rural settings, using both distance and face-to-face approaches. In a 3-year study of face-to-face PD, focusing on scientific inquiry and inquiry-based instruction, research showed an improvement in teachers' science pedagogy as determined by the researchers (Akerson & Hanuscin, 2007). However, evidence shows PD providers must be cautious about the focus of their PD. Jarvis and Pell (2004) reported that elementary teachers, provided with an intensive PD program with follow-up classroom visits, showed an increase in confidence and enthusiasm for teaching science, but that their scientific misconceptions persisted.

Harland and Kinder (1997) suggested that the effectiveness of PD should be judged by its impact on teachers' classroom practice. Murphy, Neil, and Beggs (2007) identified five key PD approaches that increase teacher confidence and knowledge about science teaching. These include in-class support, distance/technology support, approaches that increase pupil interest in science, out-of-class intensive workshops, and production of materials. The study described in this article includes aspects of professional development related to in-class support, approaches that increase pupil interest, out-of-class intensive workshops, and the production of materials. During the workshops, materials are examined and manipulated, pedagogical approaches are examined and practised, and misunderstandings about content are clarified.

The Project

This research is part of a Centre for Research in Youth Science Teaching and Learning (CRYSTAL) grant, sponsored by the National Science and Engineering Research Council (NSERC), a Canadian federal granting agency. The research examines perspectives about the learning of science through outreach projects supporting school science. One part of the project was to support elementary science teachers in a large, rural school board in eastern Canada. In eastern Canada, the term *school board* refers to the school jurisdiction or district. In this school board, most elementary schools are 50-100 kilometres away from each other. Kits were created by the researchers based on the Grades 4 and 5 provincial science curriculum outcomes. In Canada, each province sets its own provincial curriculum outcomes for each subject area. The provincial science outcomes are mandated by the province's Department of Education and all elementary teachers of science are required to teach to these outcomes in their classrooms.

The Grade 4 kits focus on light, sound, rocks, minerals and erosion, and habitats, while the Grade 5 kits deal with the human body, weather, simple machines, properties and changes in matter, and exploring forces. Appendices A, B, and C exemplify the contents of, and activities in, a kit. The kits contain materials and resources needed for hands-on inquiry science activities related to the curriculum. Sample lesson plans, matched to the provincial curricular outcomes, are included. Photographs of the kit materials set up in proper format are included, as are videotapes of experiments occurring using the materials. For many pieces of equipment, several different suggestions about uses are given so teachers can make choices based on their own students.

Materials vary depending on the topic covered by the kit. For example, the kit on weather includes apparatus needed to build home-made weather measurement instruments. The kit on sound includes a variety of tuning forks, small musical instruments (tambourine, castanets, bells, a small drum, and a rain stick), and a digital sound level meter.

The kits are housed at a local university and distributed to teachers through a large rural school board's courier system. Presently, a grant provides funding to restock consumables and a university BEd student is hired to update the kits. Once requested by a teacher, the university Resource Centre librarian distributes the kits. Because of their popularity, the number of kits and the area serviced by them is expanding. The school board is duplicating the kits and assisting with data collection about their use.

Each time the kits are used, teachers complete a participant survey and participate in interviews. To date, over 40 teachers have been interviewed and surveyed. Focus group interviews have also been conducted. Responses have described the impact on both practice and planning for science teaching. Researchers have visited schools and have provided full-day workshops for each kit. It is insufficient to provide the resources alone. It is important to provide guidance for the use of the resources and opportunities to engage with the materials in a way similar to how the students will be invited to engage with them (Stein, Ginns, & McRobbie, 2003).

The local school board is very supportive of teachers participating in the professional development that teaches them about possible uses for the kit materials. The local school board has released teachers during school times to attend the workshops. During the workshop sessions, teachers practise with the materials, setting up experiments, creating activities in much the same way their students will do, and talking through the science content related to each activity. For some new teachers, this is an introduction to the science content they are about to teach and for more experienced teachers it is meant to be a content refresher session. Some of these teachers explain to us that is the first time some of the science has been explained in a way that they truly understand. The teachers not only work with the materials, but also discuss pedagogical content knowledge for each kit and explore, with their colleagues, different strategies that might work as they introduce new concepts to their own students. The researchers act as the organizers and leaders of the workshops and use pedagogical strategies that are inquiry-based. Suggestions are offered in response to teachers' questions about ways to incorporate experience-based, inquiry-based learning strategies into science classes.

Teachers' Comments

Time and materials for science. Teachers described the impact of current math- and literacy-centric thinking on their science teaching. They admitted that less than 10 percent of their classroom time is typically spent in teaching science. The increased focus on mathematics and literacy has reduced the amount of time spent on science teaching. "We should be doing almost as much science as mathematics but it isn't happening." Teachers suggested they need to be both efficient and effective in the little time they have to spend on science because "most teachers are teaching science, but are they getting the required time per cycle? . . . I don't think so." Another teacher summarized as follows: "There is a tremendous push by the Department of Education and administrators to focus on specific tasks, activities, and outcomes related to math and especially language arts. Time for science is limited."

Teachers described increasing the proportion of class time they spent teaching science with the kits. Partially, they attribute this to the fact that everything they need for each topic is together in one large box. One teacher commented:

> Presently, it is difficult to make science fun and hands-on. There are no science materials in my classroom, except for science program and books. I have purchased items myself, but it is difficult to collect everything, put it together, and it is also costly.

Teachers suggested they have developed a greater understanding of the kinds of materials needed to support science teaching. They no longer have to struggle to find the materials needed, or worry about storing large quantities of resources and materials. “They are engaging activities with the outcomes tied in. The lessons planned are ready to go and the lesson sequence is clear. It saves time.”

Another teacher described her school:

> Our school has a lot of materials but you are lucky if you find what you need. For a time we tried storing everything for the school in one place, but the school population grew and those areas are all classrooms now, so we keep our own materials, but that means keeping on top of it and having to know when you didn’t have anything left.

A teacher in another school suggested:

> If you come up to my classroom you’ll see my cupboards are full and the library is full of stuff, so I don’t think I need to be keeping anything else in my classroom. You’re on the right track with the kits because I order the kit, the kit comes in, I open it up, set up everything, then when we’re done, I break it down and it’s gone.

Teachers described a cost saving because expensive pieces of equipment are included in the kits and “accumulating more expensive items (tuning forks, prisms, etc.) is challenging.” The kit activities are suited for use in a regular classroom.

> The fabulous thing is that it’s not too often you get a resource that, if you didn’t have anything at all, you could still go ahead and do the activities. Everything you need is there, especially if you were a new teacher coming out. If I was new and got that kit, I would think that was wonderful.

In addition, the materials selected for the kits are generally sturdy and “they are practical and easy to use and you don’t worry about the kids breaking them or dropping them. They are manipulatives the kids can really handle.”

Teachers identify finding resources as one of the biggest challenges in offering hands-on activities (MacDonald & Sherman, 2006). In this study, a Grade 5 teacher described the challenge:

> Before the kits, some aspects of the curriculum were easier to do than others. I found the weather unit to be easy to do because most books described the material you needed, the kids could collect it, and then we would build very easy weather instruments. But I found topics like simple machines hard to do and the pond study was difficult, except the day you went to the pond.

The number of times the kits were used depended on several things. Not only did they serve to fill a gap in the amount and kinds of materials available to teachers, but the number of teachers using the kits grew as teachers gained an awareness of them. As the school board's support grew, so did teachers' awareness. As teachers met and talked about the kits at the various PD events sponsored by the school board, the use of the kits was extended. The kits were used more extensively following the conduct of each workshop aimed at explaining the use of a particular kit and allowing the teachers to experiment with its use.

Curriculum alignment. Another benefit of the kits is their alignment to provincial curriculum outcomes. "The kits have wonderful activities already planned and supported with materials. The activities are directed at outcomes. The activities are engaging for children." Another commented that "having lesson plans and materials together and meeting outcomes all in a "box" is a great idea." The kits include materials, resources, and lesson plan ideas connected directly to outcomes. Photographs and diagrams of activities are included. Videos and web sites are also provided so teachers need only follow the prepared activities if they are unsure of how to meet the science outcomes. Because they are aligned to the curriculum, "you can sort of sit down at the beginning of the year and start to lay out your year, and get a sense of where each of the kits fit in." Once teachers became familiar with a kit, using it more than once, they described how they were able to modify activities. "I've added more reflection to the activities, where I get the kids to tell me what they have learned and then write about it."

Teachers who are more confident in science teaching have used the kits' activities to add to their repertoire of science learning experiences and described increased confidence as they enhance their science program:

> The kit helped me think about the outcomes. It caused a spark; an idea. As you're looking through some of the different lessons, some you'd look at and think yes, I'll use that, but others reminded me of something I'd done before, something I knew well, and so I'd prefer the lesson I'd already done last year.

Another teacher added: "The kits are formulated in such a way a teacher can look at it and say 'I'm going to use this one way,' and another teacher might use it in another way." Her partner teacher continued: "The material used for the actual experiments and activities are very adaptable and I think teachers are pretty ingenious when it comes to using materials to fit their style or approach."

Teachers said they were better able to integrate science with other curriculum areas because they were more confident with their science teaching:

> I have learned a great deal more about each science topic. I realize I was teaching these content areas before without knowing very much about the topics. The kits have really helped me gain a greater understanding. I see how the science relates to other subject areas now in a way I didn't see before.

Sometimes integration of curricula areas was basic, like using science journals as a place to talk about paragraph construction, a language arts outcome for Grade 4. In other cases, teachers were able to identify broader overlapping curriculum outcomes in areas like Math and Science. The kits include lists of children's fiction connected to science topics. Many teachers are using these to integrate Language Arts into their science teaching. Teachers encouraged us to include more suggestions about integration for teachers who have not yet had the opportunity to think about the ways the curriculum overlaps.

Impact on teacher thinking. Having resources available with carefully described activities can increase teachers' content knowledge and their confidence (Bianchini, Johnston, Oram & Cavazos; 2003). Teachers offered children "exciting things when sometimes [without the kits] teachers' confidence in their own knowledge level prevents that from happening." Not only have the teachers been enabled to include inquiry-based science activities in their classroom, but they have moved to a higher level of thinking that includes modifying and advancing the activities. This depicts a significant level of impact on teachers' practice and pedagogic reflexivity as described by Harland and Kinder (1997).

Teachers began to take ownership of the kit development process by suggesting modifications, developing alternate activities using kit materials, and accommodating specific needs of their students. As teachers took on the creation or modification of kit activities, changes in their thinking were noted. "I did the light activity as the introduction to the unit [even though doing this wasn't mentioned in the kit] and I would never have thought to do that first, but now that I've done it, it makes so much sense."

Inspiring children. Teachers described the enjoyment students gained from learning with kit materials. "The hands-on materials would excite the students and make the learning more meaningful as they would be experiencing and playing around with things and ideas rather than being a mere passive learner." Teachers suggested the children enjoyed "kit learning" as it focuses on inquiry-based activities. "It's something hands-on and they love the kits. When we get a new kit [in the classroom] they are all trying to see into it and want to find out what we're doing next as it's exciting for them." The teachers believed their students had become engaged, active learners when science teaching was supported by the kits. "They are really excited about the experiments and I hear them talk about them during student-lead conferences with their parents."

The kit activities encourage children to engage in collaborative science inquiry and generate multiple artifacts of their understanding of science. When children engage in science inquiry, the resulting artifacts enable discussions where children compare the effectiveness of their designs with the designs of their classmates. These discussions can be highly instructional and can extend beyond the classroom, especially for the teachers, when they talk about their student's experiences with colleagues.

One teacher commented:

> The kit activities helped the kids think more like a scientist. We would set up our experiments and then I would get them to think about what they thought might happen, they made their predictions, and then we observed what happened. They wrote their conclusions down and explained what they saw. They helped each other learn by showing their work to each other.

Without the kits, many teachers admitted they had their students read science textbooks rather than engage in science inquiry.

Conclusions

The participants described using prepared science kits in a positive light. The benefits include increased teacher content knowledge, pedagogic content knowledge, teacher confidence, and enthusiasm for science. Teachers also suggested that their students seem more excited about science class, asking when they can do the next activity and readily participating in activities presented by their teachers. The kits have helped teachers feel better prepared to offer an exciting approach to science and to integrate science into other curriculum areas. Teachers have modified the kits for their own classroom context and students' needs. Having an organized set of materials with suggestions for lesson plans has helped these teachers gain content knowledge and confidence. Practical issues of collection and storage of materials have been overcome and more time is available for relevant and meaningful activities. Children in these classrooms have increased opportunity to engage in meaningful science learning.

Teachers indicated that, as a result of using the kits, students are engaged in a wider variety of science activities that are more meaningful and relevant to them. The quality of the experiences is enhanced by the fact teachers have access to more information and ways of sharing that information with students.

Kits have been utilized in a school board that is geographically large. Sharing of resources in many rural schools is limited because they have only one teacher per grade level. In addition, elementary schools in this school board can be separated by a significant distance, which means meeting with another teacher of the same grade is challenging, especially on rural winter roads. The kits provide a connection to the curriculum and to what other teachers are doing in their classrooms. "I now contact other Grade 4 teachers I know in other schools and ask how they used the kits."

The kits have facilitated a new level of conversation amongst elementary teachers in this school board. Previously, little time was spent talking about science teaching, partially because of teachers' lack of content knowledge and confidence, and partly because the amount of time spent teaching science was limited. Teachers are now telling others about their success with the use of the kits and requests for the kits have gone up dramatically. Not only are teachers talking about the kits, but they are talking about how to use the materials in the most effective way, about modifications they have tried, and about ways to add other activities to the kits. The kits have also helped teachers become more generative in their thinking about how to support science inquiry learning. In creating new and alternate activities, teachers seem able to apply what they learn from using the kits to new teaching situations. The kits include a capacity-building component for the teachers, by allowing teachers to manipulate and create different activities depending on the demands of their own classroom.

The evidence provided by these teachers suggests there is a need for substantially increasing this type of science PD for elementary teachers. The kits have increased the propensity of teachers to think about classroom-based science teaching and learning events over an extended period of time. This kind of interaction has the potential to generate teaching resources that support the development of enhanced pedagogical content knowledge through continuous professional development. As this research continues, evidence is also being collected about student achievement. While teachers report enthusiasm amongst their students, it remains to be seen what effect these kits will have on student achievement. With better-prepared teachers who are more confident and knowledgeable, it is hoped that student achievement will also be improved.

References

Akerson, V. L., & Hanuscin, D. L. (2007). Teaching nature of science through inquiry: Results of a 3-year professional development program. *Journal of Research in Science Teaching, 44*, 653-680.

Annetta, L., & Shymansky, J. (2006). A comparison of rural elementary school teacher attitudes toward three modes of distance education for science professional development. *Journal of Research in Science Teaching, 43*, 1019-1039.

Bianchini, J. A., Johnston, C. C., Oram, S. Y., & Cavazos, L. M. (2003). Learning to teach science in contemporary and equitable ways: The successes and struggles of first-year science teachers. *Science Education, 87*, 419-443.

Bryan, L. A. (2003). Nestedness of beliefs: Examining a prospective elementary teacher's belief system about science teaching and learning. *Journal of Research in Science Teaching, 40,* 835-868.
Craft, A. (1996). Continuing professional development: A practical guide for teachers and schools. London: Open University.
Falvo, D. (2003). Developing professionalism in teaching through technology skill development among rural teachers. *TechTrends*, *47*, 21-25.
Garet, M. S., Porter, A. C., Desimone, L., Birman, B. F., & Suk Yoon, K. (2001). What makes professional development effective? Results from a national sample of teachers. *American Education Research Journal*, *38*, 915-946.
Goodrum, D., Hackling, M., & Rennie, L. (2001). The status and quality of teaching and learning of science in Australian schools. Canberra: Commonwealth of Australia.
Guillame, A. M. (1995). Elementary student teachers' situated learning of science education: The big, Big, BIG picture. *Journal of Science Teacher Education, 6*, 89-101.
Harland, J., & Kinder, K. (1997). Teachers' continuing professional development: Framing a model of outcomes. *British Journal of In-service Education*, *23*(1), 71-84.
Harlen, W. (1995). *Understanding and teaching science* (SCRE Newsletter No. 57). Glasgow: Scottish Council for Research in Education.
Harris, M. M. (2001). Lessons from prairie teachers. *Action in Teacher Education*, *23*, 19-26.
Jarvis, T., & Pell, A. (2004). Primary teachers' changing attitudes and cognition during a two-year science in-service programme and their effect on pupils. *International Journal of Science Education*, *26*, 1787-1813.
King, K., Shumow, L., & Lietz, S. (2001). Science education in an urban elementary school: Case studies of teacher beliefs and classroom practices. *Science Education*, *85*, 89-110.
Koch, J., & Appleton, K. (2007). The effect of a mentoring model for elementary science professional development. *Journal of Science Teacher Education*, *18*, 209-231.
Loucks-Horsley, S., & Matsumoto, C. (1999). Research on professional development for teachers of mathematics and science: The state of the scene. *School Science and Mathematics, 99*, 258-271.
MacDonald, A. L., & Sherman, A. (2006). Children's perspectives on building science models. *Education 3 to 13, 34*(1), 89-98.
MacDonald, A. L., & Sherman, A. (2007). Pre-service teachers' experiences with a science education module. *Journal of Science Teacher Education*, *18*, 525-541.
Mulholland, J., Dorman, J. P., & Odgen, B. M. (2004). Assessment of science teaching efficacy of preservice teachers in an Australian university. *Journal of Science Teacher Education*, *15*, 313-331.
Murphy, C., Neil, P., & Beggs, J. (2007). Primary science teacher confidence revisited: Ten years on. *Educational Research, 49,* 415-430.
Sherman, A., & MacDonald, A. L. (2008). Instructional leadership in elementary school science: How can I be an instructional leader in a content area, like science, where I have little to no background experience or knowledge? *International Electronic Journal for Leadership in Learning*, *12*(Article 12). Retrieved from http://www.ucalgary.ca/iejll/sherman .
Stein, S. J., Ginns, I. S., & McRobbie, C. J. (2003). Grappling with teaching design and technology: A beginning teacher's experiences. *Research in Science & Technological Education*, *21*(2), 141-157.

Appendix A: Contents of the Light Kit (Grade 4)

Materials (one each unless otherwise marked, and as shown in Figure 1)

Fibre optics lamp, microscope, telescope, magnifiers (5), periscope kit, binoculars, kaleidoscope, masking tape, wax paper, aluminum foil, push pins (1 box), candles (30), light sticks (9), watch with LED light, clock with LED light, flashlights (8), matches (1 large box), mirrors (7.5 cm by 12.5 cm) (37), concave lenses (class set of 25), convex lenses (class set of 25), 8.5 inch x 11 inch card stock (package of 50), Rive ray box, optics set for Rive ray box (10 mirrors and 10 lenses), laser pointers (8), utility knives (4), cylinders (10, such as soup cans and/or tennis ball cans), styrofoam cups(25).

Figure 1. Materials in the light kit.

Children's Literature

"The Magic School Bus – Color Day Relay" by Gail Herman
"Awesome Experiments in Light & Sound" by Michael A. Dispezio
"The Magic School Bus makes a Rainbow" by Joanna Cole
"Inventing the Electric Light" by Lisa Mullins
"Kingfisher Young Knowledge: Light and Sound" by Dr. Mike Goldsmith

Websites

http://www.learner.org/teacherslab/science/light/
http://www.proteacher.com/cgi-bin/outside.cgi?id=3131&external=
http://www.pticalres.com/kidptx_f.html
http://www.zephyrus.co.uk/lightsources.hml
http://www.fr.edu/fellows/fellow7/mar99/light/lesson1.shtml

Appendix B: Sample Activity 1

How Light Travels

Lesson Purpose

The overall purpose of this lesson is to use a simple set-up of common materials to help students understand that light travels outward in straight lines.

Student Outcomes

Students will be expected to:

- Make observations about how light is dispersed from a variety of light sources.
- Conclude that light travels in a straight line based on evidence gathered through their own observations.

General Curriculum Outcomes

Students will develop an understanding of the nature of science and technology, of the relationships between science and technology, and of the social and environmental contexts of science and technology.

Specific Curriculum Outcomes

Students will be expected to:

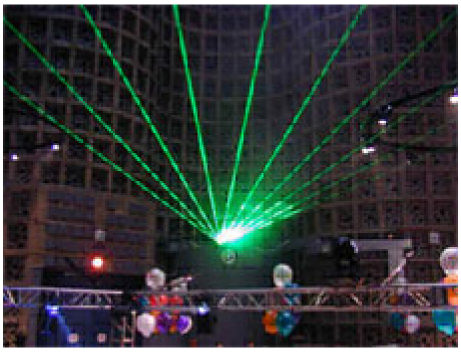
- Make observations and collect information that is relevant to a given question or problem.
- Construct and use devices for a specific purpose.

Prior Knowledge

It is assumed students will have some understanding of how light travels (i.e., household light fixtures, spot lights, flashlights, etc.). Some may not know that light travels from a source to an object. Research indicates that children equate light with a state or with its source rather than understanding it as a distinct entity.

Lesson

Ask students what they already know about light. In a whole-class discussion, create a concept map based on their preconceived ideas. Ask students to view the two photographs, showing beams of light, of Figure 1. Ask them if they can see the beams of light in both photographs. Then have them look closer and explain how all the beams of light are similar (all of them are straight). Have them explain why they do not always see these kinds of beams in everyday life, such as in the classroom. Discuss with them that when we see most light (i.e., classroom lights), it is hard to see a single ray because it is too bright and the rays are not focused. Before discussing it with them, try to have them come up with a conclusion on their own by asking them open-ended questions.



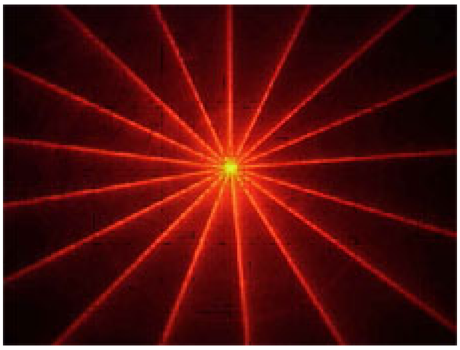


Figure 1. In what way are the beams of light in these photographs similar?

Now have them create a pinhole camera. Cameras work on the rule that light travels in straight lines. Make a pinhole camera to see if this is true. When they complete this, you can ask them how they can tell from the image formed by their pinhole camera that light travels in straight lines, and how would changing the length of the tube affect the quality of the picture they see?

Materials. Wax paper, aluminum foil, pencil, and an empty cylinder (i.e., a soup can, potato chip can, or a tennis ball can).

Procedure. Please follow these steps:

1. With an adult's help, remove both ends of the can and make your tube about 7-12 cm in length.
2. Tape, or secure with an elastic band, a piece of wax paper over one end of the container to form a screen.
3. Tape, or secure with an elastic band, a piece of foil over the other end.
4. Use your pencil point to make a small, tidy hole in the centre of the foil.
5. Presto; your camera is made (see Figure 2).
6. Point the camera with the pinhole end toward a window and look at your screen from about 15 cm away. To see the image better, put a jacket or a piece of fabric over your head and the camera screen.
7. In your notebook, draw the image you see.

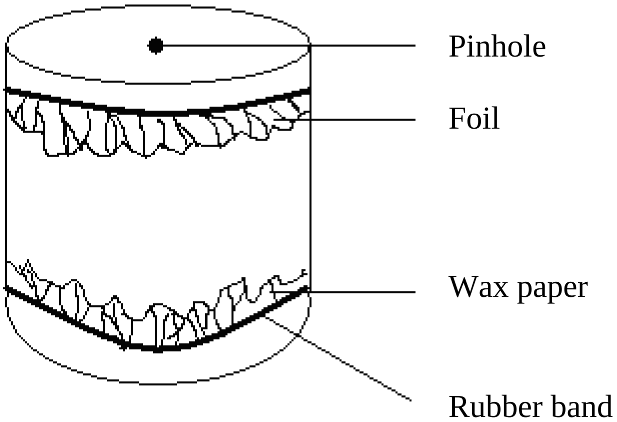


Figure 2. A pinhole camera.

Appendix C: Sample Activity 2

Lenses

Lesson Purpose

This lesson is intended to educate children about the function of lenses. The different types of lens in our world will be discussed (i.e., lens in human eye, cameras, binoculars, spectacles). The shape of the lens is important to the focusing of images, which helps us to see our environment clearly. There are two shapes that a lens can have: Convex and concave. Introduce these terms, as well as the terms converge and diverge. The function of these shapes will be expressed. Children will create a camera of their own so they can have a hands-on experience with lenses.

Student Outcomes

Students will be expected to:

- Describe examples of tools and techniques that extend our senses and enhance our ability to gather data and information about the world.
- Follow a given set procedure.
- Make observations and collect information relevant to a given question or problem.

Prior Knowledge

This lesson will be placed near the end of this unit on light. Students will therefore have knowledge about how light travels, refraction and reflection of light, and the parts and function of the eye. This information will help them understand the concept of lenses.

Children will have had experience with class discussions. Engage children in discussions to brainstorm and inquire about the function of a lens.

Lesson

Exploration phase. To begin this lesson, review the structure of the eye. Show the diagram of Figure 1 on an overhead. The students will have already seen this diagram in previous lessons.

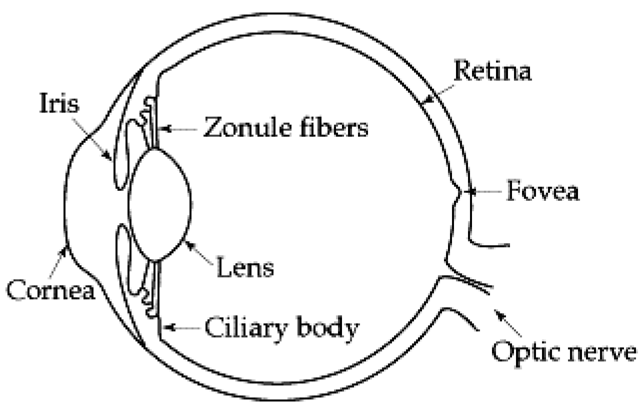


Figure 1. Structure of the human eye.

Discuss the function of each part of the eye briefly (i.e., what is the retina's function?). After becoming reacquainted with the parts of the eye, focus the lesson to the lens, giving more in-depth information about this structure. For example, sample discussion may go as follows:

> *Teacher*: You have just told me that light enters the eye cornea through the pupil and then passes through the lens. The lens in our eye is convex and helps to focus the light. Does anyone know what convex means [allow response time]. Convex is the type of shape that the lens is. Convex shape looks like this [draw on the board]. The convex lens of our eye is shaped so that it curves outward and is thicker in the middle, like this [point to the drawing on the board, stressing the shape and curve of the convex lens]. If I pass light through this lens, what do you think will happen? Keep in mind that the lens' function is to focus light [draw a beam of light passing through the lens].

Convex Lenses

Materials

Convex lens (one for each child), flashlight (enough for sharing to occur), and white paper (one sheet per child). Give each student a convex lens to experiment with for several minutes.

Procedure (approximately 5-10 minutes)

1. Lie white paper flat on your desk.
2. Hold the convex lens over the top of the paper so the rounded part of the lens is facing downwards.
3. Shine the flashlight onto the lens.
4. Observe the direction of light onto the paper. Does the light seem to "come together" or spread apart?

After this short activity, ask the children what they found. Hopefully, it will be clear that the light comes together (introduce the term *converge*). Explain that when light passes through the lens of our eye, light is refracted and focused. This is what is known as convergence (i.e., light rays are focused to a sharp point of light). It turns out that lenses that converge light also magnify images. Next, introduce the other type of lens shape; concave.

Sample Discussion

> *Teacher*: Convex is not the only shape of a lens. A lens can also be concave. Can anyone predict what shape this might have?
> *Student*: It will be the opposite of convex.
> *Teacher*: Good predicting! The concave lens looks like this [draw on the board].

Concave lenses are sunken in the middle. They are thinner in the middle and thicker around the edges. Now let them experiment with concave lenses.

Concave Lenses

Materials

Concave lens (one for each child), flashlight (shared by children), and white paper (one for each child).

Procedure (approximately 5-10 minutes)

1. Lie white paper flat on your desk.
2. Hold the concave lens over the top of the paper so that the rounded part of the lens is facing down (demonstrate the proper way).
3. Shine the flashlight onto the lens.
4. Observe the direction of light onto the paper. Does the light seem to "come together" (like the convex lens) or does it spread apart?

Students should see that the light spreads apart. Introduce the term *diverge*. Now prompt a conversation about other examples of lenses in our environment:

> *Teacher*: So we now know that there are lenses in our eyes. Can anyone think of other lenses that we use?
> *Student*: There are lenses in my glasses!
> *Teacher*: Right; mine too! What do our spectacles do?
> *Student*: Help us see better.
> *Teacher*: Yup, I know when I take off my spectacles [do this] I can't see anything [squint]. Well, almost nothing. So what do we know about the function of lenses?
> *Student*: They focus light and help us see better!
> *Teacher*: Our eye lenses sometimes change shape, and when they do it changes our vision. The different lenses in spectacles help correct the shape of our eye lenses. Explain more fully the function of convex and concave lenses. Convex lenses converge light rays and, as a result, make objects appear larger. Concave lenses diverge light rays and make objects appear smaller. Convex lenses help people who are farsighted (i.e., people who have trouble seeing close up). Concave lenses help people, like me, who are nearsighted (i.e., have trouble seeing far away).

Invention phase. In the following activity, students will construct and use a water lens.

Water Lens

Materials

Styrofoam cups (enough for each child), string, piece of plastic wrap (one piece for each child), water, coins, and various objects. Precut the bottom off the Styrofoam cups, as this will reduce time as well as any possible accident that may occur with cutting.

Procedure (approximately 20 minutes)

1. Obtain an Activity Sheet (see following).
2. Stretch the sheet of plastic loosely over the top of each Styrofoam cup and tie a string around the rim of the cup. There needs to be a little slack in the plastic so it sinks down a bit when the water is poured in.
3. Pour some water onto the top of the plastic sheet. The weight of the water stretches the plastic into a lens shape.
4. Place a coin on the palm of your hand and predict what you will see when you look at it through your water lens. Write your prediction on your Activity Sheet.
5. Do it, and record what you observe on your Activity Sheet. Find other objects in the classroom and look at them under the water lens, similarly recording your observations.
6. Complete the other parts of the Activity Sheet.

Activity Sheet

Making a Water Lens

Predict what you think will happen

Record your observations.

Did you make a lens with the plastic wrap and water?

How did this occur? Explain how water and plastic form a lens.

What kind of lens did you make?