Wylie, C.D. (2012). Teaching nature study on the blackboard in late nineteenth- and early twentieth-century England. *Archives of Natural History, 39(1),* 59-76.
https://doi.org/10.3366/anh.2012.0062

Teaching nature study on the blackboard in late nineteenth- and early twentieth-century England

C. D. WYLIE

Department of History and Philosophy of Science, University of Cambridge, Free School Lane, Cambridge CB2 3RH, United Kingdom (e-mail: cdw34@cam.ac.uk)

ABSTRACT: England's Education Acts in the late nineteenth century made school free and mandatory for all children, filling schools with more and younger students. Visual teaching methods such as blackboard drawing were used to catch young students' eyes and engage their interest. At the same time, there was high public engagement with natural history and popular science lectures, which built the perception of science as accessible, interesting and useful for people of all social classes. This "science for all" trend along with the new universal education paved the way for nature study, a new school subject based on experiential learning through observation of plants and animals, similar to the popular nineteenth-century pedagogy of object lessons. The many manuals about nature study that were published for teachers in England in the early twentieth century reveal the content, pedagogy and portrayal of science communicated to young students. In-depth analysis of one manual, *Nature teaching on the blackboard* (1910), sheds light on typical nature study lessons, including suggested images for teachers to draw on the blackboard. Visual methods of teaching science were not limited to schoolchildren: university lecturers as well as popularizers of science used object lessons and blackboard drawing to educate and entertain their adult audiences. Comparing blackboard teaching of nature study with other educational images and audiences for science explores how multisensory learning and the blackboard brought information about the natural world and engagement with science to the public.

KEY WORDS: William Plane Pycraft – Janet Harvey Kelman – popular science – science education – scientific images

TEACHING AND LEARNING ABOUT NATURE

In nineteenth-century England, public interest in science was growing, as demonstrated and encouraged by public science lectures, science shows, and widespread engagement with natural history (Allen 1976; Secord 1994; Bowler 2006, 2009; Fyfe and Lightman 2007; Lightman 2007). Popular science events focused on specimens and demonstrations of experiments for the audience to observe. The widespread nineteenth-century teaching method of object lessons drew on the same idea of learning through experience, by having students handle familiar objects while learning about their properties (Anonymous 1903; Kohlstedt 1997, 2005, 2010; Keene 2008).[1] When the Education Acts of the 1870s and 1880s made school free and mandatory for all children, there was a sudden increase in the number of pupils and in the number of new teachers recruited to teach them (Green 1990: 302; Weedon 2003: 114). A new school subject grew from this context of popular science, hands-on education, and school reform: nature study, a curriculum and pedagogical approach based on students' observation of plants and animals. A large number of teaching manuals on nature study were published in the early twentieth century to help train teachers in the new subject. These manuals promoted the use of a common classroom tool to teach nature study: the blackboard.[2] Examining the instructions given to teachers on how to teach about nature captures a unique perspective on early twentieth-century science education and science communication, as educators proposed new answers to the questions of whom to teach, what to teach, and how to teach.

The popularity of natural history and the belief in its ability to develop children's observation skills and moral character contributed to schools' adoption of nature study, which became a required subject in state schools in 1900 (Anonymous 1903; Allen 1976; Jenkins 1981). First developed in Germany and the United States, nature study was based on object lessons, which were inspired by the learning-by-doing educational philosophies of Johann Heinrich Pestalozzi and Friedrich Froebel (Scott 1901; Keene 2008; Nyhart 2009; Kohlstedt 2010). Object lessons were meant to lead students to construct knowledge based on their own experiences, by handling and discussing familiar objects. The pedagogy of learning through experience laid the groundwork for the educational philosophies promoted by John Dewey and Jean Piaget in the early twentieth century

(Dewey 1925; Piaget 1928). However, object lessons were meant for small groups of children, often within a family. Classroom object lessons had a much larger audience and thus involved stricter teacher control and less participation by individual students (Figure 1). One of the late nineteenth-century Education Acts rewarded schools with grants for the number of subjects they taught, with the result that more schools taught science (Weedon 2003: 114). New teacher training courses were established, such as science courses at the Normal School of Science (later called the Royal College of Science) in London, some of which were taught by naturalist Thomas Henry Huxley (Humberstone 1922; Forgan and Gooday 1996).

Another resource for new teachers was the numerous teaching manuals published on nature study. Manuals were not textbooks and were not intended for students' use; they therefore offer valuable insight into what kinds of information were considered useful for teachers. Manuals contain basic information and drawings about nature study topics, such as plants and animals that can each serve as a lesson. General pedagogical advice and a few suggestions for class activities were also included, but there are no step-by-step lesson plans or assignments for students to complete during lessons like those often given in teaching manuals on other subjects. Also unlike other manuals, nature study manuals encourage teachers to prepare for lessons by observing and handling specimens. During the lesson, manuals advise teachers to draw selected aspects of the specimens on the blackboard while having students observe and handle the specimens. This endorsement of the same teaching methods for children and adults portrays science as accessible to everyone, regardless of age, social class or prior education. Interactive and visual pedagogies can be further understood through historical studies of educational tools such as wall charts and models, but there is little historical work on school blackboard use or pedagogical drawing (Chew 1986; Gooday 1991; Forgan and Gooday 1996; Bodmer 1997; Bucchi 1998; Hopwood 2002, 2006; Kidwell et al. 2008).

Sources vary on the exact origin of a reusable writing surface large enough for many students to see. It is most probable that the concept was developed in several schools concurrently. One story about the origin of the blackboard tells of an early nineteenth-century Scottish schoolteacher who mounted his students' small slates on the classroom wall to create a large "slate board" on which he could write geography lessons

visible to the entire class.[3] The first documented use of a blackboard, however, was by a mathematics teacher at West Point Military Academy in the United States in 1801 (Kidwell *et al*. 2008: 23). By 1844, England's Committee of Council on Education decided that a blackboard was a standard classroom fixture, thus making its purchase eligible for a government grant (Layton 1973: 95). A blackboard was a key tool by the early twentieth century, as shown by the many teaching manuals that included instructions on how to use a blackboard to teach various subjects.

Understanding the ways in which the blackboard should be used to teach nature study according to these manuals highlights the perceived role of science as interactive, engaging, and beneficial to society. Other kinds of educational images, such as wall charts and models, and other contexts for blackboard use, such as university courses and popular science lectures, help reveal how the use of blackboard drawing shaped science education and science communication in England in the early twentieth century. Sample lessons from *Nature teaching on the blackboard* (1910), by William Plane Pycraft and Janet Harvey Kelman, demonstrate two different approaches to teaching nature study.

The tactile and visual methods of teaching science promoted by nature study manuals were a unique and integral part of the late nineteenth- and early twentieth-century popularization of science, a trend Bowler (2009) called "science for all". How did teachers teach the ideals of "science for all" while also meeting the needs of larger classes and younger students after the Education Acts? Teaching nature study with a blackboard facilitated this challenge by giving teachers the power to educate large audiences through spontaneous drawing and interactive object lessons.

AUDIENCES AND EDUCATIONAL IMAGES

The popular science lectures and shows in nineteenth-century England demonstrate that science was considered a source of wonder, entertainment and education. However, the middle- and upper-class adults and children who chose to attend were a markedly different group from the lower- and middle-class children who had mandatory school lessons on nature study. Nature study also arguably reached a much wider audience than the events put on by popularizers of science. However, historians of popular science have

largely overlooked school science. Nature study manuals offer a perspective on how science was communicated to a large, multi-class audience of young children.

Regardless of who is in an audience, new information can only be communicated by making it fit with the audience's existing knowledge. In their study of nineteenth- and twentieth-century scientific atlases, Daston and Galison (2007: 53) described scientific images as reflections of a society's way of making sense of nature:

> Behind [images of] the flower, the snowflake, [and] the solar magnetogram stand not only the scientist who sees and the artist who depicts, but also a certain collective way of knowing ... . Nature, knowledge, and knower intersect in these images, the visible traces of the world made intelligible.

Because images of nature reflect scientific values, they serve an important role in education by not only representing natural objects but also by teaching the contemporary "way of knowing".

Several historians have explored the construction of scientific and educational images. In a study of visual language in geology, Rudwick (2005) suggested that scientific images act as "proxies" for natural objects, thereby allowing information about nature to travel across distances and social groups. Similarly, Law and Lynch (1988) presented schematic drawings as useful tools of animal identification but also as purposefully simplified and thus unrealistic images of nature. Hopwood (2002) portrayed three-dimensional models as pragmatic representations of nature for teaching, particularly when specimens are not available or easily visible. Bucchi's (1998) study of educational wall charts in nineteenth-century Germany demonstrated the style and organization of printed images designed to teach students about nature. These studies call attention to how images are made to convey different kinds of information to different audiences by matching the viewers' "way of knowing" in two senses: how viewers understand the natural world and how they interpret images. By corresponding to viewers' culture-specific ways of making and interpreting images – also known as visual culture – educational images can teach viewers how to interpret that visual culture and that approach to making sense of the natural world, in addition to the factual information portrayed in the image. What distinguished different types of educational images in early

twentieth-century England, and why did teaching manuals focus on blackboard drawings?

Like blackboard drawings, wall charts make images visible to large audiences and models enlarge small or complex details. Wall charts were often similar in subject to blackboard drawings, such as depictions of organisms at different life stages, anatomized and arranged by classification group, with cross-sectional and two- and three-dimensional views (Bucchi 1998; Redi *et al*. 2000). Most wall charts, like blackboard drawings, lacked text to explain the images and thus required a teacher's explanation, giving the teacher the power to direct students' attention to selected aspects of the images.

Blackboard drawings are unique because they are drawn in an instant in front of an audience and are destined to be erased.[4] A blackboard drawing usually did not provide the details or attain the accuracy of pre-made wall charts and models. The person drawing on a blackboard decides the image's size, color and level of intricacy. This flexibility is valuable in a classroom, where information must be presented in ways that are tailored to the students' existing knowledge, levels of comprehension and interests. Making an image in front of an audience is dynamic, and thus more engaging than pointing at a pre-made image. Blackboard drawing made images accessible by allowing modifications of size and scale. In the early 1900s, because experimental apparatus was lacking and it was impractical to demonstrate a subtle experiment to a large class, physics teachers often "performed" experiments by drawing them on the blackboard: "As H. G. Wells once pointed out, such experiments have never been known to fail" (Chew 1986: 42).[5]

In addition to adaptability and spontaneity, the low cost of blackboard drawings contributed to their widespread use in schools, universities and public lectures. Wall charts and models were expensive and often too complicated for young children to understand (Bucchi 1998; Redi *et al*. 2000). Models in particular were more common in universities, especially to replace rare or invisible specimens such as embryos and microscopic structures (Hopwood 2002, 2006). Nature study would not have needed detailed models to replace plants and animal specimens, because lessons were supposed to include real organisms. On the other hand, a useful image could be drawn immediately on a blackboard, with no prior set-up, printing, or purchasing. A 1901 teaching manual advertised a wall-mounted blackboard, four feet by two feet, "strongly framed" and

"absolutely unwarpable", for 18 shillings, while a twelve feet by four feet board cost 96 shillings (£4. 16s. 0d.) (Hewitt [1901]: 8). Blackboards were reusable and long-lasting and thus a good investment for a school. The cost could also be further reduced by making a less durable but quite functional blackboard according to instructions provided in some manuals, for example, by painting a mix of shellac, lampblack, and powdered pumice stone on to a board or cloth (Wood 1903: 33-35). Cheaper, more temporary options like "slate-paper" and "American cloth" served as portable chalk-writing surfaces that could be mounted as needed (Hewitt [1901]: 8; Arthur 1908: 346; Durley 1914: foreword). Types of chalk were also important to the authors of these manuals: "The 'chalk' used is not the true chalk, or calcium carbonate, known to chemists, but is a compressed stick mainly of calcium sulphate" (Horspool 1909: introduction). Most manuals encouraged teachers to "give additional brightness and interest to the lessons" (Belsey 1896: 8) by using colored chalk, which had been available since the early nineteenth century and was often used to draw portraits (on paper). Hewitt ([1901]: 9) advertised colored chalk at 2 shillings per gross and the same quantity of white chalk for 1 shilling.

VISUAL LEARNING

Images and image-making also trained students to observe. Students would watch their teacher draw and modify an image while talking about and pointing out salient aspects of both the drawing and the specimen being drawn, thus demonstrating what was considered to be good observation. If students saw only a finished image, they would not witness its creation as the result of their teacher's attention to detail and selection of important traits to draw. Watching the teacher drawing on the blackboard showed children what they should notice in their own observations: "Children ... must be encouraged and stimulated to be discoverers: they must be taught how to learn" (Shoosmith 1906: v). According to nature study manuals, teaching "how to learn" did not just mean letting a student handle a specimen or go outside to explore nature; the development of a pupil's skill was considered dependent on the teacher's explicit instructions and demonstration of the qualities of proper observation (Wylie 2011).

Manuals only give hints of what kinds of classroom activities should be used to teach children how to be "discoverers". Many manuals offer only background information and blackboard drawings for each lesson for the teacher, without mentioning whether students should be writing or drawing or performing any other activity during the lesson (for example, Shoosmith 1906, [1920]; Pycraft and Kelman 1910). This omission might seem strange when compared with teaching manuals on other subjects, which often included suggested assignments for students as well as scripts for recommended dialogues between the teacher and the class (Wylie 2011). In nature study, however, the manuals were addressed to teachers who presumably already knew how to teach but needed specific information on a subject new to the curriculum.

Nature study manuals do suggest some activities for students, such as going on nature walks and collecting specimens. Examining specimens of plants and animals, ideally with a hand lens, was emphasized. Manuals also recommend that students dissect organisms. I have found only one manual, F. F. Lydon's *Nature lessons with the blackboard* ([1902]), that included "teaching notes", which are explicit statements to the teacher of what he or she and the students should do during a lesson. For a lesson on the primrose, Lydon ([1902]: 26) listed a variety of actions:

> Place the sketch of the whole plant on the board. Let the children examine their flowers, and elicit that calyx and corolla are each in one piece … . Let the children carefully tear down the corolla … . Sketch the sections on the blackboard, and by recapitulation of former lesson elicit functions of pistil and stamens.

Lydon also provided "blackboard notes" that show what the teacher should write on the blackboard during the lesson. For the primrose, these included scientific terms and the main ideas from the lesson, such as "corolla and calyx each in one piece" (Lydon [1902]: 26). Observation, dissection, discussion, and blackboard drawing were combined in nature study classes with the aim of encouraging children to use their senses. ?? highlights the value of combining tactile, aural, and visual learning in nature study. At the end of Lydon's "teaching notes" is a further clue as to what students did to learn nature study: "In the succeeding drawing lesson the sketch of the plant should be taken" (Lydon [1902]: 26). According to this manual, nature study should extend into other subjects,

such as by using the same plant or animal from a nature study lesson as a model for a drawing lesson.

In the United States, students were encouraged to write about specimens and draw what they had observed, as shown by the nature study notebooks and sketchpads produced for schools (Kohlstedt 2010: 116). Covington (1904: 701) wrote about the necessity of having young children draw as well as write as part of nature study lessons: "Drawing and painting should be taken as a matter of course; and written records of nature-study should be regarded as incomplete without the drawings and paintings to accompany them." Drawing lessons were standard practice in schools in England as well as in the United States, and plants and animals were often recommended as models for students to draw (Hewitt [1901]; Dean 1904). It is likely that nature study lessons were often tied to drawing lessons, because both shared the goal of teaching children how to observe.

The role of writing assignments for students in nature study is unclear. The only mention I have found of written work is in W. Francis Rankine's *Nature study and brush drawing* (1908: 61), which warned that observation may be impeded by too much writing: "Promiscuous and wholesale listing of observances is worthless and bewildering, and only helps to veil the ultimate of the true Nature-teacher", meaning nature itself. This comment suggests that nature study's hands-on pedagogy might have been a reaction against school lessons that focused on learning by oral and written drill. However, Rankine recommended that students take some notes about such matters as the environments that certain organisms are found in, which requires describing the weather, plants, animals and soil of a location. Also, "probably the most valuable records are those of the first appearances of flowers, insects and migrants" (Rankine 1908: 61). The educational value of noticing and recording natural occurrences seems to have been balanced with a desire to avoid "worthless" writing assignments.

It is probable that advice on activities for pupils was omitted from nature study manuals because writing and drawing were so commonplace in lessons that they did not need explanation. Perhaps it was assumed that teachers would have students describe specimens in words and by drawing them, as ways to practice their observation skills. Nature study manuals are strikingly more flexible in their recommended practices than

manuals on other subjects, with their repeated advice to teachers to adapt the content of lessons to students' interests, the local environment, and the season (Wylie 2011). Thus it could be that nature study activities for students were also left to teachers' discretion.

Nature study manuals include recommendations on how teachers should learn about natural history – an inclusion just as unusual as the omission of activities for pupils. Manuals encourage teachers to learn by observing nature, guided by the manuals' text and drawings. In *Nature study and the blackboard*, Shoosmith ([1920]: xiv; emphasis in the original) insisted that teachers should not copy the manual's images or memorize its text because the information "should be *thought through*, rather than read through, with due reference to Nature itself", just as children should learn from observing specimens. Similarly, when describing mammalian red blood cells as lacking nuclei, the authors of *Nature teaching on the blackboard* suggested an activity specifically for teachers (Pycraft and Kelman 1910: **3**: 1):

> By the fact that these blood-discs [blood cells] have no kernel [nucleus], it would be possible to distinguish the blood of a 'mammal' at once from that of a bird or reptile … . But it is obviously a test which children could not employ. All teachers, however, should use at least a low-power microscope, and a drop of blood drawn from the finger with a needle will afford a lesson that will never be forgotten

Thus learning directly from nature was presented as beneficial for learners of all ages.

SPECTACLE ON THE BLACKBOARD

A challenge for many teachers was learning to draw unfamiliar objects (such as diverse views of plants and animals) in the public context of the classroom. But their efforts were encouraged by the educational benefits of spontaneous drawing that were evident from other settings. The blackboard was considered a valuable teaching tool within numerous subjects including religion, geography, drawing, needlecraft, and even temperance, for both children and adults (Belsey 1896; Wethey 1896; Hewitt [1901]; Sindall [1904]; Hambridge [1913]). Lecturing while performing spontaneous drawing was thought to hold an audience's attention while also helping the listeners to understand and remember information: "When the drawings are made in the presence of the class … [is] one of the best means for stimulating the interest of the pupils", even if the drawings are "mere sketches of details, or of parts that … cannot be readily seen in the actual object" (Lydon

[1902]: 1). The appearance of the drawings was thus not as important as their spontaneous production, although "no drawing is equal in interest, or in usefulness for illustration, to the actual object itself" (Lydon [1902]: 1).

Even outside of schools, drawing on a blackboard allowed a lecturer to easily create and modify images to meet the needs of the audience, unlike inflexible pre-made images and models. Huxley used the in-the-moment adaptability of a chalk drawing to illustrate evolution (Figure 2) in his university courses for adults. According to Huxley's student Jeffrey Parker, "His blackboard illustrations were always a great feature of his lectures, especially when, to show the relation of two animal types, he would, by a few rapid strokes and smudges, evolve the one into the other before our eyes" (Bodmer 1997: 281). Although young nature study pupils have not left records of their reactions to blackboard drawing, we might assume that they were similarly captivated by their teachers' sketching.

The "performance" of spontaneous drawing was considered more important than the images themselves in popular science shows, as well as in teaching manuals. The late nineteenth-century popularizer of science John George Wood became famous for illustrating his public natural history lectures. Wood drew with colored pastel crayons on an enormous black canvas, which he wiped clean after each lecture. It would have saved time to make a reusable image for each topic, especially because Wood often gave the same lecture several times, but Wood valued the spectacle of spontaneous drawing. Its impressive effect was manifest in the audience's reaction, as reported by Wood in 1883: "When I opened the lecture … by drawing the whale, eleven feet long, in two strokes, there was first dead silence, and then such a thunder of applause that I had to wait" (Lightman 2000: 658). On-the-spot drawing of even rough images like only two lines of chalk representing a whale was considered a fascinating performance, suggesting that the appearance of the drawing itself was not the primary concern of blackboard drawing because exactness was likely to be sacrificed to speed. Antarctic explorers Captain Robert Falcon Scott and Ernest Shackleton illustrated public lectures at Owens College, Manchester, in 1904 and 1909, respectively, by drawing a penguin on a blackboard (Figure 3). The blackboards with these drawings were saved and given to the Scott Polar Research Institute at the University of Cambridge (Lewis-Jones 2008).[6] The value of the

process of spontaneous drawing, more than the accuracy of the drawings, is clear even in drawings by famous naturalists such as Huxley, Wood, Scott, and Shackleton. This emphasis would have also reassured teachers who might not have been talented in draftsmanship that their performance was more engaging and thus more educationally beneficial than strictly accurate drawings.

NATURE TEACHING ON THE BLACKBOARD

One nature study manual in particular embodies a rare grouping of teaching methods, showing that different pedagogies co-existed. *Nature teaching on the blackboard* (1910), by William Plane Pycraft and Janet Harvey Kelman, is a three-volume book containing drawings of more than a hundred plants and animals, with each organism serving as a lesson.[7] Its "lessons" are only background information, however, with no teaching notes and few pedagogical suggestions. *Nature teaching* is the longest and most expensive blackboard manual I have found[8] and one of only a few to have its publication announced in *Nature* (Anonymous 1910).[9] Kelman, an illustrator of children's books about natural history, wrote and illustrated the first two volumes which are about plants. Pycraft, a zoologist at the British Museum (Natural History) and author of several books and articles for the public about natural history and particularly about birds (Stearn 1981: 190), wrote and illustrated the third volume on animals.[10] A nature study manual co-authored by a well-known naturalist like Pycraft was more likely to merit a high price and be announced in *Nature* than a manual by an artist like Kelman, an educator like Lydon, author of *Nature lessons with the blackboard* [1902], or even a lesser-known naturalist like Shoosmith, author of *Nature study and the blackboard* [1920]. The striking similarity of these book titles and the diverse backgrounds of their authors suggest that manuals about nature study were in high demand at this time.

Perhaps to compete with these other manuals, *Nature teaching* emphasized its pedagogical and practical usefulness. The lessons were presented as informative and flexible, with the manual claiming "to put into the teacher's hands matter that could be used in connection with Nature Study lessons in classes of very young children … [or] more advanced classes along with a botanical text-book" (Pycraft and Kelman 1910: **1**: v). The book highlighted hands-on pedagogy: "The drawings can only be helpful in such

lessons when they are used along with, and not apart from, actual specimens … which can be handled, examined, and dissected" (Pycraft and Kelman 1910: **1**: v). Further,

> It cannot be too strongly emphasised that the object of these studies is to lead pupils to look at, to observe, and to learn to interpret Nature for themselves, and that these plates [blackboard drawings] can only meet this end if they are used along with living twigs, leaves, flowers, and fruits. (Pycraft and Kelman 1910: **1**: vi.)

These statements succinctly define nature study, making its interactive methods and its objective of developing observation skills clear even to teachers unfamiliar with the relatively new subject. When Pycraft wrote (1910: **3**: 56) that "gold-fish … afford a most valuable object-lesson", he linked teaching nature study to the tradition of object lessons. Like the appeal to familiar objects to teach children, *Nature teaching* presented nature study as familiar pedagogy to teachers, rather than as a new subject that might seem confusing or overwhelming.

The blackboard images were described as "have intentionally been kept simple, and the limitations that are imposed by the material with which the teacher has to work, namely, blackboard and chalk, have been studiously kept in view" (Pycraft and Kelman 1910: **1**: v). Also, the drawings are "of such a nature that any one may reproduce them without possessing any but a rudimentary knowledge of or aptitude for draughtsmanship" (Pycraft and Kelman 1910: **1**: v).[12] Teachers were encouraged to adapt the drawings as needed: "The figures could be simplified still further by the omission of details" or by separating one into a few drawings, which "will be easily and correctly done if an actual specimen is always used along with the figure" (Pycraft and Kelman 1910: **1**: vi). The images were designed to be ideal for teachers' needs by minimizing the tools, time, and attention required for their production, while also enabling teachers to control the drawings' design and content.

In addition to their simplicity and adaptability, *Nature teaching*'s images depicted the aspects of plants and animals considered most relevant for classroom instruction. The book promised to assist teachers "in producing easily and rapidly a really effective blackboard illustration of the features of interest to which the attention of the pupils is to be directed" (Pycraft and Kelman 1910: **1**: v). *Nature teaching* thus appears to be a

picture of efficiency, providing factual information adaptable to suit learners of all ages complete with quick, achievable illustrations of the exact features teachers needed. Such claims would have been appealing to teachers with little scientific training and large classes.

The subjects of this informative text and "simple" images were species that were familiar to English children: "All the animals selected are such as can be seen alive even by children in crowded cities, or can be obtained without the slightest trouble, 'in the flesh'" (Pycraft and Kelman 1910: **1**: vi). The study of familiar species ensured availability – a practical concern for teachers – but also emphasized the value of learning about nature that was accessible to students. Lessons should also match the season, such that "in the plates of trees, the twigs and buds that can be had in winter and early spring should be studied then" (Pycraft and Kelman 1910: **1**: v). Seasonally appropriate lessons addressed students' current surroundings, so that children learned about familiar plants and animals that were therefore interesting and relevant to their lives.

These common species served as examples of broader natural phenomena. As examples of fishes, Pycraft selected "the Haddock, Plaice, Eel, and Stickleback, each because it teaches some important truth, or affords a broad insight into fish life in general", specifically adaptations for different environments (Pycraft and Kelman 1910: 1: v).[11] Species were also selected to represent taxonomic groups. Pycraft first described mammals, birds, fishes, and "jointed animals", then followed each with lessons on species that represent subgroups, such as rodents, carnivores, and insects. However, Kelman does not explain any specific order or classification system for her sequence of lessons.

Examining a lesson from each author elucidates Pycraft's and Kelman's teaching goals and techniques. The lessons on the primrose and on the frog serve as typical representations of the authors' styles, and also were archetypal nature study topics that were included in virtually every manual (for example, Lydon [1902]; Shoosmith 1906, [1920]). These lessons can be treated as a kind of object lesson in themselves, such that studying them closely reveals more general themes of nature study content and pedagogy. Furthermore, these lessons exemplify how nature study allowed the teacher to control which aspects of nature students could access. By choosing the lesson topics and

specimens and by designing blackboard images, teachers directed students' attention to selected features.

The two volumes of *Nature teaching* that Kelman wrote focus on the aesthetic aspects of natural history, perhaps because of her work as an illustrator. For example, the text of her lesson on the primrose resembles an extended caption, with separate entries for each of the thirteen component images (Figure 4). Kelman begins most lessons with a "Figure 1" depicting an entire plant in bloom, similar to the standard conventions of botanical drawings. The description identified structures *in situ* on the image, then succeeding figures provided close-up or cross-sectional views of the various parts of a primrose. The description also discussed the two types of primrose, the pin-eyed and the thrum-eyed, offering a comparison to distinguish between them (Pycraft and Kelman 1910: **1**: 30):

> FIGURE 6 shows, enlarged, the case that contains forms that may develop into seeds from a pin-eyed flower whose corolla is seen in Figure 5. The top (stigma) of the pillar (style) that rises from the case reaches the mouth of the petal tube, and is at the same level as the tips of the stamen heads (anthers) of the thrum-eyed flowers. … FIGURE 8 shows, enlarged, the case that contains forms that may ripen into seeds from a thrum-eyed flower, whose corolla is seen in Figure 7. The top (stigma) of the pillar (style) that rises from the case reaches only half-way up the petal-tube, and is at the same level as the stamen heads (anthers) of the pin-eyed flowers.

The inclusion of scientific terms after the definitions allowed teachers to adapt the information for different ages and levels by choosing whether to teach the scientific terms. By referencing other images, such as "Figure 5", the text indicates multiple views of the same structures as well as comparisons of the different flower types. Without the images, the text and its reference to the positions of the various structures relative to each other would be virtually incomprehensible; without the text, the differences between the comparative images might be difficult to identify. Kelman's explanation of the specific differences between two types of the same species reflects the importance of guided observation in nature study. Thus her lessons focus on teaching students how to gather information from both blackboard drawings and specimens.

Perhaps to aid students' learning-by-seeing, Kelman's drawings range from three-dimensional, life-like images to simplified diagrams composed of only a few lines. When observing primroses, students would benefit from a comparatively simplified, magnified image like Figure 1 to illustrate and clarify the plant's complexity and to enlarge its small size. The zoomed-in diagrams show specific aspects that Kelman deemed important, such as the difference between the two primrose types. These diagrams do not need to be strictly realistic because they represent only the features central to the lesson, which can be depicted effectively even if the diagram is a mere line with circles at both ends like Figures 6 and 8 of the ovary, style and stigma. Thus images can make nature more intelligible by selectively depicting only certain parts, thereby communicating limited but purposefully chosen information.

In contrast, Pycraft's lessons focus on the morphology and life history of animals, employing detailed and engaging text with images used only as examples. Pycraft described the frog as "one of the most perfect object-lessons illustrating the meaning of a 'life-history'" (Pycraft and Kelman 1910: **3**: 51). Accordingly, the lesson on the frog focuses on growth and development, providing detailed descriptions of all developmental stages. Like Kelman's example of the two types of primrose, Pycraft (Pycraft and Kelman 1910: **3**: 51) relied on comparisons with other animals to elucidate unique characteristics of the frog.

> The frog is a member of a lowly group of animals known as the 'Amphibia' … . They differ entirely from the reptiles in many things, and resemble, on the other hand, the fishes … . The adult form is reached only after a 'metamorphosis' … . It commences life as a fish-like larva, breathing by gills: thus it recalls the caterpillar and the butterfly, and differs absolutely from the reptiles (*q.v.*).

Reptiles were studied in previous lessons and fish lessons follow the frog lesson, thus allowing learners (both teachers and students) to understand the new information about the frog relative to what they already know and what they will learn next. Thus Pycraft's lessons form a sequence that builds upon existing knowledge by presenting animals as similar or dissimilar to other species, thereby constructing a framework to show students how animals are classified. If, however, teachers obey the preface's encouragement to

adapt the lessons and do not follow Pycraft's intended order, the comparisons he used are familiar enough to be meaningful to students who have not yet studied a species in depth. One comparison, for example, clarifies the anatomy of a frog's tongue by contrasting it with a human tongue: "This tongue in frogs, toads, and their kind differs from that of other creatures in being fixed so that the tip points *toward the throat*, and not forwards as in ours" (Pycraft and Kelman 1910: **3**: 51; emphasis in the original). Pycraft recommended that students "get a 'grip' of the essential characteristics of distinctive features of an animal" by comparing it with familiar animals, thus adding new information into students' prior framework of knowledge (Pycraft and Kelman 1910: **3**: 11).

Pycraft advised that pupils should study the frog using both passive observation and hands-on activities. "During March and April ponds and ditches should be searched for the eggs of the frog. These are laid in masses known as 'spawn.' … A mass of frog-spawn should be kept in a glass bowl and examined daily" (Pycraft and Kelman 1910: **3**: 51). A field trip to collect frog-spawn and then observe its development exemplifies nature study's focus on direct observation of specimens. Pycraft also suggested that students explore anatomy: "If a dead frog be examined and the eyes pressed down, it will be found that they convert the roof of the mouth into a channel well adapted to facilitate the swallowing of large mouthfuls of food" (Pycraft and Kelman 1910: **3**: 52). Thus for Pycraft, observation and anatomical study produce general information about nature from a well-known animal, using the frog as an example of how animals develop and of how their bodies' structures allow certain functions (such as swallowing large prey).

Pycraft's frog drawings are more detailed than Kelman's primrose drawings (Figure 5). Unlike Kelman's text-free images, words that serve as captions and labels occupy almost as much space on Pycraft's page of images as the images do. Text alongside the images would be convenient for teachers to read while they are drawing on the blackboard, whereas they would have to turn the page to read Kelman's image descriptions. These images would also be valuable when used alongside specimens as the preface recommends, to avoid such practical difficulties for teachers as obtaining specimens of all the life-stages, witnessing the tongue in action, or glimpsing the teeth of a tadpole. Images can thus enhance nature study by offering a broader understanding of a

species through multiple representations of it, and by allowing unlikely or impossible views.

Although Kelman's and Pycraft's lessons include both tactile and visual modes of teaching and learning, the focus of their lessons is different. Kelman's volumes look like an art book and read like a dictionary of botanical anatomy. Her images lack text (besides figure numbers), and her text page explains the plant's lifecycle and identifies the plant's anatomical parts without mentioning habitat or function. Pycraft's volume emphasizes function, using images to depict and explain both the structures and their functions. Pycraft's text is organized in paragraphs of connected prose according to topics such as food, reproduction, and "mode of life" based on habitat and life-cycle (Pycraft and Kelman 1910: **3**: 67). Pycraft's images are not numbered like Kelman's and are referred to in the text by the nonspecific indication of "(Diagram)", requiring the reader to search through the drawings to identify the appropriate one. These two approaches printed as separate volumes of one book show the plurality of accepted ways to teach nature study in the early twentieth century. Where these approaches give the same advice indicates nature study's defining aspects, such as handling specimens, viewing blackboard drawings, and learning the defining characteristics of organisms as selected by the teacher.

CONCLUSION

In the early twentieth century, manuals were published to address the problem of teaching a new school subject with a relatively new tool, the blackboard. The diversity of the ways recommended to teach nature study is evident in manuals, such as *Nature teaching on the blackboard*, that present multiple methods. But the overall purpose of the content and pedagogy recommended by all nature study manuals was to engage students. Nature study taught young children to perceive science as familiar and interactive, by making local species into object lessons that illustrated broader lessons about natural phenomena, such as the frog's life cycle as an example of animal growth and development. Blackboard drawing helped teachers capture the attention of their pupils through visual spectacle, and then direct their eyes to selected features and facts. Blackboard drawing thus enabled teachers to control nature in a sense, by limiting depiction to only the details

that they chose. Nature study can also be viewed as a form of crowd control, in that its attention-grabbing pedagogy aimed to engage even large classes of children, particularly for the youngest pupils. Nature study may also have appealed to educators because it involved things that children liked, such as familiar plants and animals, hands-on activities, and occasional trips outside the classroom. Thus educators endorsed nature study not only to offer engaging lessons for students, but also to improve classroom control.

On a broader scale, England's new mandatory and state-funded education in natural history served to encourage rationality and stability among its youth. A report on a 1902 nature study conference in London claimed that nature study had national benefits: "Accurate observation and correct inference are the ministers of sound judgment, on which depend the manifold varieties of efficiency which make up the total of national welfare" (Anonymous 1903: 9). Shoosmith ([1920]: xiii) claimed that nature study protected an individual's mental well-being and therefore was beneficial for society as a whole:

> *Of all the influences that tend to steady and calm the mind and keep it sane* under the stress of modern life *the love of Nature is unrivalled*. That alone would justify, and should secure, the inclusion of the subject in the curriculum of every school in the land … to be regarded as something that makes for the happiness of mankind. [Emphasis in the original.]

As such, nature study and blackboard teaching were key components of both the new state-sanctioned education and the new science education. Through visual spectacle, the handling and observation of familiar plants and animals, and claims to improve society, nature study and blackboard teaching embodied the growing value placed on the communication of scientific knowledge to the public and instilled the principle of "science for all" in the next generation of English citizens.

ACKNOWLEDGEMENTS

With thanks to Jim Secord, Richard Barnett, the staff of the Whipple Library at the University of Cambridge, and a very helpful reviewer.

NOTES

[1] KEENE, M. J., 2008 Object Lessons: Sensory Science Education 1830-1870. Ph.D. thesis. University of Cambridge. T. H. Huxley's famous "On a piece of chalk" lecture in 1868 was an object lesson for adults, in which Huxley used a common object (chalk) to illustrate broader information about natural history, specifically geology and fossils (Huxley 2006).

[2] "Chalkboard" refers to mid-twentieth-century green-colored "blackboards". The British Library holds 86 titles with keyword "blackboard" published before 1950, with the earliest published in 1847 and the majority (sixty books) published between 1890 and 1920. See Wylie (2011) on blackboard teaching in other subjects in addition to nature study.

[3] This story is on several websites, including: URL (accessed 17 August 2011): www.articlesbase.com/education-articles/history-of-the-chalkboard-660163.html (W. Fernley, 2008 "History of the chalkboard"); URL (accessed 17 August 2011): www.ergoindemand.com/about_chalkboards.htm (Anonymous, 2009 "About blackboards"); URL (accessed 17 August 2011): www.wisegeek.com/what-is-the-history-of-the-chalkboard.htm (S. Mithra, 2011 "What is the history of the chalkboard?").

[4] Preservation is possible, such as a blackboard inscribed with Albert Einstein's teaching notes that is now in the Museum of the History of Science at the University of Oxford. Also, blackboards with chalk drawings by Antarctic explorers Robert Falcon Scott and Ernest Shackleton are preserved on blackboards at the Scott Polar Research Institute at the University of Cambridge (see Figure 3).

[5] Wells was a student in Huxley's science courses for teachers at the Normal School of Science in the 1880s.

[6] URL (accessed 17 August 2011): http://www.spri.cam.ac.uk/friends/polarbytes/46 (H. Lewis-Jones, 2008 "Astonishing find in the Museum's basement!").

[7] *Nature teaching* has 104 pages of chalk-on-blackboard-imitative white images on black background, a style that is typical of teaching manuals' images of blackboard drawings. Early nineteenth-century astronomer John Herschel preferred this type of image for depicting constellations. He thought that representing stars as black against a white background "'is extremely likely to puzzle and to create misconception'" (Schaffer 1998: 448). The same could be said of the images in teaching manuals, in that black-on-white images might be confusing to translate into white-on-black blackboard drawings.

[8] At 7 shillings 6 pence (7s. 6d.) per volume (£1 1s 6d. for the complete work), *Nature teaching* cost much more than comparable nature study manuals (for example, *Nature lessons with the blackboard* (Lydon [1902]) cost 3 shillings, and the two-volume *Nature study and the blackboard* (Shoosmith [1920]) sold for 9 shillings) or popular science books for children (usually 3 shillings to 6 shillings) (Bowler 2006: 169), and fell in the higher price range of late nineteenth-century science textbooks (from 1 shilling to 30 shillings, with the majority under 5 shillings and the best-sellers under 2 shillings) (Weedon 2003: 136).

[9] *Nature* (Anonymous 1910) referred to *Nature-study on the blackboard*, rather than *Nature teaching on the blackboard*. One of the two copies that I consulted had "Nature study" on the title page of the first volume, while the second and third volumes had "Nature teaching", and the other copy had "Nature teaching" in all volumes. This inconsistency suggests that the title was changed soon after the first volume was issued.

[10] Pycraft's copious fan mail is extant: Natural History Museum, London, archives (DF 234:31).

[11] Shoosmith ([1920]: ix) reproduced this exact sentence. Recycling text from older nature study blackboard manuals may indicate the genre's popularity.

[12] The striking absence of discussions of evolution in *Nature teaching* and other manuals may reflect the "eclipse of Darwinism" period from the late nineteenth to the early twentieth century, as described by Julian Huxley (Bowler 1983).

REFERENCES

ALLEN, D. E., 1976 *The naturalist in Britain: a social history.* Harmondsworth.

ANONYMOUS, 1903 *Official report of the Nature-Study Exhibition and Conferences held in the Royal Botanical Society's Gardens, Regent's Park, London. July 23rd to August 5th, 1902.* London.

ANONYMOUS, 1910 Notes. *Nature* **83**: 500.

ARTHUR, J. W., 1908 *Blackboard talks with boys and girls*. London.

BELSEY, F. F., 1896 *The Bible and the blackboard: scripture lessons for EYE and EAR*. London.

BODMER, G. R., 1997 The technical illustration of Thomas Henry Huxley, pp 227-295 in BARR, A. P. (editor), *Thomas Henry Huxley's place in science and letters*. London.

BOWLER, P. J., 1983 *The eclipse of Darwinism: anti-Darwinian evolutionary theories in the decades around 1900*. Baltimore.

BOWLER, P. J., 2006 Experts and publishers: writing popular science in early twentieth-century Britain, writing popular history of science now. *British journal for the history of science* **39**: 159-187.

BOWLER, P. J., 2009 *Science for all: The popularisation of science in early twentieth-century Britain*. Chicago.

BUCCHI, M., 1998. Images of science in the classroom: wallcharts and science education 1850-1920. *British journal for the history of science* **31**: 161-184.

CHEW, V. K., 1986 Bring out your dead apparatus: the science teaching collection at South Kensington. *School science review* **68**: 36-47.

COVINGTON, A., 1904 Drawing and painting in connection with nature-study. *The elementary school teacher* **4**: 701-704.

DASTON, L. and GALISON, P., 2007 *Objectivity*. New York.

DESMOND, A., 1982 *Archetypes and ancestors*. London.

DEWEY, J., 1925 *Experience and nature*. Chicago.

DURLEY, T., 1914 *The king's crown; and thirty other addresses, dedicated to "worshipping young people" in their mid-teens. With twenty-two blackboard illustrations*. London.

FORGAN, S. and GOODAY, G., 1996 Constructing South Kensington: the buildings and politics of T. H. Huxley's working environments. *British journal for the history of science* **29**: 435-468.

FYFE, A., and LIGHTMAN, B. (editors), 2007 *Science in the marketplace: nineteenth-century sites and experiences*. Chicago.

GOODAY, G., 1991 'Nature' in the laboratory: domestication and discipline with the microscope in Victorian life science. *British journal for the history of science* **24**: 307-341.

GREEN, A., 1990 *Education and state formation: the rise of education systems in England, France, and the USA.* London.

HAMBRIDGE, E. R., [1913] *Blackboard diagram drawing for teachers of needlecraft*. Bath.

HEWITT, F., [1901] *Elementary lessons in free-arm drawing.* Third edition. Leeds.

HOPWOOD, N., 2002 *Embryos in wax: models from the Ziegler studio.* Cambridge.

HOPWOOD, N., 2006 Pictures of evolution and charges of fraud: Ernst Haeckel's embryological illustrations. *Isis* **97**: 260-301.

HORSPOOL, R., 1909 *Blackboard drawing in line and mass*. London.

HUMBERSTONE, T. L, 1922 Science and education at South Kensington. *Nature* **110**: 79-81.

HUXLEY, T. H., 2006 On a piece of chalk pp. 38-53 in HUXLEY, T. H., *Autobiography and selected essays*. Teddington.

JENKINS, E. W., 1981 Science, sentimentalism or social control? The nature study movement in England and Wales, 1899-1914. *History of education* **10**: 33-43.

KIDWELL, P., ACKERBERG-HASTINGS, A., and ROBERTS, D., 2008 *Tools of American mathematics teaching, 1800-2000.* Washington, D.C.

KOHLSTEDT, S. G., 1990 Parlors, primers, and public schooling: education for science in nineteenth-century America. *Isis* **81**: 425-445.

KOHLSTEDT, S. G., 1997 Nature study in North America and Australasia, 1890-1945: international connections and local implementations. *Historical records of Australian science* **11**: 439-454.

KOHLSTEDT, S. G., 2005 Nature, not books: scientists and the origins of the nature-study movement in the 1890s. *Isis* **96**: 324–352.

KOHLSTEDT, S. G., 2010 *Teaching children science: hands-on nature study in North America, 1890-1930*. Chicago.

LAW, J. and LYNCH, M., 1988 Lists, field guides, and the descriptive organization of seeing: birdwatching as an exemplary observational activity pp 267-300 in LYNCH, M. and WOOLGAR, S. (editors), *Representation in scientific practice*. London.

LAYTON, D., 1973 *Science for the people: the origins of the school science curriculum in England.* London.

LIGHTMAN, B., 2000 The visual theology of Victorian popularizers of science: from reverent eye to chemical retina. *Isis* **91**: 651-680.

LIGHTMAN, B., 2007 *Victorian popularizers of science: designing nature for new audiences.* Chicago.

LYDON, F. F., [1902] *Nature lessons with the blackboard*. London.

NYHART, L. K., 2009 *Modern nature: the rise of the biological perspective in Germany*. Chicago.

PIAGET, J., 1928 *The child's conception of the world*. London.

PYCRAFT, W. P. and KELMAN, J. H., 1910 *Nature teaching on the blackboard.* London. 3 volumes. (Volume **1** also issued as *Nature study on the blackboard*.)

RANKINE, W. F. 1908 *Nature study and brush drawing*. London.

REDI, C. A., GARAGNA, S., ZUCCOTTI, M., CAPANNA, E., and ZACHARIAS, H., 2000 *Visual zoology: the Pavla collection of Leuckart's zoological wall charts (1877).* Como.

RUDWICK, M. J. S., 2005 *Bursting the limits of time: the reconstruction of geohistory in the age of revolution.* London.

SCHAFFER, S., 1998 On astronomical drawing, pp 441-471 in JONES, C. and GALISON, P. (editors), *Picturing science, producing art*. London.

SECORD, A., 1994 Science in the pub: artisan botanists in early nineteenth-century Lancashire. *History of science* **32**: 269-315.

SCOTT, C. B., 1901 *Nature study and the child*. London.

SHOOSMITH, F. H., 1906 *Object lessons in plant life*. London.

SHOOSMITH, F. H., [1920] *Nature study and the blackboard.* London. 2 volumes.

SINDALL, R. W., [1904] *The Band of Hope blackboard: a simple treatise on the art and principles of blackboard teaching as applied to the weekly meetings of the Band of Hope*. London.

STEARN, W. T., 1981 *The Natural History Museum at South Kensington.* Norfolk.

WEEDON, A., 2003 *Victorian publishing: the economics of book production for a mass market, 1836-1916.* Hants, England.

WETHEY, E. R., 1896 *A geography lesson: the blackboard and oral teaching*. London.

WOOD, E. N., 1903 *Chalk, or we can do it. Practical work with chalk and blackboard.* London.

WYLIE, C. D., 2011 Teaching manuals and the blackboard: accessing historical classroom practices. *History of education* DOI: 10.1080/0046760X.2011.584573.