The effects of inquiry-based professional development on the attitudes and confidence levels of teachers introducing scientific inquiry into their classroom

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ABSTRACT
Although the use of inquiry is proving to be successful in many studies, it is a concern that teachers having worked in the field for lengthy periods of time may struggle in transitioning to this new style of teaching (Thadani, 2010). Effective professional development is used as an aid in this transition, exposing teachers to inquiry-based learning practices through actually doing scientific inquiry. The question arises though in the necessity of workshops such as these. Do teachers that attend inquiry-based professional development sessions have more positive attitudes and higher confidence levels when introducing scientific inquiry practices to their classrooms?

This study assesses changes in teacher attitudes and confidence levels among two groups: a test group having had a professional development session, and a control group, not having had professional development. Through self-completed surveys, a poll of attitudes and confidence levels was taken before and after participation in inquiry-driven programming with Cleveland Metroparks Zoo. Survey results were compared and analyzed using a t-test with predictions being that an inquiry-based professional development session would cause a significant increase in the attitudes and confidence levels of teachers introducing inquiry to their students.

Statistical analysis showed, overall, that professional development did not significantly affect the attitudes and confidence levels of teachers introducing scientific inquiry to their students. There was no significant difference between the test group and the control group.

INTRODUCTION
Cleveland Metroparks Zoo has been providing educational programming to schools in the greater Cleveland area for over 50 years. With animals and plants in the collection representing life from all over the world, the Zoo has been able to offer varied and dynamic programming, readily adapting to meet the needs of the ever-changing public, private and charter school curriculums. Cleveland Metroparks Zoo (CMZ) is located in Cleveland, Ohio, where teachers and students of the Cleveland Metropolitan School District (CMSD) attend the majority of the Zoo's educational programs. Cleveland Metropolitan School District is one of the largest public school districts in the state with 114 schools serving over 50,000 students in grades preK-12. In 2009, CMSD had the nation's third highest high school dropout rate and has been on academic watch since 2006 (Cleveland Metropolitan School District, 2010). The Zoo aims to work closely with teachers and administrators of CMSD to develop programs and resources aligned with the mission to increase the academic performance of the district.

The state of Ohio is making a push for education as a whole, CMSD included, with the release of newly revised academic content standards in 2011. The Ohio Department of Education has recognized the measurable success of incorporating inquiry-driven learning practices into the classroom, writing the use of science inquiry into the mandated standards (Ohio Department of Education, 2010). Research has shown that when inquiry-driven science education is paired with close contact to the curriculum designers, that standardized educational outcomes can be very successful (Geier, 2008; Marx, 2004). Cleveland Metroparks Zoo has designed programs to build on that success. With the opening of a new exhibit, *African Elephant Crossing*, set for spring of 2011, new theme-related educational programming needed to be created. With research supporting the success of inquiry-based learning and the Ohio Department of Education requiring its use in science classrooms, the Zoo integrated the use of inquiry into its new program design.

Although the use of inquiry is proving to be successful in many studies (Geier, 2008; Marx, 2004; Thadani, 2010), it is a concern that teachers having worked in the field for lengthy periods of time may struggle in transitioning to this new style of teaching (Thadani, 2010). Effective professional development is used as an aid in this transition, exposing teachers to inquiry-based learning practices through actually doing scientific inquiry. The use of hands-on exercises creates opportunities for teachers to become active participants and problem-solvers (Wilson, 1999).

Cleveland Metroparks Zoo has offered professional development and continuing education workshops to the public for years but always held a relatively low response rate, often having to cancel sessions due to low enrollment. With new teaching standards and new program offerings coming in 2011, CMZ decided to gear its professional development sessions to the use of scientific inquiry in hopes of not only increasing the success of the programs, but also to provide a much needed service to area educators. The question arises though in the necessity of workshops such as these. Do teachers that attend inquiry-based professional development sessions have more positive attitudes and higher confidence levels when introducing scientific inquiry practices to their classrooms than teacher who have not had an inquiry-driven professional development session? Past and current research leads one to believe that professional development sessions will improve attitudes and increase confidence levels of teachers introducing inquiry to their classrooms.

METHODS

1. A team of zoo educators designed inquiry-based curriculum for both an on-site program and classroom toolkit related to the theme of the African Elephant Crossing animal exhibit and satisfying Ohio Academic Content Standards (Appendices A and B).
2. Assembled program toolkits.
    a. Classroom Toolkits: tape measure, hand lenses, 1 pair of professional binoculars, 1 elephant molar model, 1 sustainability classroom experiment kit, DVDs: “Echo the Elephant” and “Life in Africa”, books: *Inquiry in the Classroom, Elephants, Habitats, Experiments for the Classroom*.
    b. On-grounds backpack: tape measure, trundle wheel, 1 pair professional binoculars, stopwatch, clipboard and writing utensils.
3. Conducted on-line registration for teachers to test this new programming with their students, both the portion at the Zoo and the toolkits in their classrooms. Pilot testing programs were offered over the span of 2 weeks with 3 available on-grounds zoo programs each day. One week of programming involved the teachers having to attend a professional development session while participants in the other week’s programs did not have to attend such a session (serving as the control). Professional development was not indicated on the registration page as a component so as not to influence the group choice made by the teachers. Teachers were put into the two sample groups at random as they blindly selected a date that may or may not have been linked to a professional development session. Free transportation to and from the Zoo for programming was provided to participating schools on our Zoo Bus.
4. Contact was made with each registered participant to be sure they agreed to partake in both the on-grounds zoo program as well as at least one activity from the classroom toolkit. Participating teachers also had to agree to an attitude and confidence survey before and after participation as well as to attend a professional development session about general inquiry-based learning practices if their sample group so required.
5. Toolkits and surveys were delivered to the schools two weeks prior to their scheduled field trip date. Surveys consisted of a brief back ground summary and 11 evaluative statements: 5 evaluating attitude, 5 evaluating confidence levels and 1 addressing administrative support at the participant’s school (Appendix C). Teachers were to respond to the surveys indicating their agreement with each statement. Response options ranged from “strongly disagree” to strongly agree”. Surveys were mailed back to the Zoo using a provided pre-paid envelope.
6. Information from completed surveys was collected and entered into pre-visit tables both as one large collective group and as separated sample groups of those with and without having had professional development sessions. Assessment scores were calculated by assigning a numerical

value to each response category option: 1-Stongly Disagree, 2-Disagree, 3-Neutral, 4-Agree, 5-Strongly Agree.

7. Three professional development sessions were conducted for those teachers in the professional development sample group. The sessions explored the basic idea of scientific inquiry and had participants making observations, forming hypotheses and designing and conducting scientific tests to discover answers.
8. Participating teachers and their students attended the on-grounds Zoo program over the course of two weeks. Before leaving the Zoo, teachers were given the participation survey again (Appendix C).
9. Information from the post-participation survey was collected and compared to the previously collected responses using the aforementioned numerical scale. Changes noted in attitude and confidence levels of each sample group were analyzed using a t-test to determine if there was any significant difference in attitude and confidence levels between those teachers having had professional development and those not having had professional development before and after participation in the pilot-test programming.

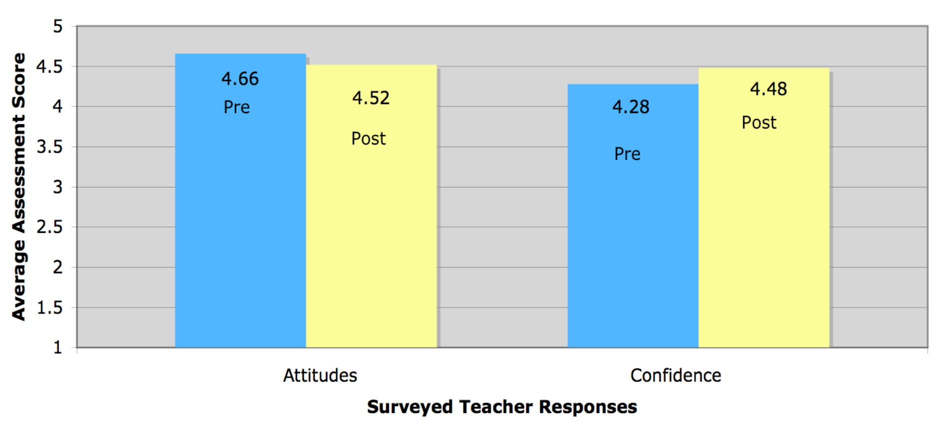
RESULTS

The measured attitude and confidence responses addressed in the results correlate to survey questions answered by the teachers. The full survey can be found in Appendix C.

Of 20 teachers originally registered to participate in pilot-testing the on-grounds program and classroom toolkits, 2 cancelled and 2 did not fully complete the pilot testing program. Sixteen returned completed surveys, 7 from the professional development group and 9 from the control group. Respondents overall had been teaching for an average of 19 years and rated themselves as already devoting an average of 29% of their classroom time to student-driven inquiry learning. Teachers also responded to a statement affirming support received from school administration with 43% saying they strongly agreed with this statement, 36% agreeing and 21% feeling neutral about it.

The results in comparing the pre-participation survey responses (pre surveys) to the post-participation survey responses (post surveys) found a decrease in attitude and an increase in confidence among those teachers in the professional development group (Fig. 1.1). The pre survey and post survey comparisons for the control group (Fig. 1.2) were analyzed with a t-test to determine if there was a significant difference in teacher attitudes and confidence levels after participating in the program (Appendix D). The results from this t-test showed that there was no significant gain or loss in attitude (p= 0.2262) or confidence (p= 0.2577) for the professional development test group. T-tests also showed no significant gain or loss in attitude (p= 0.6903) or confidence (p= 0.2420) for the control group.

Fig 1.1 Professional Development Group: Average attitude and confidence levels of teachers pre and post participation in pilot-testing



The respondents were then sorted into four subgroups based on comments made in writing during the pre and post surveys. Those that positively expressed in writing, their eagerness to try this new teaching style are hereon referred to as the "positive teachers" for this study (3 in the professional development group and 3 in the control group) and those that expressed either apprehension or nothing extra at all in writing are hereon referred to as the "other teachers" for this study (4 in the professional development group and 6 in the control group). T-tests were run to determine if there was a significant difference in the attitude and confidence gains among the positive teachers when compared to the other teachers (Fig. 2.1). It was found that there was no significance in attitude gains, but the confidence gains were found to be statistically significant in both the professional development group (p= 0.0329) and the control group (p= 0.0222) (Appendix E).

Fig 1.2 Control Group: Average attitude and confidence levels of teachers pre and post participation in pilot-testing

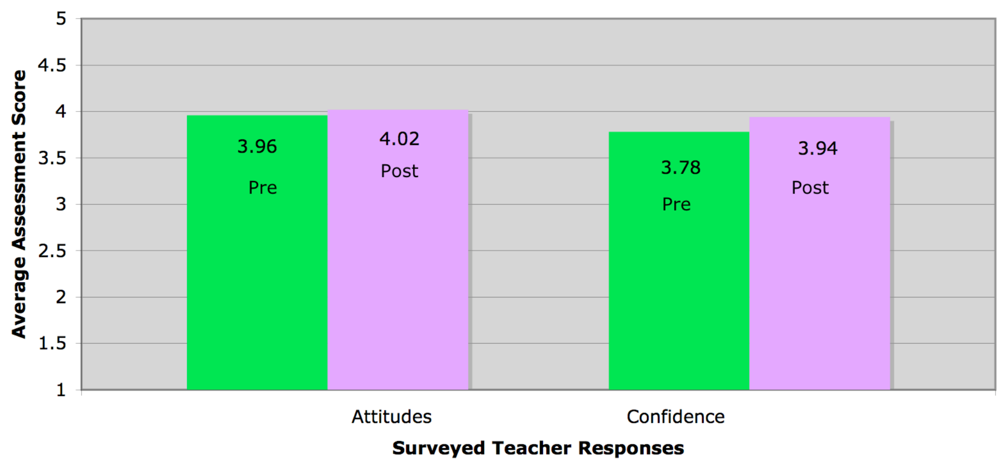
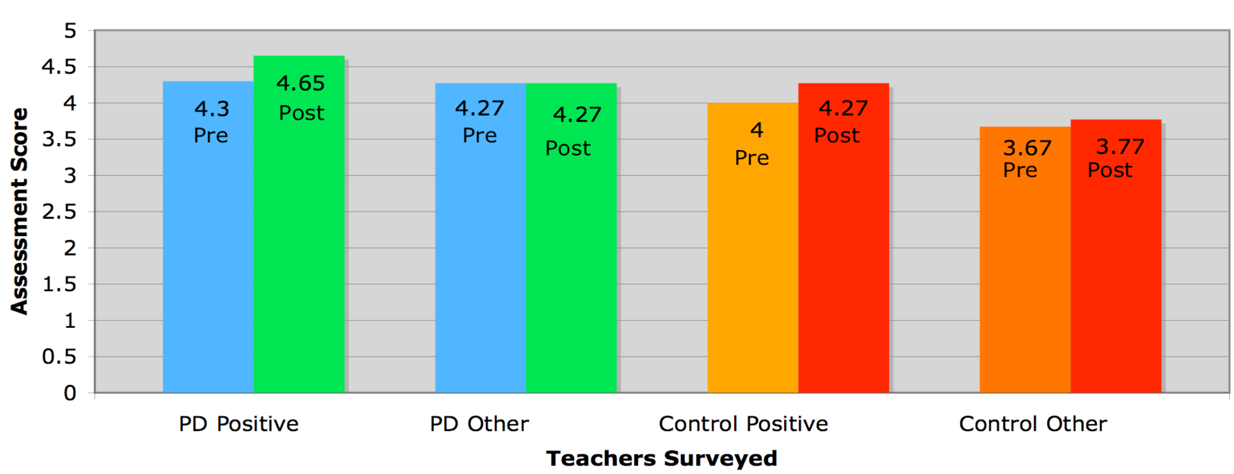


Fig. 2.1 Confidence assessments of the "positive teachers" and the "other teachers" from both the Professional Development group (PD) and the Control group



DISCUSSION

The statistical analyses showed, overall, that professional development did not significantly affect the attitudes and confidence levels of teachers introducing inquiry to their students. However, when the total surveyed group was broken into subgroups, based on their written expressions of "enthusiasm", there was found to be some significance. The study showed that regardless of whether a teacher participated in a professional development session, if the teacher had expressed in writing, on the pre and post surveys, their eagerness and excitement to try this new teaching method, he or she showed significant gains in confidence between the initial surveys and the finalization of the pilot-testing program. In a related study dealing with the same test group, knowledge gains among elementary students were assessed to see how teacher attitudes and confidence levels affect learning outcomes of students. It was found in that study that the students of these "positive teachers" were also those that held the most significant knowledge gains among all students tested (Korhnak, 2010).

Multiple factors could have affected the results of this study. One such factor would be the lessening of commitment from the teachers as the study progressed. The entire project may have been too much of a time commitment for some of the participating teachers. Initial deadlines for program conclusions had to be pushed back to accommodate teachers who needed extra encouragement from Zoo staff to successfully finish the post-assessments. Two teachers ended up pulling out of the study and never turned in their post-surveys. Another factor could have been the weather. There were three days of on-site program testing that participants experienced foul weather in the outdoor portion of the program. Teachers participating on those days seemed to respond negatively about the program as a whole. It is hard to say what role the bad weather may have played in the overall assessments that these particular teachers gave. Another factor could be in the structure of the survey. The study was designed so that teachers would take the same survey before and after participation in the pilot-testing program. The answers would be compared and any differences would be noted. The error may have been in the wording of the survey. The statements teachers were given to assess were not worded in a way that encouraged them to look at the effect that their participation may have played on their attitudes and confidence levels. If asked more reflective questions, teachers may have been prompted to give different answers.

ACTION STEPS

Throughout this study, Zoo staff became involved with Cleveland Metropolitan School District teachers and students in a way that had not existed in the past. Working relationships were formed and positive partnerships were born. While it was definitely a step in the right direction for the Zoo to become more active in helping to create a more successful student population in Cleveland, it also led to some challenging realizations. There were multiple teachers, some study participants and some encountered while traveling through participating schools, that openly and publicly expressed low expectations for CMSD students. Some of our participating teachers dismissed the idea of ever successfully using inquiry with their students, claiming that such a learning style is not suited for Cleveland's inner city children. Elementary students were openly told by their teachers that they were not "real" scientists.

As challenging as the atmosphere may have been, it did clearly highlight where the Zoo can play a lead role in the further development of CMSD students and staff. Although this study showed professional development having no significant impact for teachers, previous studies suggest otherwise. The Zoo will provide future professional development sessions geared more toward the step-by-step processes of introducing inquiry into the classroom as well as a more detailed look at how Zoo offered programs run. By providing more specific information and applicable hands-on experiences to teachers, the Zoo will be able to better serve as a resource and guide as new instructional practices are introduced (Garet, 2001). Through effective professional development, the Zoo can encourage teachers to embrace new educational changes and can, thus, change the way that teachers and students both perform in the science classroom (Fishman, 2003).

CONCLUSION

After running a statistical analysis on the differences observed in teachers surveyed responses before and after participating in our pilot-testing program, it was shown that professional develop sessions had no significant impact on the attitude and confidence levels of teachers introducing inquiry-driven learning to their classrooms. A decline in attitude values among the professional development group was actually observed. The confidence levels did increase in this group, but even that was not by a significant amount. These findings were contrary to the aforementioned prediction, proving the null hypothesis: that having a professional development session did not improve attitudes and confidence levels of teachers introducing inquiry to their classrooms. It was only when the comparison was made between teachers based on written enthusiasm levels that a significant difference was found. This study suggested that regardless of whether a teacher participated in a professional development session, if the teacher was eagerly willing and excited to try a new teaching method in the classroom, he or she showed significant gains in confidence between the initial surveys and the finalization of the pilot-testing program.

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APPENDIX A: ON-SITE PROGRAM GUIDE

Connections to Africa

Getting Started…

- Use the tools inside this kit to explore and navigate the Lion exhibit and experience *Connections to Africa*.
- The notes and examples provided within this guide are for the use of the teachers and chaperones. Please allow the students to develop their own ideas and hypotheses.
- **Please visit the stations in the order listed on this sheet.**

Station 1: Survival Need: SPACE Location: Lion Exhibit

- Look at the amount of space that the lions have in their exhibit.
- How **BIG** do you think this space is? How might you measure it?
- Try to estimate the size of this space using a measurement method of your choice.
  - ✓ Your group can be as creative as you like. Think of all the different measuring tools that you could use. Are there any other things that you could use to measure?

Station 2: Get-Close Encounter Location: Exhibit Hall

- Lions are not the only animals found throughout Africa. They share their habitat with many different types of animals.
- Find the volunteer with an African animal inside of the Exhibit Hall, near the front entrance of the Zoo.
- Go over to meet this volunteer and their animal. If you listen carefully and follow instructions, you might even be able to touch this animal!

Station 3: Animal Behavior **Location: Lion Exhibit**

- Do you think that lions act the same way when they are inside the building as they do when they are outside in their exhibit?
- What do YOU think?
  - ✓ Make a guess. (This is called making a **hypothesis**). There are no wrong guesses.
- Now help to find out the answer…
- Find the lions in the exhibit and stand where you can easily observe them.
- Choose **ONE** lion to watch.
- For 3 minutes, watch that **ONE** lion and record the behaviors that you see it doing.
  - ✓ (eating, walking, drinking, etc.)
- Use the **Data Recording Sheet** on the provided clipboard inside of your Inquiry Backpack to record the observations you see.

Station 4: Reporting Your Data **Location: Lion Exhibit**

- An important part of being a scientist at the Zoo is to be sure to add **YOUR** findings to the findings of other scientists.
- Find the volunteer near the lion exhibit with a computer. Report to them and enter into the computer the observations your group collected.
  - ✓ This is our Master Database, a place that we store ALL of the *Connections to Africa* data collected by scientists just like you!
- If you see another group using the computer, please feel free to visit one of the other stations before returning to enter your data into the computer.

Return Your Backpack…

- Now that you have completed your exploration of the Lion exhibit, hopefully you and your class feel a *Connection to Africa*.
- Please remember to return the **ENTIRE BACKPACK AND ALL OF ITS CONTENTS** to one of the volunteers you visited.

APPENDIX B: TOOLKIT PACKET (Classroom Component)

Introduction

With newly revised Ohio Science Standards on the horizon and Cleveland Metroparks Zoo's newest exhibit, African Elephant Crossing, set to open, the education division is joining the excitement too with a new, inquiry-driven approach to teaching. *Inquiry Learning* is learning through discovery. Students develop critical thinking skills; they learn scientific concepts and begin to recognize themselves as scientists. Students discover their world through making observations, creating hypotheses and developing scientific tests. Inquiry can be *guided*, with the teacher providing general topics and activities, or it can be *open*, where students are free to create their own explorations based on personal observations. You will find both styles included in this kit. Inquiry is most successful when the students and teachers both recognize that they can be scientists and that discovery led by students is, indeed, *real* science. With that in mind, enjoy what this kit, and what your students, both have to offer.

Table of Contents

Standards-Based Science Instruction and Classroom Inquiry

Learning Cycle

What key features distinguish science lessons with positive effects on learning and student achievement?

Instructional practices must be aligned to ensure positive student outcomes. Students learn best when instruction, assessment, and differentiation practices are woven together in a learning cycle to enhance teaching and learning. A recent study conducted by Horizon Research, Inc. concludes that the key factors that distinguish effective science lessons from ineffective lessons are opportunities for the lesson to:

1. Engage students with content by inviting purposeful student interaction with the dynamic body of scientific knowledge.
2. Create conducive environments for learning by providing respectful and rigorous opportunities for individual and group learning
3. Ensure access for all students by differentiating instruction to meet learning needs.
4. Use questioning to monitor and promote understanding by posing questions to encourage students reflection, planning, monitoring and self-evaluation.
5. Help students make sense of the content by facilitating students' intellectual work and conceptual connections among ideas, explorations and explanations.

From the standards-based science curriculum perspective, it is essential to differentiate processes, products and expectations to address learning needs throughout the learning cycle. Instructional and assessment practices employed throughout a learning cycle differe as students progress from engagement to exploration to explanation to expansion but always include ongoing collection of evidence of understanding and skills.

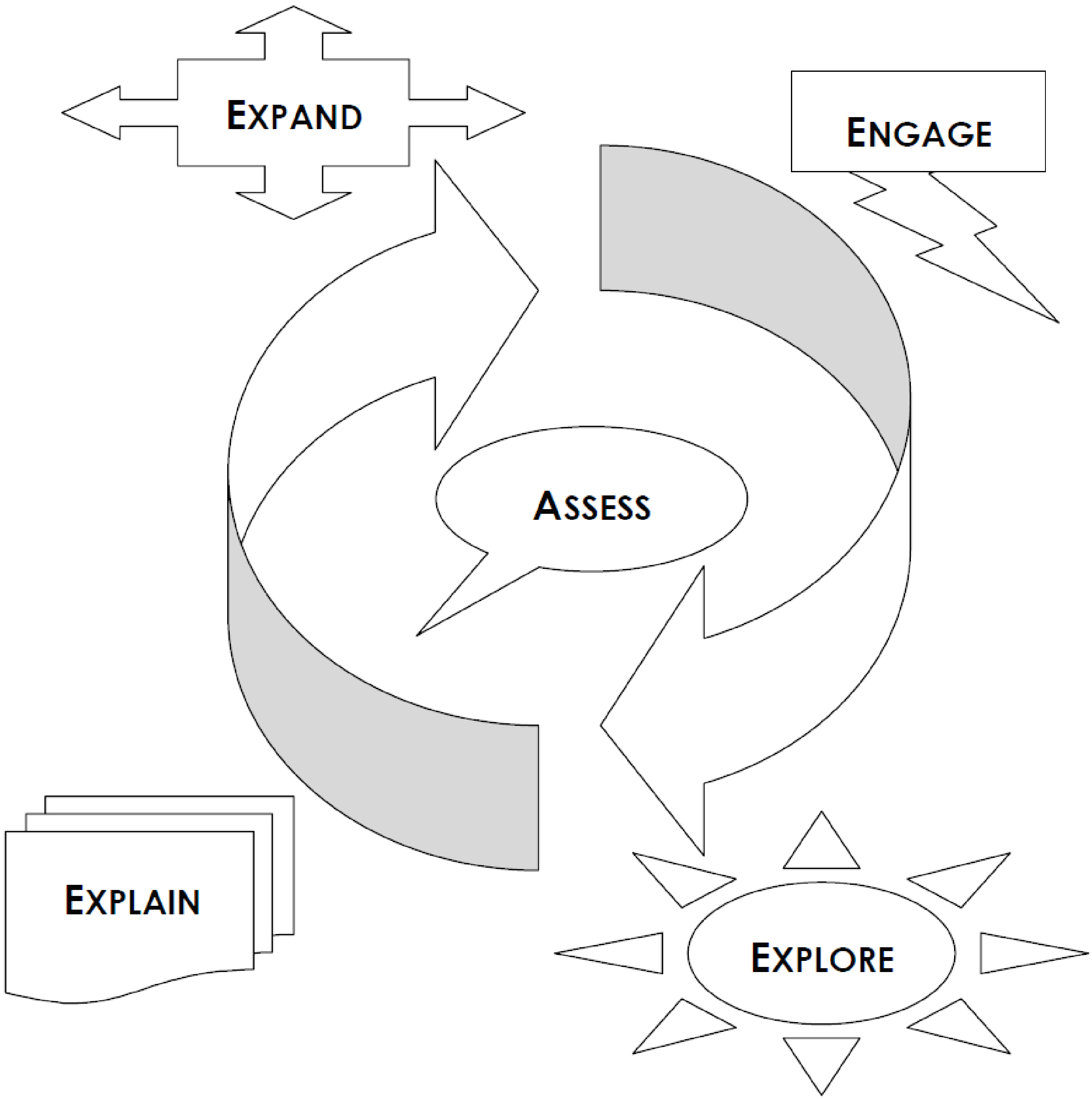
What do we know about effective instructional models for classroom inquiry and assessment that enhance science teaching and learning?

One standards-based instructional model for science is based on our understanding of how people learn and of learning cycles. The model includes engagement, exploration, explanation and expansion and revolves around assessment as an ongoing process. Effective planning uses this learning cycle model as a reference, not as a rigid template.

A learning cycle approach is an effective strategy for bringing explorations of the natural world and scientfic questioning into the classroom. A summary of research supports the conclusion that a learning cycle approach can result in greater achievement in science, better retention of concepts, improved attitudes toward science and science learning, improved reasoning ability, and superior process skills than would be the case with traditional instructional approaches (Abraham & Renner, 1986; Ivins, 1986; McComas III, 1992; Reghubir, 1979; Renner, Abraham & Birnie, 1985).

Standards-Based Instruction and Classroom Inquiry

Learning Cycle



Standards-Based Instruction and Classroom Inquiry

Learning Cycle

Engage: Set up motivating conditions to initiate and sustain students' engagement in inquiry. Use standards-based questions, demonstrations, discrepant events, and perplexing case-based or technological-design scenarios to strategically capture and channel student thinking. Help students access a learning cycle at multiple entry points. Select and design motivators to help students access the prescribed concepts, skills and cognitive demands described by the *Ohio Academic Content Standards, K-12 Science.*

Explore: Provide opportunities for students to explore and ask questions that can be tested scientifically through student-centered inquiry, including manipulating materials, making observations and keeping appropriate records. Align student-centered investigative activities with the standards, placing special emphasis on the standards *for Scientific Inquiry* and *Scientific Ways of Knowing.*

Explain: Use guided questioning based on teacher observation of students doing inquiry to help students focus on uncovering the standards-based concepts and skills of the lesson. This teacher-guided process is compatible with how people learn and helps students challenge misconceptions and develop preconceptions into more accurate conceptions, which students relate to prior experiences and learning.

Expand: Help students contextualize and deepen their understanding of the concepts and skills of the lesson. This will provide real opportunities for teachers to naturally address the Ohio science standards *for Scientific Ways of Knowing* and *Science and Technology*. Student questions often help expose new problems for inquiry and may be a springboard for new cycles of learning.

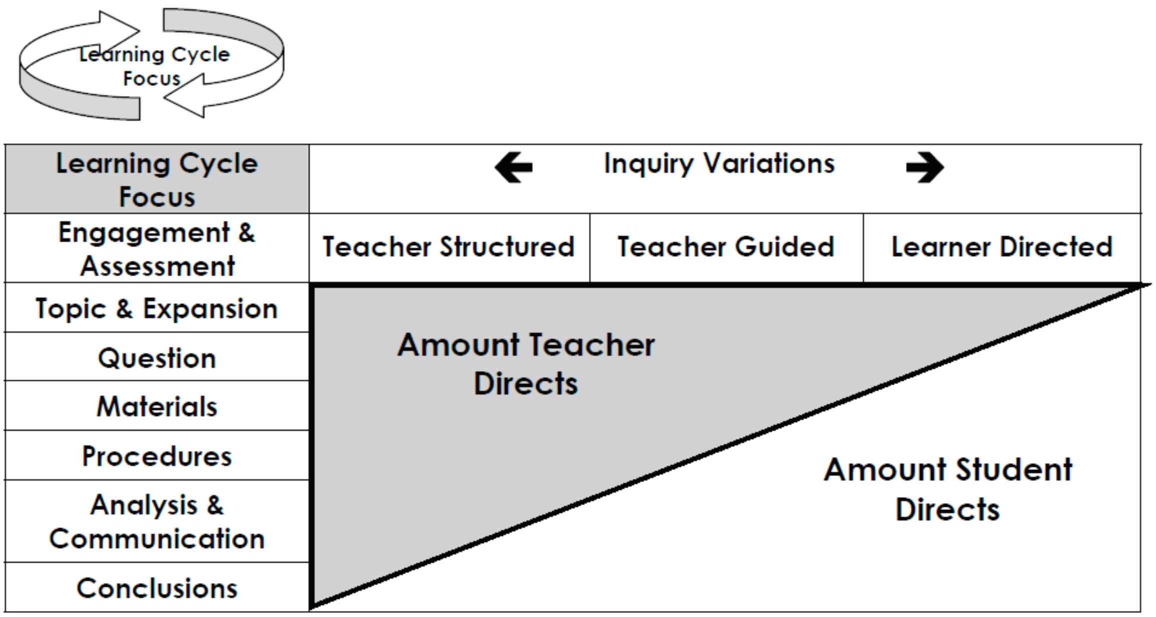
Assess: Assess for learning as students conduct classroom scientific inquiry. Assessment should reflect teacher expectations for substandtive intellectual student work and provide opportunities to collect evidence of what students know and are able to do. Use a variety of assessment strategies including journaling, concept maps, portfoios, authentic problem-solving and interviews. Provide timely feedback to help students self-monitor and clarify learning. An expected outcome of the standards-based science curriculum is student achievement of the prescribed science content.

Standards-Based Instruction and Classroom Inquiry

Inquiry Teaching and Learning

What do we know about the essential features of classroom inquiry that enhance science teaching and learning?

In classrooms, an effective working definition distinguishes inquiry in the general sense from inquiry as practiced by scientists. Effective patterns of instruction, differentiation and assessment may be viewed as falling along an inquiry continuum, based on how people learn and the



identified learning needs.

- Teachers model inquiry and ramp up student responsibility for doing inquiry and monitoring their own learning. The assessment, content, processes and products of classroom inquiry range from "teacher structured" to "teacher guided" to "learner directed" at each juncture in a learning cycle depending on students' needs.

- As a learning cycle moves from assessment and engagement, blending into exploration (e.g., questions and procedures), students' needs guide whether more explorations are needed before moving on to explanation (e.g., analysis and communication). Explanation gives way to expansion which leads back to more inquiry questions and continuation of the cycle.

- At the learning directed level, the student is responsible for everything beyond the selection of the general topic, the content of the summative assessment and maybe a little teacher guidance with question development.

- It is a best practice to match the level of shared responsibility for classroom inquiry with the specific learning need, the environment and the readiness of teachers to provide instruction and for students to assume responsibility.

Materials in the Kit

Books

Face to Face with Elephants by Beverly & Dereck Joubert
Our Ecological Footprint: Reducing Human Impact on Earth by William E. Rees
Protecting Our Planet series by Angela Royston
- *Disappearing Forests*
- *Disappearing Wildlife*
- *Global Warming*
- *Oceans and Rivers in Danger*
- *Polluted Air*

Inquire Within: Implementing Inquiry-Based Science Standards by Douglas Llewellyn

DVDs

Echo and Other Elephants starring David Attenborough and Cynthia Moss
BBC Atlas of the Natural World: Wild Africa starring Fergal Keane

Scientific Equipment

Binoculars
100 foot measuring tape
pocket magnifiers
renewable energy kit

Biofacts

African elephant molar
elephant Poo Paper Journal & Papermaking Instructions

Living Things Need Food

Engage

This activity is designed to start your students in recognizing themselves as scientists and thinking critically about problem-solving. The goal is to teach concepts through discovery and to encourage using a scientific thought processes. As with all lessons provided, please feel free to adapt them according to your students' abilities. Some of your students may be early readers, in which case you may find it more successful to lead activities and discussions as a whole group rather than using individual Research Plan sheets. Certain scientific vocabulary may or may not be appropriate for your students' level of understanding. Take these ideas, make them your own and your students will have a greater chance at success.

Can I identify a situation where elephants and people might have to compete with each other for food?

1. Begin this lesson by telling students that they will be investigating one of the basic needs of all animals.
2. If your students are familiar with brainstorming and recording their ideas, break them into small groups. If your students need more guidance, work with them as a large group. Engage your students in a discussion of what they predict the answer to this question to be. More importantly, why do they think this?

Explore

3. Continue with the above discussion and encourage the group to come up with ways that they could investigate the question and test their predictions scientifically (all suggestions are welcomed). What tools might they need to carry out their suggested explorations? Are there materials that would help them find the answer? Should they be making observations? What kinds of records will they need to keep? What will they do with the information once they have it? And how will they know that they've successfully answered the question? Allow a wide variety of ideas and encourage conversation amongst the students to refine the details of their ideas.
4. Ideas should be recorded on the Research Plan sheets. Small groups can record their own answers or you can record ideas as a group.

Explain

7. Explain to the group that you have an activity that might help to give them some insight in to the situation.
8. Set up "food tokens" in two areas of the classroom. These will serve as natural areas where elephants are eating. Choose several of the students to represent elephants eating in this area.

9. In a third area of the classroom, set up an African village farm with "farm food tokens" representing the farmers crops. Choose a few of the students to be farmers and villagers in this area.
10. With the elephants standing in the first natural area, ask the students to predict what will happen if the elephants start eating here. Have the students representing the elephants act out this behavior.
11. When no food remains in this area, have the students discuss what the elephants should do next. Take all suggestions into account and let the group decide on the best choice. If at any point, they need assistance in this activity, feel free to help, but try to leave the decision making ultimately up to the students.
12. Have the "elephants" move to other areas to find more food. After they eat all the food in the other areas, ask them to discuss what the elephants should do next to find food.
13. When the elephants have reached the African village, ask the students to discuss what they think might happen here. Be sure to get input from all parties: the villager/farmers, the seated members of the class AND the elephants as to what they each think should happen next.

Expand

14. As the students think about the situations that they have just seen through the activity, have them reflect on what happened.
15. Discuss this situation further with the students. Why might this type of elephant vs. human situation be bad for the elephants? How might it be bad for the people?
16. Brainstorm ideas for possible solutions that they may have for this food issue.
17. Feel free to repeat the activity in any number of ways with any number of situations that your students can come up with.

Assess

18. Was the outcome the same as what they had predicted? Was the situation they found in which elephants and people compete for the same food a situation that they had thought of before the activity?
19. If the students are working in small groups, observe their work and review what they are writing on the Research Plan. If working as a whole group, fill in the Research Plan together.

Name:________________________________

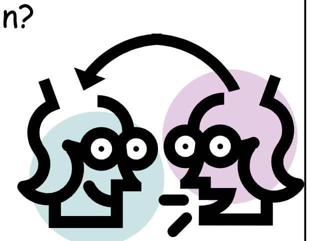
Research Plan – Living Things Need Food

1. What is my research question? Is it a good question?

Can I identify a situation where elephants and people might have to compete with each other for food?

2. How can I get my information?

3. What will I do with this information?



4. How will I know I did my job well?

Living Things Need Water

Engage

This activity is designed to start your students in recognizing themselves as scientists and thinking critically about problem-solving. The goal is to teach concepts through discovery and to encourage using a scientific thought processes. As with all lessons provided, please feel free to adapt them according to your students' abilities. Some of your students may be early readers, in which case you may find it more successful to lead activities and discussions as a whole group rather than using individual Research Plan sheets. Certain scientific vocabulary may or may not be appropriate for your students' level of understanding. Take these ideas, make them your own and your students will have a greater chance at success.

How easy or difficult do I think it would be for people and elephants to share water?

1. Begin this lesson by telling students that they will be investigating one of the basic needs of all animals.
2. If your students are familiar with brainstorming and recording their ideas, break them into small groups. If your students need more guidance, work with them as a large group. Engage your students in a discussion of what they predict the answer to this question to be. More importantly, why do they think this?

Explore

3. Continue with the above discussion and encourage the group to come up with ways that they could investigate the question and test their predictions scientifically (all suggestions are welcomed). What tools might they need to carry out their suggested explorations? Are there materials that would help them find the answer? Should they be making observations? What kinds of records will they need to keep? What will they do with the information once they have it? And how will they know that they've successfully answered the question? Allow a wide variety of ideas and encourage conversation amongst the students to refine the details of their ideas.
4. Ideas should be recorded on the Research Plan sheets. Small groups can record their own answers or you can record ideas as a group.

Explain

5. Students will now participate in an activity that will help them understand what sharing water would be like.
6. The included "water droplets" represent the water available to your students. Place them all together at one spot in the classroom that is accessible to all students.
7. Each student is given a card which tells them who they are and what task they will need water to complete. Have the students read the cards so that they are familiar with what they will need to complete their task.

8. The order of students is completely dependent on the teacher's choosing. There is no proper order. The first student is told to come up to the water droplets and take as much as they will need to complete their task. Allow them to take whatever amount they believe they will need.

9. When one student returns to his or her seat, have the next student perform their task. Continue until all of the water droplets are gone. When the water is gone, no remaining tasks can be completed. This lack of water can simulate a drought or the end of the rainy season.
10. Ask the students basic questions about the game. How many of them were able to complete their task and how many were not? What do they think would happen to the students that were unable to complete their tasks?

Expand

11. Ask students to reflect on the results of the activity and review their ideas of how to get the information they would need to answer the original research question. How difficult was it for people and elephants to share water? Was there enough water for everyone? Are there some tasks they consider more important than others? Can you list the tasks that require more water and the tasks that require only a small amount?
12. Allow students time to discuss and plan how they could make the activity more successful. Do they need to gather any additional information before they can answer the question? Did they think of additional ways to gather information based on the activity they've just done?

Assess

13. Monitor your students as they continue to research and develop their method for communicating their results. Make sure to help them continue their discussion on the difficulty of people and elephants sharing water.
14. Once the students feel as though they've completed their research, have the students participate in the activity again.
15. Using what they have learned, see if they can come up with different ways to make the activity more successful. Were they able to complete more tasks? Were they able to get water to more of the people and elephants?
16. Conclude the lesson by looking back at the original research question. Did the students' answer to the question match their prediction? What would happen to either people or elephants if they were not able to figure out how to share a resource as important as water?

Name:________________________________

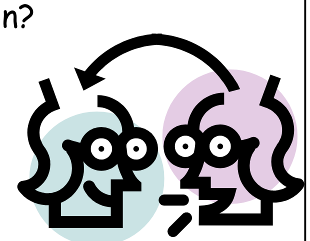
Research Plan – Living Things Need Water

1. What is my research question? Is it a good question?

How easy or difficult do I think it would be for people and elephants to share water?

2. How can I get my information?

3. What will I do with this information?



4. How will I know I did my job well?

Living Things Need Shelter

Engage

This activity is designed to start your students in recognizing themselves as scientists and thinking critically about problem-solving. The goal is to teach concepts through discovery and to encourage using a scientific thought processes. As with all lessons provided, please feel free to adapt them according to your students' abilities. Some of your students may be early readers, in which case you may find it more successful to lead activities and discussions as a whole group rather than using individual Research Plan sheets. Certain scientific vocabulary may or may not be appropriate for your students' level of understanding. Take these ideas, make them your own and your students will have a greater chance at success.

In what ways are African shelters the same or different than shelters found in the United States?

1. Begin this lesson by telling students that they will be investigating one of the basic needs of all animals.
2. If your students are familiar with brainstorming and recording their ideas, break them into small groups. If your students need more guidance, work with them as a large group. Engage your students in a discussion of what they predict the answer to this question to be. More importantly, why do they think this?

Explore

3. Continue with the above discussion and encourage the group to come up with ways that they could investigate the question and test their predictions scientifically (all suggestions are welcomed). What tools might they need to carry out their suggested explorations? Are there materials that would help them find the answer? Should they be making observations? What kinds of records will they need to keep? What will they do with the information once they have it? And how will they know that they've successfully answered the question? Allow a wide variety of ideas and encourage conversation amongst the students to refine the details of their ideas.
4. Ideas should be recorded on the Research Plan sheets. Small groups can record their own answers or you can record ideas as a group.

Explain

5. Explain to the students that they are going to use a method of scientific exploration to answer to this question.
6. Assign each student an animal or person that represents either Africa or the United States. The student is in charge of finding out everything that they can about the shelter used by their assigned individual. They can use whatever means necessary and whatever resources are available to discover this information.

Expand

7. After gathering information, have the students discuss as a group what they think they should do with this new information. Any suggestions and ideas should be encouraged and welcomed. The students should then choose what they would like to do with this new information.
8. Discuss these different shelters. Why do different individuals require different types of shelter? Are the reasons that individuals need shelter in Africa the same as the reasons that individuals need shelter in the United States? What are other factors that may influence shelter structures and use?

Assess

9. Review the information that was collected and discuss if the group's predictions on shelter similarities and differences were a match to the ones that were actually observed.
10. If the students are working in small groups, observe their work and review what they are writing on the Research Plan. If working as a whole group, fill in the Research Plan together.

Name:________________________________

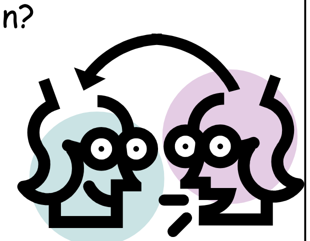
Research Plan – Living Things Need Shelter

1. What is my research question? Is it a good question?

In what ways are African shelters the same or different than shelters found in the United States?

2. How can I get my information?

3. What will I do with this information?



4. How will I know I did my job well?

Living Things Need Space

Engage

This activity is designed to start your students in recognizing themselves as scientists and thinking critically about problem-solving. The goal is to teach concepts through discovery and to encourage using a scientific thought processes. As with all lessons provided, please feel free to adapt them according to your students' abilities. Some of your students may be early readers, in which case you may find it more successful to lead activities and discussions as a whole group rather than using individual Research Plan sheets. Certain scientific vocabulary may or may not be appropriate for your students' level of understanding. Take these ideas, make them your own and your students will have a greater chance at success.

In how many ways is shrinking space alike or different for elephants and for humans?

1. Begin this lesson by telling students that they will be investigating one of the basic needs of all animals.
2. If your students are familiar with brainstorming and recording their ideas, break them into small groups. If your students need more guidance, work with them as a large group. Engage your students in a discussion of what they predict the answer to this question to be. More importantly, why do they think this?

Explore

3. Continue with the above discussion and encourage the group to come up with ways that they could investigate the question and test their predictions scientifically (all suggestions are welcomed). What tools might they need to carry out their suggested explorations? Are there materials that would help them find the answer? Should they be making observations? What kinds of records will they need to keep? What will they do with the information once they have it? And how will they know that they've successfully answered the question? Allow a wide variety of ideas and encourage conversation amongst the students to refine the details of their ideas.
4. Ideas should be recorded on the Research Plan sheets. Small groups can record their own answers or you can record ideas as a group.

Explain

5. Explain to the students that you have an activity that will help them imagine what it would be like to have to live in less space than they are used to.
6. Have the students measure your classroom. How they measure the space is up to you and your students abilities.
7. Now explain to the students that their space, or classroom habitat, is being cut in half. Calculate with your students what half the size of the classroom is and decide which half of the space is best to now live in. Have all the students move within the boundaries of this new space for the remainder of the activity.

8. Ask the students what it feels like to now be in their new habitat. Have them think about and create a list of all the things that happen in the classroom on a given day and how they will accomplish those things now that their space is smaller. Are things easier to do or harder to do? Are there some things that can no longer be done?

Expand

9. Ask students to reflect on the results of this activity and review their ideas of how to get the information as they begin to think about elephants. How do elephants go about their daily activities if their habitat is cut in half? Allow the students time to discuss and plan for the next steps of this research plan. Do they still need to gather additional information before they can answer this question? Did they think of additional ways to gather information based on the activity they've just done?

Assess

10. If students are working in small groups, monitor their work as they continue their research and developing their method for communicating their results. If you are working with the class as a whole, facilitate their work and discussion of how habitat loss is affecting elephants.
11. To conclude this lesson, did the students answer to this research question match their prediction? What happens if the basic needs of living things aren't met? How does this relate to habitat loss, or shrinking space.

Name:________________________________

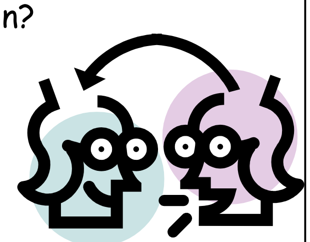
Research Plan – Living Things Need Space

1. What is my research question? Is it a good question?

In how many ways is shrinking space alike or different for elephants and for humans?

2. How can I get my information?

3. What will I do with this information?



4. How will I know I did my job well?

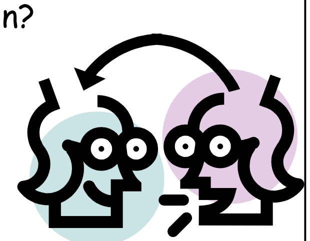
Name:________________________________

My Research Plan

1. What is my research question? Is it a good question?

2. How can I get my information?

3. What will I do with this information?



4. How will I know I did my job well?

APPENDIX C: TEACHER SURVEY

TEACHER SURVEY

Connections to Africa Pilot-Testing Program

Thank you so much for participating in the pilot-testing of Cleveland Metroparks Zoo's newest elementary school program, Connections to Africa*. In an effort to gain a better understanding of our audience, we ask that you take a few moments to fill out this survey. It is a total of 15 questions and should only take you a few minutes. Feel free to be honest in your responses as these results will not be shared with anyone outside of our Education Division.*

Thank You again for helping us to provide the best educational programming possible.

Name:

____

School:

____

Grade taught:

____

Part 1

1. How long have you been teaching?

   ____

2. How long have you been teaching in your current grade?

   ____

3. How long have you been teaching in your current district?

   ____

4. What percent of time would you say that your class spends engaged in inquiry?

   ____

Part 2

Indicate your level of agreement with the following statements by marking an "X" in the appropriate box.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1. I enjoy teaching science. *(attitude)*					
2. I enjoy allowing my students to run their own investigations in order to make discoveries. *(attitude)*					
3. I see my students as *actual* scientists doing *real* science. *(attitude)*					
4. I feel confident about using student-driven inquiry-based learning practices in my classroom. *(confidence)*					
5. I am likely to try a completely new way of teaching a science concept. *(confidence)*					
6. I am comfortable letting my students ask their own questions and design their own ways of testing answers to these questions, providing to them only general support and access to various tools and materials. *(confidence)*					
7. I think it is important for students to recognize themselves as *real* scientists. *(attitude)*					
8. I am confident when it comes to teaching the subject of science. *(confidence)*					
9. My school administration is supportive of teachers introducing new and/or varied methods of teaching into the classroom.					
10. I feel confident when introducing a new educational practice to my students. *(confidence)*					
11. I think science education is very relevant to current real-world issues. *(attitude)*					

Thank You!

APPENDIX D: STATISTICAL ANALYSIS OF RESULTS

Professional Development vs. Control Group

(t-tests were run using graphpad.com, free online t-test calculator)

Attitude Assessment: Test Group (Professional Development)	
Pre Survey Scores (mean values)	**Post Survey Scores (mean values)**
4.7	4.7
4.9	4.4
4.4	4.4
4.6	4.4
4.7	4.7

T-test result

p=0.2262
Not statistically significant
(statistical significance ≤ 0.05)

Confidence Assessment: Test Group (Professional Development)	
Pre Survey Scores (mean values)	**Post Survey Scores (mean values)**
4.6	4.4
4.4	4.3
4.0	4.4
4.4	4.7
4.0	4.6

T-test result

p=0.2577
Not statistically significant
(statistical significance ≤ 0.05)

Attitude Assessment: Control Group (No Professional Development)	
Pre Survey Scores (mean values)	**Post Survey Scores (mean values)**
3.9	3.9
3.7	3.7
3.4	4.0
4.2	4.1
4.6	4.4

T-test result

p=0.6903
Not statistically significant
(statistical significance ≤ 0.05)

Confidence Assessment: Control Group (No Professional Development)	
Pre Survey Scores (mean values)	**Post Survey Scores (mean values)**
3.3	3.8
4.1	4.0
3.6	3.9
3.8	4.0
4.1	4.0

T-test result

p=0.2420
Not statistically significant
(statistical significance ≤ 0.05)

APPENDIX E: STATISTICAL ANALYSIS OF RESULTS

Positive Teachers vs. Other Teachers

(t-tests were run using graphpad.com, free online t-test calculator)

Attitude Assessment: Test Group (Professional Development)			
Positive Teachers		Other Teachers	
Pre	Post	Pre	Post
4.7	4.7	4.8	4.8
4.7	4.0	5.0	4.8
4.3	4.0	4.5	4.8
4.7	4.3	4.5	4.5
4.7	4.7	4.8	4.8

T-test result (statistical significance ≤ 0.05)

Positive Teacher Pre vs. Other Teacher Pre
p= 0.3977, Not statistically significant

Positive Teacher Post vs. Other Teacher Post
p= 0.0898, Not quite significant

Confidence Assessment: Test Group (Professional Development)			
Positive Teachers		Other Teachers	
Pre	Post	Pre	Post
4.3	4.3	4.8	4.5
4.7	4.0	4.3	4.5
3.7	4.0	4.3	4.8
4.7	4.7	4.3	4.8
4.0	4.3	4.0	4.8

T-test result (statistical significance ≤ 0.05)

Positive Teacher Pre vs. Other Teacher Pre
p= 0.9332, Not statistically significant

Positive Teacher Post vs. Other Teacher Post
p= 0.0329, YES statistically significant

Attitude Assessment: Control Group (No Professional Development)			
Positive Teachers		**Other Teachers**	
Pre	**Post**	**Pre**	**Post**
4.3	4.7	3.7	3.5
3.7	3.7	3.7	3.7
3.3	4.3	3.5	3.8
4.7	4.3	4.0	4.0
4.7	4.7	4.5	4.3

T-test result (statistical significance ≤ 0.05)

Positive Teacher Pre vs. Other Teacher Pre
p= 0.4517, Not statistically significant

Positive Teacher Post vs. Other Teacher Post
p= 0.0729, Not quite significant

Confidence Assessment: Control Group (No Professional Development)			
Positive Teachers		**Other Teachers**	
Pre	**Post**	**Pre**	**Post**
3.3	4.0	3.3	3.7
4.7	4.3	3.8	3.8
3.3	4.0	3.7	3.8
4.3	4.7	3.5	3.7
4.3	4.3	4.0	3.8

T-test result (statistical significance ≤ 0.05)

Positive Teacher Pre vs. Other Teacher Pre
p=0.3343, Not statistically significant

Positive Teacher Post vs. Other Teacher Post
p= 0.0222, YES statistically significant