Networks: An Online Journal for Teacher Research

Volume 6 | Issue 1 Article 2

1-1-2003

Science Teaching and Learning: Teachers and Children Plan Together

Zoe Donoahue
Zoe.Donoahue@wtel.tdsb.on.ca

Science Teaching and Learning: Teachers and Children Plan Together

by Zoe Donoahue

Zoe Donoahue currently teaches grade 2 at Lambton-Kinsway School, Toronto District School Board, Toronto, Canada.
Correspondence: Zoe.Donoahue@wtel.tdsb.on.ca

When I started teaching, the science curriculum was not prescribed for each grade. We were able to teach topics that we knew were captivating for children of a certain age and to share our particular passions and knowledge with our students. Many a time a whole unit of study would evolve from a "teachable moment". A child bringing in a robin's egg or a rock collection would pique our interest and we would pursue that topic until we had satisfied our curiosity. We were covering the same skills that the curriculum now details, children were learning how to learn about science topics, but this learning was in the context of a topic that was initiated by them.

These days, five science topics are assigned to each grade and they must be taught that year. As a teacher, I feel that I have lost that element of choice and that it is more difficult for children to feel empowered and involved in shared decision making about the content of the curriculum. Fortunately, the government does not (yet) tell teachers *how* they should go about teaching each topic, so this is an area about which there can be some negotiation and co-planning with the students.

Planning Together: A Unit on Sound

Last year, I was on maternity leave and approached a colleague and friend, Janna Adair, to see if she would allow me to come into her grade four class to conduct an inquiry about one of her class's science units. We wondered how we could work within the new curriculum to involve the children in their science learning. We decided to look at how we could structure a unit on Sound so that the children could help to plan the unit and how they would learn about sound. Rather than the teachers looking at the question alone, the students would co-research along with us. Atwell (1989) believes that we "demonstrate thoughtfulness" when we "ask students to collaborate with us as partners in inquiry". She feels that teacher research is "a model for our students of how adults can function as life-long learners and of learning as a social activity". We hoped that, within this unit and our inquiry, students would learn from one another and from us.

In DICEP, the teacher research group to which I belong, our focus at the time was on how children perceive the learning activities that we give them. What types of activities do they feel help them to learn best? What types of activities are enjoyable? And does their perception of what they are learning match the teacher's intent for the activity? Janna and I designed a sheet that the children would fill out during an activity, asking them to think about these questions. This was another focus of my time in the grade four class.

Before the unit started, I interviewed the children in groups of six. To get them thinking, I asked them to talk about what science is and then to think about how you *do* science. They were asked to reflect on previous science units and talk about what makes a science unit interesting, fun and effective for learning. I wondered if there was anything they would have done differently to make a science unit more enjoyable or to help them learn more. If they were the teacher, how would they teach science? The children re-iterated their ideas several days later when we planned the unit together.

Throughout the six groups, there were themes that came up over and over again. The children said that experiments were the best way to learn as they could touch things, do tests, predict and observe. They liked the problem solving nature of experiments. Some children said they didn't understand that much when they were reading, and were more focused when working with hands-on materials. They liked being able to touch the objects, rather than looking at pictures on a photocopied page. They liked working in groups because they had more ideas, more choices and more answers. They saw the power of the collective knowledge of the group.

Some children mentioned listening to the teacher as a good way to learn. They also stressed talking about their findings with others. Writing was important too: predicting what would happen before the experiment, reporting on findings afterwards and as a way to help them to remember what they had learned. Researching from books and the Internet and making jot notes was also mentioned, as the children felt they could learn from what others had already learned. They also felt that reading was a good way to learn about science when in concert with hands-on work.

After the interviews, we started our whole class work. We began by focusing on the "learning outcomes" for the unit. The children needed to understand that these were non-negotiables, but that they could have input as to *how* they would learn. Some of the children may not have been accustomed to having teachers ask their opinions about units of work, and may have felt that we already knew how the unit would look and were not sincere in requesting their ideas. By being very clear about what was and wasn't negotiable, we hoped that the children would trust that we really did want and value their input. We hoped that planning the unit together would allow the curriculum to better meet the children's needs and that they would feel they had more invested in their learning.

To get the children engaged and thinking, we started with their questions about sound. Janna wrote one outcome on each of six pieces of chart paper and posted them around the room. These were the givens. We would use ideas from the interviews when planning how to learn about these outcomes. As a precursor to group work and talk, we wanted the children to do some thinking on their own, in writing. They filled out a sheet that asked them what they already knew about sound, questions they had about sound, the ways they felt they could best learn about sound and how they could use the scientific method, which had been introduced in a previous unit, in their learning.

The children then wrote questions about sound on sticky notes and affixed them to the appropriate "learning outcome" chart. The following day Janna and the children reviewed the

questions and, in light of the suggestions they had made during our interviews, "discovered" the unit together. They decided they could best find the answers to their questions by:

- doing experiments in groups
- studying books and other print resources (to find out what the ear looks like and how it works) and having a teacher guided lesson on the ear
- building a musical instrument
- researching a topic of interest relating to how we use sound in our everyday lives

Using these suggestions, they mapped out the unit and Janna then pulled together appropriate resources.

The following is a discussion of each of the teaching methods employed in this unit and how they contributed to the children's learning and engagement. The children's interview comments from before and after the unit about how they best learn science and written ratings of and comments about each type of activity at the end of the unit are included. Also considered are their written comments from sheets filled out as they worked on various types of activities. On these sheets they were asked what they felt they were learning and if the activity was a good way to learn it.

Ways of Learning

Experiments

Janna started the unit with experiments, as this seemed a good way to get the children engaged and involved right away. Before beginning this "hands-on" work on their first experiment, Janna wanted the children to make some predictions and do some writing on their own. So she asked them to complete a sheet incorporating the scientific method, starting by recording a hypothesis: what they thought would happen when they extended their ruler over the edge of a table, held down one end and struck the other end so that it moved. Janna then explained the procedure for the experiment, which the children wrote down in their own words, and then they did the experiment. This writing was an important accompaniment to the experiment, as it helped the children to focus and gave them something specific to think about as they worked with the materials.

The children were fascinated by what they found out from striking the rulers and moving them so that the part overhanging the table was longer or shorter. Time was given for them to report their findings to the class, and several children were then inspired to continue experimenting on their own. At home, a few children worked out how to play songs with their rulers and some even figured out a way to record their songs, as music, on paper. As an extension, another child, again at home, made a bass with a box, a string and a meter stick. By pressing the string against different points on the meter stick and strumming, the bass made different sounds. This "home" work will be explored in greater detail in a later section.

The children's desire to extend their learning was a critical point in the unit. By freely and joyfully giving time for children to share what they were doing at home, Janna conveyed the

message that their discoveries and evolving knowledge were valuable. Duckworth (1987) writes that the children's "divergence and creations" will not happen if "teachers feel that their class must do things just as the book says and that their excellence as teachers depends on this" (p.8). At this point, the unit became more than just a school study. The sharing, and resulting discussions, gave the unit richness and depth that far exceeded what we would have been able to do in the classroom alone. We were so excited that the children were motivated to continue to extend their learning at home. To us, this reflected our goal of helping the children be empowered and in control of their learning.

This spontaneous extension of a classroom activity brings to mind Duckworth's phrase, "the having of wonderful ideas". She argues that "wonderful ideas are built on other wonderful ideas. In Piaget's terms, you must reach out to the world with your own intellectual tools and grasp it, assimilate it, yourself". (p.7) As in this case, she feels that the children's work "cannot help being inventive" when "schools and teachers provide materials and questions in ways that suggest things to be done with them".

Janna provided books about sound, many containing ideas for experiments, and she set up the opportunity for children to participate in basic experiments, but the fact that the "unexpected is valued" was key. Duckworth writes of a similar classroom, where "instead of expecting teachers and children to do only what was specified in the booklets, it was the intention of the program that the children would have so many unanticipated ideas of their own about the materials that they would never even use the booklets" and they would "start producing and following through on their own ideas". (p.8)

The children extended their understanding with a second experiment where they worked on their own to make a telephone out of cups and string. They had a choice of plastic or Styrofoam cups and three different thicknesses of string. When they were done, they tried their telephones out. Previous to this lesson, a couple of children had made telephones at home on their own initiative and had brought them to school. At that time someone had wondered what would happen if a third cup and string were tied onto the initial string, so some children tried this out in the classroom. Others experimented with pinching the string while their partner was talking into the cup to see if this had an effect on the sound traveling through the string (it did). We were pleased to see the children's engagement in their work and their willingness to do more than the initial task had required.

When doing experiments, there was a good match between what Janna hoped the children would learn and what they felt they were learning. When asked to fill out a sheet during the activity about what their teacher hoped they would learn from doing experiments, the children seemed to be very aware of the concepts she had in mind (sound, vibration, frequency, how sound travels, music and sound, the ear, and communication). The second part of the sheet asked the children if they felt that experiments were a good way to learn. Many wrote that experiments, by their nature, are a good way to learn because you "get more ideas", "have examples to help me " and "actually get to make sound". Someone said, "You kind of find out if you do something, then, what would happen". Experiments are preferred over reading because "if we always read papers it gets boring but if you do experiments it is fun". Someone thought they "might be learning more by amplifying sound more than just reading about it". The children felt that experiments

are more engaging. Michael wrote, "Everybody pays attention and it's fun". Kathryn recognized that the teacher might need to do some preliminary work with the class before doing the experiment when she wrote, "She taught us something first and then it became really fun".

Because they involve hands-on work, the children see experiments as linking to the real world. One child wrote, "I have proof (that sound vibrates best through solids)" and another wrote, "We have no reason to disagree because we have witnessed sound traveling through solids". The children believe that this real life learning leads to better understanding and allows them to "see how everything really works". A simple but powerful comment about hands-on work came from one child who wrote, "If I do something I learn really well".

Working in groups was mentioned as another positive part of doing experiments. "We get more ideas this way", you can share ideas and "it shows how creative we are and not only alone, but in a group". The children appreciated that group work allowed them to "get to know other people" and to "see what other people think".

The word "fun" came up time and time again when describing experiments. The children were convinced that having fun would lead to more learning and better concentration. One child wrote that doing experiments and having fun is "how I like to learn". Even though experiments are fun, they are still thought to be "scientific". One child even thought that they combined art and science. Experiments were said to be "easy", but this was not seen as a problem, rather that experiments make learning accessible and understandable to everyone because of their hands-on nature. One child, however, disagreed that experiments are easy, writing that they are "very fun and hard and teachers like mixing these two up". A third descriptive word was "noisy", which is "great for us to learn, bad for the teachers because of the noise!" But a by-product of this noise is the increased understanding that children have from sharing their ideas with others.

At the end of our study we asked the children to fill out a questionnaire about each part of the unit. They were asked to rate each activity in terms of learning and enjoyment on a scale of one to five, with five being the highest rating. They were also asked to write a comment to support their ratings. For each rating, I tallied from each child's sheet. The best possible score would be 24 children giving the activity a five, for 120 points. I translated the points into percentages for the purpose of comparison and also ranked each activity for learning and for enjoyment.

The children felt that experiments were quite good for learning (86%): better than filling out work sheets or making instruments, but they only ranked sixth for learning, compared to other activities. Predictably, enjoyment scored very high (94%), matched only by the children's positive feelings about presenting their research projects in front of the class at the end of the unit. It is interesting that two such diverse activities were rated the most enjoyable. We do believe that a great deal of learning about concepts occurred when working on the experiments. In future, we thought we might be more explicit in telling the children what they were learning from this hands-on work, and to help them to express the concepts and their learning even more than we did, either orally or in writing.

Worksheets

About half way through the unit, Janna asked the children to fill out a worksheet asking them to think of real life examples of absorption, amplification and reflection of sound. This was a change from previous lessons where the children did hands-on experiments, and we were curious about how their perceptions of and attitudes toward a paper and pencil task would be different from those about the experiments.

The point of the exercise was quite obvious to the children, as the worksheet asked them for specific information. The children knew that they were learning about absorption, reflection and amplification, and how they come into play in everyday life. In actual fact, however, this worksheet did not teach them anything, but was asking them to list what they had learned. Several children out of the 26 realized this, and one even thought that the teacher might be using this activity for evaluation: "I think this is her way at seeing if we know what amplified, absorb and reflected means, and what examples we can come up with". Michael said, "Every unit we started we just have that and also, we already knew most of the items, we were just showing we were just writing it down". Another thought Janna might be looking at "what we have learned and what we still need to know" and two others saw it as an opportunity to "reflect on the work we've done so far". Another stated positively that "now that we know about the stuff it is fun to test us". All were right on the mark!

Adam agreed that "we don't really learn anything from asking [answering] questions" and he had a suggestion to improve the activity. "I would like it more if there was writing at the top like a page telling about it or something and then questions on it 'cause then we're learning and it's in our memory as well".

Molly thought that the teacher's input was an important part of learning from doing worksheets. "I would just write a few things down and then if I may have missed some, sometimes Mrs. Adair would correct me so I would know it's right, because she said so. I think I learned a lot, but I don't like doing worksheets".

Some children said they would rather do this type of activity as a class. Brock said, "It's good when you get to say the answer to the teacher instead of writing it down on paper" and Victoria added that it is better "if Mrs. Adair is writing on the chart while you give your ideas. Not just sitting there, writing". Brock liked Victoria's idea, because "you learn more because you have everyone's ideas instead of [just] your ideas". Molly liked the idea of working collaboratively as a class, rather than individually, on a worksheet because "when you do a worksheet, sometimes she might mark you on it and if you get a bad mark you feel so bad. And then [when] you just say it, she'll say, 'No, I think that's wrong', or something, if you got a question wrong. So she doesn't mark you on it [when working as a class] and then you feel a lot better about yourself".

The children seemed to understand the purpose of the activity and to think that it was a good way to learn, but the word "fun" did not come up much. Most children clearly saw the difference between an experiment or hands-on experience and this type of activity that involved only writing. Although experiments were deemed to be best because they combined fun, learning and group work, the children seemed to see the value in a written experience. They realized that they could show what they had learned and that the teacher was able to see what they understand so

far in the unit. I should mention that this written activity was likely better received than some worksheets, as the children were permitted to work with a partner and to share their ideas.

Filling out the worksheet was rated the lowest for both learning (77%) and enjoyment (62%). The children's feedback suggests that, in order to keep interest and engagement high, teachers might try to avoid giving science worksheets on their own very often. Children such as Danisha and Kathryn, who said "we get that every time, like when we started like a new unit, we get that all the time" and "everything you do, there's a worksheet" seem to be typical. They know that worksheets are going to be a part of all of their learning at school. When it is necessary to have them fill out worksheets, the children need to know why they are being required to: what does the teacher want them to learn, or what is she trying to find out about them and their learning? By being explicit and revealing the purpose ahead of time, children might be inspired to put more effort into an activity that they don't feel that positively about.

Even though the children did not enjoy it, Janna did get information about their understanding of these concepts after doing several experiments, and it showed her whether they were able to apply the concepts to examples from their daily life. As well as assessment information, doing an activity such as this part way through the unit could help the teacher to plan future activities and lessons, based on what the children knew and understood. For these reasons, we felt that this type of worksheet would be worth doing in a future unit.

Box Experiment

After doing several hands-on experiments whose goal was to teach the children different concepts about sound, Janna asked the class to do an activity that would allow them to apply their knowledge of the concepts of amplification and absorption. The children set themselves up in groups of two or three and were given one of two problems to solve. Each group brought in a shoebox and was given a plastic cup containing 15 pennies. Their challenge was to tape the cup to the box and then to add materials to the inside of the box that would either amplify or absorb the sound of the pennies when the box was shaken.

Before beginning the hands-on work, the children were given one period to plan and were asked to record their plans on a planning sheet. They needed to identify the problem and plan what they were going to do to solve it. They were permitted to bring materials from home and to use what was available to them in the classroom.

It was interesting to see the different groups' interpretations of the task and how they chose to solve the problem. A couple of groups succeeded in absorbing the sound by filling their boxes with cotton, fabric and egg cartons. One group covered the inside and outside of the box with a great deal of masking tape, and, to our surprise, was also quite successful.

The groups working on amplification had a more difficult time. Most of the groups' interpretations made us realize that the directions for the task, which had been photocopied from a resource book, were not specific enough. This did not become apparent to us, however, until the children were presenting in front of the class. A couple of groups added hard objects to the inside of the box, such as wrenches, paper clips and pens, but did not attach them to the box.

They rattled around and made noise when the box was shaken and we could hardly hear the pennies! In retrospect, we realized that the children should have been instructed to attach materials *to* the inside of the box that would amplify the sound of the pennies.

A couple of other groups made holes in the box to let the sound out; one group cut away so much of the box that one of their members, Molly, apologized at the beginning of their presentation, saying, "This isn't much of a box!" This cutting did, of course, amplify the sound, but not because of any materials that were added to the box. There was only one group that seemed to complete the task exactly as the authors intended. They attached tin cans and tin foil to the inside of the box so that the sound would be reflected and they made holes through which they poked cones on the outside of the box so that the sound would be amplified when it came out of the cones. As is often the case with science activities, we came away with good ideas about how the task could be refined another year.

The children's comments about the activity on their during-the-task sheet showed that they thought they were learning about amplification, reflection and absorption. This was true, but it was also a task that would show the teacher what they had already learned, and how they could apply this knowledge to a new challenge. One child correctly summarized, "We must *know* how sound is amplified and absorbed" and another thought the task provided a "better way of using the words amplified and absorbed in a different way". Again, we might have been clearer about the purpose of this task, letting the children know that we would be observing how they could apply the knowledge they had learned thus far. (This task was not rated separately from the other experiments on the end-of-unit evaluation sheet.)

Teacher Demonstration

A whole class experience that evolved from an activity that a child did at home on his/her own initiative was blowing over the top of glass bottles filled with different amounts of water. This was a different situation than the experiments, as Janna set up some bottles in class and was demonstrating, rather than having the children do the activity. The demonstration was accompanied by ongoing discussion, which influenced what Janna did next with the materials.

This demonstration provided an excellent opportunity to learn about pitch. More water in the bottle meant less air (a smaller resonating chamber), and less air vibrating meant the sound had a higher pitch. Conversely, less water in the bottle created a larger resonating chamber, which caused the pitch to be lower. The children were fascinated to discover that tapping the bottle had the opposite effect of blowing over the top of it. When the bottle was tapped, it was the water that was vibrating, so more water vibrating created a lower sound. As they worked through this experiment together, Janna demonstrated and asked the children to express their ideas. She had them begin their utterances with "my hypothesis is" and she often encouraged them to "explain your thinking". Their ideas led to further experimenting, which eventually led to children proposing the conclusions detailed at the beginning of the paragraph.

Again, this activity was not included on the rated evaluation at the end of the unit. I wrote about it because it seemed to be a workable alternative to having the whole class conduct an experiment. Demonstrations would seem to be best when there are limited materials, when the

experiment would be too hard for the students to do themselves or when time is an issue, and the teacher must either demonstrate or not do the experiment at all. When time is not an issue, children could do the experiment themselves and then watch, share their findings and discuss as the teacher repeats it in front of the class. Demonstrations can be effective, but the children's comments about experiments highlight how important it is for them to be doing most of the hands-on work themselves.

Home Extensions

As mentioned earlier, many children, on their own initiative, tried activities and experiments at home and brought in their work to show the class. Some children had ideas or got books from libraries and others took advantage of books that were available for borrowing from the classroom. These sessions resulted in wonderful discussions, meaningful links with activities and learning in the classroom and, I believe, more in-depth learning of the concepts. They also, however, played havoc with Janna's plans and meant that lessons were continually pushed back. This was not seen as a problem, but as a happy circumstance that made the unit richer and more interesting to the children. Their efforts were celebrated and recognized, and time was always made to hear about what they had learned. Van Tassell (2001) writes about this "process of coming to understand" as "the root of sociocultural theory. Through questioning, exploring, discussing, and reflecting with others during the course of the science unit, the learning became more meaningful and exciting" (p.50). This was certainly the case with the children's presentations of their work from home.

Another strength of learning through these child-initiated investigations is that the learning is pitched in the children's "'zone of proximal development' (zpd) a window of potential learning that lies between what he or she can manage to do unaided and what he or she can achieve with help" (Galbraith, Van Tassell and Wells). In their article, Galbraith, Van Tassell and Wells go on to quote Vygotsky, who believes this type of situation is optimal for learning because the children are interacting cooperatively in their classroom environment. This sharing of work from home was an excellent vehicle for working and fostering learning within children's zones of proximal development, as they were bringing their understandings and findings to the class, refining and developing them as they explained what they had found out to their classmates, answering classmates' questions and cooperatively building new knowledge and understanding. Janna was able to scaffold this learning by adding information or asking questions that would extend the children's thinking. In this way, the activity incorporated both modes of working in the zpd adult-child and child-child (Galbraith, Van Tassell and Wells).

Jilly made a xylophone from different sized wrenches that were placed between the bumps of an upside down egg carton. The children listened to the sound the wrenches made when they were struck and hypothesized about the relationship between the length of the wrenches and the pitch of the sounds. Christopher made a bass from a box and several children composed and performed original pieces and classics such as "Ode to Joy" on their rulers. Alessia and her Dad made chimes by hanging different lengths of metal pipes from a frame. Kathryn stretched a balloon over a bowl and attached an elastic band to the middle of the bowl. She showed the children what happened when the elastic was stretched more or less taut and plucked. This followed the work children did composing songs with the rulers and box basses, and connected nicely.

Wells (1995) believes that talking about what has been learned through an investigation is important in the process of inquiry, as "the natural impulse of someone who has discovered something of interest is to share the discovery with others, both to celebrate the achievement and to receive feedback in the form of further comments or constructive criticism". He also feels that presenting findings helps the presenter to "clarify his or her own understanding". The children and teachers were learning together, extending the learning in ways that Janna and I had not planned and could not have predicted. Wells (1995) would classify this dual learning as "dialogic co-construction of meaning, rather than the teacher's authoritative transmission of information" and emphasizes the importance of language (in this case, talk) in an inquiry-oriented classroom.

Janna's willingness to take the class time to acknowledge the children's "home work" and to link it to what was being learned in the classroom encouraged others to extend their learning at home. As was the case for Galbraith, Van Tassell and Wells, "students' questions and knowledge were as valued in the learning process as those of the teachers. Consequently, the students were supported in their efforts to make sense of their world and were motivated to take risks to further their own understandings." Janna and I also found that the children's knowledge was "deeper and more meaningful".

There were a couple of times when the children presented their work out of science time when I wasn't there, and Janna asked them to re-present for me the following day. Their second presentation was for an interested audience (me), but their classmates, I believe, really benefited from hearing it all again. They were able to restate and further develop hypotheses and ideas from the day before and their discussions were more complex. In future, I might ask another teacher, an administrator or parents who were in the school to come and listen to children re-present something particularly interesting.

In the end of unit survey, I asked the children how they felt about listening to others talk about their "home work". Both learning and enjoyment of sharing findings about in-class activities and activities done at home ranked fifth out of eight activities. The children felt that learning (89%) was stronger than enjoyment (82%). Many children thoroughly enjoyed these sessions. The ones who didn't found it hard to sit, listen and stay focused. I suspect that children who participated, bringing in experiments or in the discussion, enjoyed the sessions most. Wells (1995) believes that an "atypical" situation such as this can occur frequently in a classroom "when students' real questions are taken seriously if only teachers are ready to watch and listen, and follow the students' leads", just as Janna did.

Teacher Directed Lesson

At the beginning of the unit the children and Janna had decided that the only way for them to learn about the ear and how it works would be through reading and a teacher directed lesson. What they were supposed to learn from this was certainly clear to the children. On their 'during the activity' sheets, every child but two mentioned that they were learning about the ear, how it works, its parts, care of the ear or why our ears are important. The two other children wrote that Janna wanted them to learn in a safe way and "[by] read[ing] and not doing hands-on activities". The children's comments revealed an understanding that a lesson was the best way to learn about the ear. Many wrote that "we can't do experiments on our ears so we can just read about the ear"

and that reading and looking at diagrams was good because "we can't look inside the ear". To put it bluntly, "we can't do anything else without hurting ourselves".

The children felt that reading about the ear together was valuable, and that having this information allowed them to successfully label a diagram of the ear. One child was glad that they were the ones doing the labeling, that "instead of telling us we get to see by pictures and we label it". Another child enthused, "I think she really wants us to learn about the ear and understand". And they did.

The children felt that they learned a lot from the teacher directed lesson on the ear and they gave it the highest rating in terms of learning (97.5%). Their written comments during the activity indicated an awareness that this and reading were the only way that they could learn about the ear. The lesson was ranked sixth for enjoyment (80%), but most still had a very positive attitude about receiving information this way. Adam understood how others felt, but didn't agree. "I personally found it fun, but like you said, I guess other people didn't. I don't think it necessarily means that if it's boring to us it will make us learn a lot. I think that was just kind of more of an easier subject than others. It was even so easy to some people it became boring."

Clearly, teacher directed lessons have their place in a science unit. It would seem that children will be receptive to learning this way when they see that the lesson suits the content, and when they have some input into the decision to learn this way. A whole unit delivered this way, however, would likely not receive such positive reviews!

Homework - Making an instrument

One of the expectations for the unit was that the children would use their knowledge of sound to make a musical instrument. Janna decided that this would be a good project to do at home. This activity scored second to lowest in terms of learning (81%), and second highest in terms of enjoyment (91%). We weren't surprised that this was fun for the children, but felt that we might have better explained what we hoped them to learn from this activity. Since it was the end of the unit, this would have been a good opportunity for the children to reflect on the knowledge they had about sound that helped them to create their instrument, or what their instrument showed about sound concepts. In this way they might have seen this is more than just a fun homework assignment.

Research

The last part of the unit was a research project. The children worked in twos to research a topic of their choice. The children and Janna brainstormed a list of possible topics relating to how we use sound in our daily lives. They thought about what interested them and groups were formed. Some children were loyal to their topic and ended up working with a similarly interested classmate that they did not know that well. Others were more intent on working with a friend, and chose a topic that was agreeable to that person.

The children spent the first work period making a plan -- where they would look for information and who would do what -- and writing it down. For the next week or so they made jot notes,

following the First Steps writing structure, and then decided how they would present their information to the class. They needed to present to the class and also to have some visual aids.

On their 'during the activity' sheets, the children had no trouble writing about what they were to learn from doing their research; their topics were clear and specific. But along with the content area learning, the children mentioned other kinds of learning: "how to write questions", "how to do a presentation", "study habits", "how to do things independently", "to play my part in a group", "creating things in good order", "to see our creativity" and "to know what we are saying".

The children felt that doing research was a good way to learn about a topic and that it was fun and interesting. Several were keen about "doing a bristol board to show some things we know" and one mentioned, "we are doing a presentation in front of the class". One child had a broader view: "I not only think it's good way for me to learn about this but for other people to learn about your subject in detail".

The children seemed to feel empowered about doing it all themselves. They wrote that "we are the ones who are researching, presentating [sic] and learning", "we are studying and getting information" and "we learn more information by reading books". One child wrote, "I have used resource books and the 'Net" and he thought his teacher "wants me to learn how important resource books are". Working with a partner was also seen as a positive because they could share ideas, learn together, work with different people and "it shows how well we work in a group".

The children really felt they learned a lot doing their research. It was one of the top four activities for learning (95%), along with the teacher lesson, and listening to and doing presentations and was ranked third for enjoyment (90%). My observations in the classroom matched their comments; the children were motivated, focused and excited as they worked on finding out about their topics.

The success of research for both fun and learning highlights the importance of building in an opportunity in a science unit for children to do independent work on a topic of their choice. The key is to find a place in the prescribed curriculum where this can work. In this case, the children needed to understand the role of sound in their everyday lives, and this led naturally to a multitude of research topics.

Presentations

In no other category were the scores for learning (95%) and enjoyment (94%) as high as for doing presentations about their research topics in front of classmates. This did not surprise me, as I could see the children's pleasure and how seriously they took this task as they talked in front of the class. The children's positive attitudes and the value they placed on presenting highlights how important it is for children to have an audience, besides the teacher, for their work. Research work has a purpose when children know that they will have to explain their findings to others. In this case, the children would have been confident that their classmates were interested in their topics, which made the task even more appealing. Another factor that influenced their enjoyment was that Janna did not tell them how their presentations should look. Several groups decided to

speak in role, many used props or showed experiments and all used their required bristol board displays to enhance their presentations. The presentations were a wonderful way to celebrate the children's learning at the conclusion of the unit.

Finally, there were a couple of themes that arose from the children's interviews, during the activity comments and the evaluation sheets. One was the children's feelings about group work and another was how they felt about helping to design the unit.

Working in Groups

When planning a unit that will involve group work for an extended period of time, I am often torn between making up the groups myself and giving the children a choice. My reasons for choosing groups might be to pair children that I hope would benefit from and enjoy working together, to expose children to working with classmates they might not know very well and to diminish the anxiety and possible hurt feelings that often accompany students choosing groups. Another reason for teacher choice is that there may be children whom no other children would chose to work with, and my composing the groups might help to spare that child's feelings and allow me to choose children who could best support and work well with that child. Because this is often a difficult issue for teachers, we decided to ask the children about it in their beginning of the unit interview. (See also Shechter (1994)).

The children were quick to offer their opinions about group work. Nicole showed an awareness of the possibility of making new friends when she pointed out that "say you chose your best friend and then there's this person that like you like, but sometimes you don't want to play with her and then she comes into your group. Instead it was just going to be your best friend. And then your best friend goes into another group so you're left with her. Then you're like, at the very end, 'Hey, this was really fun because they got to work with someone new.' That's why you should always try it." There were a number of other children who talked positively about the experience of working with someone they did not know that well.

Another way to form groups is to have children choose from possible topics that will be researched or worked on, and to form the groups based on these choices. One way I have approached this is to outline the options and have children privately write down a first, second and third choice. I can then form the groups, considering their choices and what I feel would be the best combination of children.

A third alternative would be to gather the children and give them a few minutes to form their own groups. This can work with a class where all children get along well, but can be a problem if there are children who are excluded and might not be chosen by anyone. Some children mentioned this as a good alternative, as they felt that the children do know one another and have a good idea of whom they can work well with.

Some children also pointed out that someone who is your friend might not be the best person to work with. Michael said, "We know who works good and who fools around and we want to be with someone who we know and who's our friend but doesn't chat that much." For Jelena, choosing their own groups showed that "the teacher trusted us to choose our own partners and

she knows that we're going to choose somebody that doesn't fool around and works quietly when she or he does his work."

Alessia wasn't sure if the teacher or children should choose:

She let us choose it and I think that was good because well, we know who works really well and who doesn't. And then if I choose, like, Kathryn, for an example, I would know that she works really well. But I still think that Mrs. Adair should have kind of chosen them because most people would go for their friends and then they wouldn't really get their work done.

Janna used a combination of two of these methods. She outlined the topic choices for the research projects, asked children what they were interested in and then formed groups from that. This was all done in front of the class with the children's ongoing input. As a result, some children did talk to a friend they wished to work with and decided on a topic in which they were both interested. Others told Janna what they were interested in and were matched up by her with a child who had a similar interest. Chris explained that "nobody really chose who to go with she gave us some topics of what we could do and we helped her make up some topics and then, what happened was she would say a topic and then if you wanted to do that topic then you would just put up your hand".

When asked about group work, some children said they preferred to work alone. Sarah said, "I can just have it in my own way". Nicole pointed out that not everyone is reliable when it comes to following through on his or her commitment to group:

When you work alone you don't have want to have to rely on the person. Say you had to bring the bristol board in on Monday, and they forget and then it also goes into your grade, too, 'cause it's both of your project, even though you're doing it separate. If you don't have the bristol board on time it's kind of a big problem.

Another consideration for the children was if they would get more done working alone or in a group. Sarah said, "I think I just get more work done" [when working alone], but Nicole wasn't sure: "But I think when you work with a partner you get more done sometimes but when you work alone you can do it by yourself and you don't have to worry that much, so there's good things between it but sometimes it's bad." Kathryn saw the advantages of working in a group, as "it's good 'cause one person could get information on bees and the other could get, you know, lizards and you would have it at the same time instead of just relying on one person to get everything."

Another issue when working in groups is reconciling everyone's opinion. Nicole took it a step further in thinking about the problems that might occur when some members of the group know one another better than others. "You need everyone's opinion if you work in a group. You can't just take your own opinion. Let's say you're working with your best friend, you can't just take her or his opinion and leave the other person out if you're working in three. So that's why it's sometimes a problem 'cause that's why you should always work with some different people instead of just your friends."

Kathryn picked up on Nicole's comments, echoing her thoughts that it might be good to work with people who aren't your best friends. "And you should choose people you know work, you just shouldn't choose, 'you're my best friend I'll be with you'. You should choose people you know work, 'cause that might happen if you choose your friends, they won't listen, they'll just talk about fun that happened that day. They might not listen. I think you should choose someone you know who works."

Molly also thought about the advantages of working with a friend:

I think sometimes when teachers thinkdon't pick someone you're really good friends with 'cause you're just going to talk all the time. I don't really agree with that 'cause sometimes you and your friends usually think alike a lotIf you worked with someone you're not closer friends with sometimes the reason you're not closer friends is because you don't agree on a lot of things and you don't get along too well. So I'm just saying I think if I worked in pairs I'd like to work with a friend of mine or something. I don't think it's necessarily working in partners that's going to mess it up, I think it might be the partner you're working with. Sometimes you don't get along with them too well.

She added that once the children have chosen their partners, the teacher could observe to see who is working well together.

Adam was concerned about being chosen by someone he didn't wish to work with and how he and that person might feel:

I think it was a bit of a problem with that because sometimes you're not the chooser and someone who might not work that well would choose you, so you're kind of in a predicament when you can't say, 'No I don't want to be with you because I don't think you work well'But if you know that he or she will eventually just let you do the work you feel bad just going ahead with it so that's another problem.

He acknowledged that uneven effort could also be a problem if the teacher chose the groups:

But also the same thing can happen, you could be put together, if Mrs. Adair chooses, with someone who doesn't work that well or anything. And it's really hard to say to someone 'I find that you're not working that hard", you know so you kind of need to be quick to choose and sometimes when you think of who you'll choose, it's too late, someone comes over to you and chooses you.

Adam's comments seemed to favour the idea of the teacher forming the groups away from the class. His solution would be:

If she asked each person individually who they would like to be with and then write them down and she might say, 'Someone would like to be with you'. But you wouldn't hurt the person's feelings if you said to Mrs. Adair, no, that I don't think that person works well or 'I had someone else in mind', 'cause then that person really wouldn't knowI think that would be easier and it

would go visa-versa. Someone might not want to be with you, but then you could choose someone else.

So what is the best way to organize children for group work? Should the children or the teacher choose? Should it be done privately, or in consultation with and in front of the whole class? I tend to think I would vary my approach depending on the time of year and the composition of the class. Earlier in the year, when some children wouldn't know each other that well, I might choose the groups. Based on what I have observed, I might purposely put some children together who I think would be productive, but might not choose one another otherwise. Later in the year, if I felt that there were no children who might be excluded, I might allow the children to choose. If I felt that there were children who might be excluded I would have them choose privately, writing their choices on paper. If I had a class that was particularly inclusive, kind and collaborative we might choose as a class, with everyone's input. For me, the prime consideration is that children end up in a group where they can be happy and productive, that children might work with someone new and that the process not be stressful or upsetting for anyone.

Designing the Unit

At the end of the unit we asked the children if being able to help design the unit had made it more interesting or better for them. Many children seemed to feel empowered by being a part of this process. Alison thought that it was a good idea to ask the children's opinions and that this would make them enjoy the unit more. "Well I find that, as a kid, you feel more important in what you're doing and I think you would like it a lot better if you feel you're important in what you're doing." Even though the curriculum is set, having a say in the design of the unit gave children like Alessia the feeling that they were not being "forced" to learn specific concepts.

Adam had a more realistic view:

Well, when Alessia said we weren't really forced, I kind of disagree because the curriculum does have certain things that you need to learn and I think it really would have turned out the same if we would have chose it or notThe overall part was just what we needed to learn. We kind of chose more like, what order we did, cause you kind of gave us the idea and we just really got to choose what or order or what we would do with that or which way we would learn it, but we still learnt it.

Several children thought that people would have less reason to complain about the unit if they had a part in the planning. Chris thought it was good "we designed the unit because then nobody could complain about what we were doing because if somebody was, then somebody could just say to them, 'Well, it was your idea, so if you don't like it you should have had another idea'." Nicole also mentioned that children might be more willing to do the work because they "agreed" to it. Jilly also thought that children would enjoy the unit more because they had a say in its design:

Nobody had anything to complain about because all of us designed it. We kind of picked what we wanted when we didn't know that much about sound, so we thought this was going to be, 'Oh yes, I'm designing it and it's going to be fun' and we're anxious to learn about it. But then if you

[the teachers] say, 'Oh we're going to do projects and we're going to read those books and we're going to do experiments' I wouldn't look forward to it that much because it's like you're telling us what we're going to do and we don't have any choice.

Sarah P. liked the combination of being asked for input about the design of the unit and talking about the best way to learn science in our initial interviews because "on the tape we were saying what we thought would be the best learning environment for us kids and a point of view of us. And I think that was a good way to put it that way so we could have some say in it too". Some children said that they liked knowing what was coming up. Cameron said, "I thought it was really good because everybody knew what we were going to do with, and whatever somebody wanted to know we would figure it out because it was on the chart" and Emily pointed out that "at the beginning of it we planned out what we were going to do, but we did switch things around a little bit. We did organize it at the first thing so we knew the plot, what we were going to do". She thought it was helpful to be "prepared for it" and to "know what you were going to learn".

Jilly thought that asking the children what they wanted to do resulted in a mixture of ways to learn: reading, doing experiments, projects. She liked the balance between the children having some say and the teacher choosing some of the specific activities and suggesting some topics for research projects.

Sarah K. felt that they learned more when they planned the unit and Danisha thought it was "funner" this way. Nicole was somewhat tactful in her comparison: "When the teachers sometimes plan the unit, it sometimes is a bit bor-. Like you think, 'Ah, it will be really fun' but sometimes it won't turn out how you thought it will." Motivation also seemed to be better. According to Danisha, "If you get to pick your own topic you're into itand you want to get starting right at it because it's what you want to do."

Conclusions

When Janna and I started the unit, we thought we would need about four weeks to complete it. In the end, the unit spanned eight weeks and took on a life and direction of its own. Finding answers to their questions led to more questions and experiments done or demonstrated in class inspired many children to apply or extend this work at home.

A benefit of asking the children if they enjoyed and were learning from various activities is that they developed a meta-awareness of their own learning styles. They came away from the unit with a better sense of how and under what conditions they do their best learning. We found that a benefit of co-researching with the students is that we were more explicit with them about the decisions we, as teachers, make during a unit and about our reasons for choosing certain types of activities to meet specific learning goals. We also came away with a greater meta-awareness of our teaching and decision-making processes.

Answering the children's questions about sound was important for this particular unit, but finding out from the children how they feel they best learn science and the types of activities they enjoy had implications that could be applied to future science units. It was clear from the children's

responses that they did not feel that filling in worksheets and answering someone else's questions is the best way to learn science. Finding the answers to their own questions through active, hands-on activities and doing research on topics of interest was their preferred way to learn about sound. We all realized, too, that teacher directed lessons and demonstrations are an important component of a complete science unit.

Strickland (1988) writes that "engaging teachers in classroom inquiry may be one of the very best ways to encourage teacher self-confidence and feelings of empowerment. Teacher researchers tend to give a great deal of attention to why they think the way they do. They are more apt to know that others believe about a subject and to relate that knowledge to their own thinking. They are acutely aware of the questions that still need answers for them." Janna and I came away from this unit feeling positively about the children's experiences and confident that we could use our new knowledge to design future science units. Engaging the children in co-research gave us so much more information than we would have learned had we been doing teacher research "on", rather than "with" the children.

This type of action research question, writes Hume (2001), is "different. They [the questions] are about how we are, how we live together and how we learn. Addressing these questions is deeply satisfying because we are the only ones who can address them. We can create knowledge that is genuinely new, particular to us, and of great fascination. At the same time, we can take action and in the process change both ourselves and our environment." The teachers came away from this unit with knowledge that will help them to plan science units that better meet the needs and interests of children. The children acquired a greater metacognitive understanding of the conditions under which they can learn with richness, depth and joy.

The children's ideas for learning science were not unique or novel, and a teacher designing the unit on his or her own might come up with very similar ideas. But the children's engagement and interest in the unit were definitely enhanced by their involvement in the planning of it. It is encouraging to think that "child-centred" learning can still occur in a mandated curriculum. Janna and I learned so much by asking the children about how they learn best and what they enjoy, and by finding out about their perceptions of activities as they were doing them. In future, we will be better equipped to approach the new science curriculum in a way that better meets the needs and interests of our students.

References

1. Atwell, Nancie (1989). The thoughtful practitioner. *Teachers Networking*, June 1989.
2. Duckworth, Eleanor (1987). *The having of wonderful ideas and other essays on teaching and learning.* New York: Teachers College Press
3. Galbraith, B., Van Tassell, M. A., Wells, G. (1999). On learning with and from our students. In *Dialogic inquiry: Towards a sociocultural practice and theory of education*, (pp. 293-312), by G. Wells. New York: Cambridge University Press.
4. Hume, K. (2001). Coresearching with students: Exploring the value of class discussions. In G. Wells (Ed.), *Action talk and ext: Learning and teaching through inquiry* (pp. 41-59). New York: Teachers College Press.

5. Shechter, M. (1994). Children Learning Science. OISE/University of Toronto: Unpublished paper.
6. Strickland, D. S. (1988). The teacher as researcher: Toward the extended professional. *Language Arts, 65* : 754-763.
7. Van Tassell, M. A. (2001). Student inquiry in science: asking questions, building foundations, and making connections. In G. Wells (Ed.), *Action talk and ext: Learning and teaching through inquiry* (pp. 41-59). New York: Teachers College Press.
8. Wells, G.(1995). Language and the inquiry oriented curriculum. *Curriculum Inquiry, 25(3)*, 233-269.