Faculty of Science

## INVESTIGATING THE EFFECT OF A SUMMER SCIENCE CAMP ON ELEMENTARY SCHOOL CHILDREN'S CONTENT KNOWLEDGE AND ATTITUDES TOWARDS SCIENCE

2014 | SPENCER MORRAN

**B.Sc. Honours thesis** 





## INVESTIGATING THE EFFECT OF A SUMMER SCIENCE CAMP ON ELEMENTARY SCHOOL CHILDREN'S CONTENT KNOWLEDGE AND ATTITUDES TOWARDS SCIENCE

by

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A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF BACHELOR OF SCIENCE (HONS.) in the DEPARTMENT OF BIOLOGICAL SCIENCES ANIMAL BIOLOGY MAJROR

THOMPSON RIVERS

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### ABSTRACT

Previous research has shown that hands-on learning is a highly effective method for delivering science lessons. The Science Centre that is the focus of this study is a non-profit centre that provides opportunities for children and adults to experience science through labs, shows, and an exhibition room filled with various hands-on activities. Based on my experience and that of others associated with this Science Centre, it appears that quality learning is going on at this science centre. However, previously published literature has stated that learning does not occur at such facilities and they are only for fun. The previous literature does state that going to such science centres can influence children's attitudes about science. This research is focused on trying to determine whether science activities at the Science Centre foster science learning as well as influence attitudes about science. A summer science camp for children aged nine to eleven was studied to try and make this determination. A questionnaire, video recordings, and audio recordings were used to collect data about the camp participants and track their progress based on attending the camp. Specific camp activities were also looked at to determine engagement level and relate the engagement level to specific questionnaire answers. The results showed that attending the summer science camp did increase the participants' knowledge about science. The attitudes of the campers did not change after attending the camp. It was difficult to determine whether engagement related directly to learning because it is difficult to determine from the video recordings whether a child is learning. Overall, it appears that learning does occur during a science camp at the Science Centre. This research can provide insight into how science camps at this and other facilities can be structured.

Thesis Supervisor: Assistant Professor Dr. Carol Rees

## ACKNOWLEDGEMENTS

I would first like to thank my thesis supervisors Dr. Carol Rees and Dr. Nancy Flood for all their continued support. I also want to thank Dr. Sharon Brewer for assisting as part of my thesis review committee. This research was funded by an Undergraduate Student Research Experience Award from the committee at Thompson Rivers University. Completing this research to this extent would not have been possible without the generous funding provided. Finally, I want to give a huge thank you to The BIG Little Science Centre. Without their support and cooperation, this research would not have been a pleasure to work with them.

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### INTRODUCTION

The Science Centre that is the focus of this study is a non-profit organization for children and adults alike to learn science concepts through hands-on learning. There is a large exhibit room filled with various activities promoting science learning through hands-on activities. Shows and labs are also offered for visitors allowing them to learn about science in a more structured manner. Large portions of the visitors to the Science Centre are from school groups during the school year and families dropping in for a visit. However, during the summer, science and robotics camps are offered for children of various ages. I worked at this particular Science Centre in the summer of 2012. During that time I was able to get a firsthand look at the science learning that occurred at this learning facility.

There has been lots of research pertaining to hands-on learning in science. It is said that hands-on activities allow the student to use their sense of touch and tactility (Kerrison and Jones 1994) in addition to their sense of sight and hearing to learn a task. The increased sensory input can allow the student to experience the activity more fully (Kerrison and Jones). Their skills in science can be improved upon if they have instruction and support, but most important are the hands-on experiences relating to science (Haden 2010). These kinds of research findings have influenced how The Science Centre presents science information to the public.

Fostering science learning through lecturing and test giving (such as the format found in most school systems) is becoming a less favoured method of education (Auger and Rich 2007). It has been shown that children need to get involved actively in the lesson for learning to be most effective (Wells and Arauz 2006). This includes dialogue between the children and their teacher in order to foster an increased depth of understanding of the subject (Wells and Arauz 2006). However, it can be difficult to create discipline-specific dialogue in a classroom setting (Engle and Conant 2002). Engle and Conant (2002) discuss what should be done to foster what they call "productive disciplinary engagement" in the classroom. They describe this as engagement in a particular subject (for example math, biology, or chemistry) by

students that allows them to make intellectual progress. In other words, it is when they have those "aha" moments in which they are actually learning something. To allow such engagement to occur, Engle and Conant suggest learning environments should include providing students with subject-related problems, giving them the authority to tackle these problems, making sure they are accountable both to disciplinary norms and to other people when solving these problems, and giving them the resources needed to solve the problems given. Problem solving can be difficult to implement in a classroom setting, but these kinds of activities can easily be provided in less formal learning settings. Such settings could include science centres and museums such as the Science Centre that is the focus of this study.

Studies have been conducted showing that visits to science education centres increase children's awareness about science and can have an impact on their opinions about choosing science as a career (Rennie 1994). This would indicate that being exposed to science in a location outside of the classroom influences attitudes held by children towards science. The reason for this could be that in this less structured form, science can be practiced in ways similar to that of science professionals (Adams et al 2012).

On the other hand, there are perceptions that hands-on activities at science centres and museums are only for fun, and that they do not actually produce any learning. Children who have been asked what they learned in hands-on discovery type spaces often state that there is no learning going on there and it is only for play (Griffin 1994, in Gardner 1994). People who work at science centres have also been quoted saying that the main objective of the science centre is to entertain and not to teach (Johnston and Rennie 1994, in Gardner 1994). These workers, however, do believe that people learn from the science centre without even realizing it, and also that they learn best when they can relate the topics to their everyday lives (Johnston and Rennie1994, in Gardner 1994).

From my experience at the Science Centre that is the focus of this study, I would disagree with the notion that science centres are only for play and I believe that others who are involved at this science centre would agree. This discrepancy between my views (and those of the Science Centre staff and volunteers) and the views of some educational researchers is one of the reasons I wanted to conduct this research.

For this project I studied the children at a summer science camp at the science centre where I had worked and I followed their progress during the week. My goal was to see if their science knowledge improved after a week at science camp and if their attitudes towards science changed. This was done using a pre and post camp questionnaire. I also observed and compared how they learned when doing hands-on tasks independently in the exhibit room at the centre and during structured lab time. Observational data was collected using video recordings, audio recordings and ethnographic observations.

The purpose of my research project was to see what effect a summer science camp had on children's attitudes towards science as well as their science knowledge.

There were four main questions I wanted to answer during this research project.

1) How do the attitudes of children towards science change after attending a weeklong summer camp in which they participate in hands-on activities?

2) How does children's participation in structured science programs such as labs and lectures influence their content knowledge of science?

3) How does children's participation in unstructured hands-on activities influence their content knowledge of science?

4) How do children engage in camp activities and how does this influence their learning?

The results of this research will give educators at the Science Centre insight into how their science camps improve on the camper's science knowledge and attitudes towards the subject. This knowledge can be used to make improvements on how camps are run so that the children are learning as well as having fun. These results can also be applied to institutions other than this particular Science Centre.

### MATERIALS AND METHODS

#### **Ethics** Approval

It is important to note that this study required the Thompson Rivers University Research Ethics Board to give ethics approval. Potential participants were not contacted until this was completed on June 5, 2013 (file number 100401).

#### **Participants**

I recruited my participants by inviting all children taking part in the Senior Science Camp at the Science Centre in the summer of 2013 to participate in the study. The camp ran from July 22-26, 2013 and was open to children aged 9-12. An invitation letter (Appendix A) was sent out to parents or guardians of the children signed up for camp. The letter outlined the research project and what participation would include. Informed consent forms (Appendix B) were also sent with the invitation letter for parents or guardians to officially give permission for their child to participate. They were asked to inform the child of what the research would entail and to only sign the form if the child and the parents/guardians agreed to participate. The children and their parent/guardian had the right to withdraw from the study at any time. Participant feedback forms (Appendix C) were also sent with the invitation package to give participants a chance to comment on the methods used in this research, if they felt the need to do so. Eleven children signed up for the camp and all of them gave permission to participate. Five of them were boys and six of them were girls, which gave a fair gender ratio.

The eleven children signed up for camp ranged in age from eight to eleven. Senior Science Camp specifies that children need to be nine by the end of the calendar year to attend camp. A few of the campers were eight at the time of camp but these children would be turning nine later in the year and therefore were permitted to attend.

There was a difference in the science background of the campers because some had completed the grade five science curriculum while others had only completed the grade three science curriculum. One participant was home schooled and was not sure what grade he or she had completed. None of the participants attend a local Science and Technology School, which is a school of choice that focuses on the sciences.

Two of the participants had been to a summer camp at the Science Centre before. One had been to a similar science camp offered for younger children and the other had been to a robotics camp. One participant had been to another summer science camp offered in the same city. Two of the participants had been to a different science camp before. Most of the participants had been to the Science Centre that was the focus of this study before either during a school visit or with their family and/or friends outside of school time.

The participants had had a wide range of science learning experiences during school time. Some had never done science experiments in school while others had done them often. In the classroom, some participants had learned science from books and movies while others had studied the topic from one but not the other or neither.

#### **Data Collection**

I used various research methods to conduct my research including a questionnaire, video recording, audio recording, and ethnographic notes which included observations of instructor and student activities. The questionnaire allowed me to obtain data that can be analyzed quantitatively and the recordings and notes allowed met to obtain data for qualitative analysis.

A questionnaire was administered to the children twice during the camp. First they were given the questionnaire on the first day of camp (Monday) in order to obtain a baseline. The campers were then given the same questionnaire on Thursday allowing me to compare their answers before and after specific activities. The second questionnaire was administered on Thursday rather than Friday (the last day of the camp) for logistical reasons. All participants wrote the questionnaire in the same room with the exception of one camper who arrived late to camp and wrote their pre-camp questionnaire with me a few hours later. The children were allowed to ask questions about what a specific question was asking, but were not allowed to ask whether their answer to a question was correct. Children were asked to include their name, age, grade, and gender on the questionnaire. The child's name was later removed and replaced with a number to ensure confidentiality. These same numbers were also used to indicate which child is speaking or completing an action during all video transcriptions used in this research.

The questionnaire consisted of three parts (Appendix D). The first part included questions regarding the child's previous science experience. This portion of the questionnaire attempted to measure the child's previous experiences at the Science Centre during class time or outside of school as well as what kinds of science activities they participated in at school. First there were simple "Yes" or "No" questions such as, "Have you been to the Science Centre outside of school time". This was followed by statements ranked on a Lickert Scale (scale of 1 to 5 with 1 being strongly disagree and 5 being strongly agree) in order for children to have a variety of options for an answer. This is how I collected the science background data reported in the *Subjects* section above. An example of a background questions can be found in Appendix D. This section also included two short-answer questions, "Can you give an example of using science in everyday life?" and "Can you give an example of a science experiment you have done before". These questions were included to get a sense of what the children's perceptions were about science.

The second part of the questionnaire deals with the children's attitudes towards science. Statements about the child's interest in science and science related activities were presented and the children were then able to show their feelings about the statement by answering on a Lickert Scale. Statements included "I want to be a scientist when I grow up", "I enjoy watching science shows on TV", and "When I am older, I would like to take more science classes". There were also statements relating to activities the children would be participating in during the camp, for example "I enjoy doing experiments with a chemical reaction". These kinds of statements allowed me to investigate whether participating in a specific activity at camp has an influence on a child's attitudes about that activity.

Finally, the third part of the questionnaire included content knowledge questions regarding specific hands-on science activities in the exploration room, that the children would be participating in during camp. Questions were asked about four labs that they would be participating in during the week. The labs I chose to look at were the pH lab, chemical reactions lab, salmon dissection, and investigation of pond invertebrates. These labs covered topics such as the pH scale, what indicates a chemical reaction, chemical reactions with gases, external and internal physiology of a salmon, what an insect is, and identification of insects based on basic exterior morphology. A more detailed description of each of these labs is given in Appendix E.

Questions were also asked about three specific activities in the exhibit room at the Science Centre. Each of the activities in this room had specific learning outcomes and instructions accompanying the activity that aided the user to meet these learning outcomes.

The first activity dealt with pulleys and how the number of pulleys changes the amount of effort needed to lift a load. Three pulley systems were set up with one, two, or three pulleys being used to lift a 2.2 kg load (Figure 1). The set up with three pulleys is the easiest, while the set up with only one pulley is the hardest. A more subtle difference between the three pulley systems is the distance the string needs to be pulled to lift the load. For example, lifting the load to a height of 10 cm from the table will require the string to be pulled farther when there are three pulleys present than if only one pulley is present. There are questions in the questionnaire about both the ease of lifting the load and the distance the string must be pulled. I included both these topics because the ease of lifting the load is easy to determine just by trying the activity, while discovering that the string needs to be pulled a further distance requires more in-depth thinking. Comparing answers to these two questions can give insight into the depth of learning associated with this activity.



Figure 1. Pulley activity used for the independent exhibit room based questions.

The second activity I studied in the exhibit room was a balancing lever (Figure 2). In this activity, weights were provided that can hook onto a lever in different locations. This allowed the children to balance the lever by placing weights at different distances from the pivot.



Figure 2. Leaver activity used for the independent exhibit room based questions.

A mirror activity was the third subject of study in the exhibit room. This activity is more complex than the other two. It involves investigating how changing the angle between two mirrors affects the number of images shown in the mirrors (Figure 3). In the past, it has seemed that children went to this activity less often than the others in the exhibit room. However, it has very good learning outcomes which is why it was included in my research.



Figure 3. Mirror activity used in the independent exhibit room portion of the questionnaire

I chose to have content knowledge questions based on labs as well as exhibit room activities so I could compare two of the most used methods of delivering information at the Science Centre. The labs were structured and included a fifteen minute pre-lab talk and then a handson activity based on the information given. For example, in the pH lab the instructor first explained what pH is and how it is measured as well as what constitutes an acid or a base. The children then used litmus paper to test the pH of various mixtures. After most labs a post-lab discussion took place recapping what happened during the lab and what information was learned.

The exhibit room at the Science Centre has lots of science-based activities for children to try in a less structured manner. The campers were brought to the exhibit room three times during the study for between twenty and thirty minutes each time. They were allowed to freely explore the room and try out any activity as much or as little as they wanted in an unstructured manner. The labs and the exhibit room activities I chose to ask content knowledge questions about each had unique learning outcomes. This means that the information was presented in only one place, either the lab or the exhibit room. For example, there are no activities in the exhibit room regarding pH and there was not a lab activity based on pulleys. This allowed me to distinguish between learning from structured labs and learning from unstructured time in the exhibit room in order to see if the learning methods differ. The exhibit room activities each had different learning outcomes so it was also easy to determine which activity would have influenced the questionnaire answers. For the labs, only questions relating to specific labs were asked. This means that for each lab-based content knowledge question it was easy to pinpoint which lab may have influenced the children's answers.

All the questionnaire answers were recorded in an Excel spreadsheet. Content knowledge questions were scored as being right or wrong. This data was then used for quantitative analysis.

I also collected data through video and audio recording. A video camera (JVC HD Everio GZ-E200) and three voice recorders (Sony ICDPX333 4GB Digital Voice Recorders) were used to observe the children's activities during the labs that were included in the content knowledge portion of the questionnaire as well as the time spend in the exhibit room between the two questionnaire writing sessions.

For the labs, the video camera was set up to view the entire lab room and one voice recorder was placed in the vicinity of each table of campers (three in total). These devices were used to record the pre-lab background and instructions as well as the campers' participation in the hands-on portion of the lab. The general set up of the lab is shown in Figure 4; this was the view of the video camera for each recording session.



Figure 4. View of the lab room as seen in the video recordings showing the general lab set up.

The three activities found in the exhibit room that I asked questions about on the questionnaire were placed on the same table for easy viewing. A video camera was mounted to the wall so all three activities could be viewed at once. One voice recorder was placed on the wall above each activity. Figure 5 shows the view of the video camera.



Figure 5. View of the three activities in the exhibit room as seen by the video camera

Ethnographic notes were also used to collect a small portion of the data used in my study. During the structured labs that were being video and audio recorded, I was also taking ethnographic notes. I wrote down some of the questions and answers given during the lab as well as some comments that the campers made during the activity. These notes were used along with the audio recordings in analysis only when a portion of the video recording was hard to decipher. Each of these data collection methods were used because they would pose the least disruption in the camp setting. Other than the questionnaire, the activities studied would have occurred anyways and they were not changed to suit the study. The video, audio and ethnographic recordings were taken as discreetly as possible and did not disrupt the campers in any way.

#### Statistical Analysis

First, I dealt with the statistical analysis for the content knowledge portion of the questionnaire. I tested all the data for normality before conducting any further analysis. Data sets being compared were also tested for equality of variance. The appropriate statistical tests (i.e., parametric or nonparametric) performed were each chosen based on results for the normality test, test for equal variances, and whether the data sets were considered independent. All statistical tests were performed with Minitab 6 statistical software.

To see if the camper's content knowledge related to the structured lab portion of the camp changed, I also performed a paired t-test. I compared the scores for the lab portion on the precamp questionnaire and the post-camp questionnaire. I did the same analysis for the scores on the exhibit room portion of the questionnaire. Total scores (exhibit room and lab portions) pre and post-camp were also compared using a paired t-test.

Next I wanted to see how the scores on the lab-based questions compared to the exhibit room based questions. First I compared the scores for the lab and exhibit room questions in the pre camp questionnaire. Second, I compared the scores for the lab and exhibit room questions in the post camp questionnaire. Finally, I compared the change in scores for lab and exhibit room questions. For each of these comparisons I used a two-sample t-test in Minitab.

The total change in scores was also compared. I found the difference between the scores for the two types of questions (lab pre-camp scores minus lab post-camp scores and exhibit room pre-camp scores minus post-camp exhibit room scores) and used a paired t-test to compare them. Content knowledge answers were next compared based on gender. Scores were categorized into male (n = 5) and female (n = 6). The following parameters were compared for each gender; pre and post lab scores, pre and post exhibit room scores, change in lab and exhibit room scores, change in total scores. All of these comparisons were done using a two-sample t-test or a paired t-test, whichever was appropriate.

I also did statistical tests to compare male and female answers. Two-sample t-tests were used to compare the following between the two genders; pre lab scores, post lab scores, change in lab scores, pre-camp exhibit room scores, post-camp exhibit room scores, change in exhibit room scores, total pre content knowledge scores, total post content knowledge scores, and total change in content knowledge scores.

Next, I performed statistical analysis after separating the data by grade level that the child had completed. Two campers were entering grade six in the following school year and four campers were entering grade five. I grouped their scores together into one category because they had completed either grade four or five which are considered "intermediate" grades in the elementary school system. Therefore, I would expect that their science knowledge would be higher. Four of the remaining campers were entering grade four and the final camper was a home-school student. I grouped the home-school student with the younger grade level because the child was unsure about his or her grade equivalency. This camper also said he or she had not yet done much science in his or her home-school program. Finally, based on the camper's age he or she should be placed with the younger children. Taken together, I would expect the five younger campers to score lower on the content knowledge questions based solely on the fact that they have completed less of the elementary science curriculum than the older campers. These older campers will be labeled as "intermediate" and the younger campers as "primary" from henceforth.

The same statistical tests were done comparing intermediate and primary students as described above for gender. Tests were done on each grade category individually for the same parameters, followed by a comparison of the intermediate and primary students, again with the same parameters as above.

The second portion of statistical analysis I conducted was related to the attitude questions on the questionnaire. First I wanted to see if the children's attitudes as a whole changed during the week. Since these questions were answered on a Lickert scale, I was able to add up each child's answers to give a total attitude score. Eleven of the twelve attitude questions were answered on the same scale, meaning that a score of 5 indicates a very positive attitude towards science and a score of 1 indicates a very negative attitude towards science. This meant that I could add up the scores for those eleven attitude questions and omit the one that is on the opposite scale (i.e. 5 indicates a very negative attitude towards science and 1 indicates a very positive attitude towards science and 1 indicates a very positive attitude towards science and 1 indicates a very positive attitude towards science and 1 indicates a total attitude score with a maximum of 55 (obtained by answering 5 for all eleven questions).

Before comparing the attitude scores I had to test if the data was normally distributed. At first the test showed that the data was not normally distributed. After looking back at the questionnaires I found that one participant missed a whole page on the pre-camp questionnaire. This page contained seven of the eleven questions so this participant potentially missed 35 points (if they had answered 5 for each question). I wanted to see if this outlier was significant so I tested for normality again after removing the pre and post scores for this participant. The data was considered normally distributed after this, so I decided it was fair to omit this participant's scores for the attitudes portion of the analysis. After this I was able to perform a paired t-test to compare the campers' attitude scores before and after the camp.

As with the content knowledge scores, I wanted to compare the attitudes of the campers based on gender and grade level. The outlier was omitted for this analysis. I first compared the pre and post attitude scores for females, males, primary grades and intermediate grades. This was done using a paired t-test for each category except intermediate grades. The data set for the intermediate grades did not pass a normality test for pre or post attitude scores. A Wilcoxon Matched Pairs Signed Ranks Test was used to compare the difference between pre and post attitude scores for the intermediate campers. I then used a two-sample t-test to compare the pre attitude scores, post attitudes scores, and change in attitude scores for males and females. For grade level, pre attitude scores and post attitude scores were compared using a Mann Whitney U Test because the intermediate pre and post scores were both not normally distributed. However, change in attitude was normally distributed for both primary and intermediate campers, so a two-sample t-test was performed to compare the change in attitude.

After comparing the attitude questions as a whole, I selected six of the questions to analyze on their own. I chose "Science is important in daily life" and "I want to be a scientist when I grow up" because these could indicate general attitude towards science. I also chose attitude questions for which the children's attitudes might have been changed based on participating in specific camp activities. "I enjoy doing science experiments" was chosen because the children conducted many science experiments during camp and therefore their answers may have changed based on their participation in these activites. I also picked questions related to the specific labs that I was observing. These questions included "I enjoy doing experiments with a chemical reaction", "I enjoy learning about bugs", and "I enjoy learning about animals" For all of these questions I performed a Wilcoxon Signed Ranked Test on the prequestionnaire answers and the post-questionnaire answers. I used this test because the question was answered on a Lickert scale and therefore can be categorized as ranked data.

#### Video and Audio Analysis

The video and audio data was used to observe how the children engaged in the camp activities. While watching the video recordings for all four labs and all three exhibit room sessions, I looked at level of engagement. The approach I took to looking at engagement level was based on some of the methods used in Engle and Conant's paper "Guiding principles for fostering productive disciplinary engagement: Explaining an emergent argument in a community of learners classroom" published in 2002. In their paper, Engle and Conant (2002) categorize level of engagement into three categories. The first category is simply engagement, meaning that children are engaged in the topic at hand. Next, if a child is

engaged in the topic but is also participating in a way that relates to the topic at hand, the category now becomes disciplinary engagement. For example, a student simply paying attention to a teacher while they talk about a subject or showing interest in an activity is considered engagement, but if that student was participating in a discussion (in this case, science related), that would be disciplinary engagement. The last category of engagement is productive disciplinary engagement. At this level, a child is engaged and participating in a topic and they also have a specific learning event (Engle and Conant 2002). This is like the "aha!" moment where a child demonstrates learning. The principles in this paper have been used by other researchers such as Scott et al. in their 2006 paper "The tension between authoritative and dialogic discourse: A fundamental characteristic of meaning making interactions in high school science lessons", thus demonstrating the validity of Engle and Conant's work.

For the video recordings of the labs, I looked for signs of each level of engagement. For engagement, signs include a child facing their body towards the instructor, not talking to other campers while the instructor is talking, and not fidgeting with equipment while the instructor is talking. Once the campers were actually participating in the lab, I categorized the engagement level as disciplinary engagement. Things that would constitute disciplinary engagement are working on the lab task, asking questions about the lab, and engaging in discussions related to the lab. For example, if the instructor posed a question to the campers, the ones responding would be engaging in disciplinary engagement. I categorized instances of engagement as productive disciplinary engagement if the campers connected ideas related to the lab topic together or they related ideas in the lab to other situations.

The recordings for the exhibit room were a bit easier to categorize in terms of engagement. If a camper went to an activity and simply looked at it or played with it in a manner different from that intended, or if they only read the directions and did not try the activity, it was just considered engagement. This is because the campers were paying attention to the activity, but they did not participate in the activity in the way it was intended. If campers participated in a exhibit room activity properly, in the manner intended, it was considered disciplinary engagement. Finally, if it appeared the camper demonstrated that they understood the learning outcome of the activity, the interaction was categorized as productive disciplinary engagement.

### **Relating Instances of Engagement to Questionnaire Answers**

Since instances of productive disciplinary engagement are defined as instances where a child actually demonstrates learning about a topic, the data was also evaluated to see if these instances match up with questionnaire scores. The hypothesis was that if productive disciplinary engagement demonstrated learning, the children who showed signs of productive disciplinary engagement while interacting with the exhibit room activity would answer the related question(s) correctly in the post-camp questionnaire. Relating instances of productive disciplinary engagement during the labs to questionnaire answers was difficult. There were only a few examples of productive disciplinary engagement that were evident. Among these few examples, only three of them related directly to a specific question on the questionnaire. For these specific instances, I compared the camper's pre- and post-camp questionnaire answers to see if these instances of productive disciplinary engagement resulted in a change in their answer.

For the instances of engagement with the exhibit room activities, this comparison was easier to do since the questions on the questionnaire were very specific to each activity. For each exhibit room activity, I picked out the instances that were categorized as productive disciplinary engagement. Next I looked at the child's pre- and post-camp questionnaire answers to see if interacting with the activity was associated with a correct response in the post-camp questionnaire.

## RESULTS

### Statistical Analyses

For simplicity, the mean and standard deviation for each category upon which a parametric test was done is shown in for comparisons of the group as a whole Table 1, for comparisons based on gender Table 2, and for comparisons based on grade level Table 3. The median for each category upon which a non-parametric test was done is shown in Table 4.

Table 1. Mean and Standard Deviation of data sets used for parametric tests comparing questionnaire answers of the group as a whole.

Category	Mean	Standard Deviation
Total Pre-Camp Content	3.4	1.5
Knowledge Scores		
Total Post-Camp Content	5.1	1.7
Knowledge Scores		
Pre-Camp Lab Question	3.4	1.5
Scores		
Post-Camp Lab Question	5.1	1.7
Scores		
Pre-Camp Exhibit Room	2.0	1.5
Question Scores		
Post-Camp Exhibit Room	2.9	1.5
Scores		
Pre-Camp Attitude Scores	43.2	8.8
Post-Camp Attitude Scores	44.8	7.7

Table 2. Mean and Standard Deviation of data sets used for parametric tests comparing questionnaire answers of girls and boys separately.

Category	Mean	Standard Deviation
Total Pre-Camp Content	3.6	0.8
Knowledge Scores, Girls		
Total Pre-Camp Content	7.6	2.5
Knowledge Scores, Boys		
Pre-Camp Lab Scores, Girls	2.6	1.2
Pre-Camp Lab Scores, Boys	4.4	1.5
Pre-Camp Exhibit Room	1.0	0.9
Scores, Girls		
Pre-Camp Exhibit Room	3.2	1.3
Scores, Boys		
Total Post-Camp Content	7.3	2.9
Knowledge Scores, Girls		
Total Post-Camp Content	9.0	2.9
Knowledge Scores, Boys		
Post-Camp Lab Scores, Girls	4.8	1.9
Post-Camp Lab Scores, Boys	5.6	1.5
Post-Camp Exhibit Room	2.5	1.6
Scores, Girls		
Post-Camp Exhibit Room	3.4	1.5
Scores, Boys		
Change in Content	3.6	2.9
Knowledge Scores, Girls		
Change in Content	1.4	2.5
Knowledge Scores, Boys		
Change in Lab Scores, Girls	2.2	2.0
Change in Lab Scores, Boys	1.2	1.3
Change in Exhibit Room	1.5	0.6

Scores, Girls		
Change in Exhibit Room	0.20	1.3
Scores, Boys		
Pre-Camp Attitude Scores,	46.0	4.6
Girls		
Pre-Camp Attitude Scores,	40.4	11.6
Boys		
Post-Camp Attitude Scores,	45.2	3.1
Girls		
Post-Camp Attitude Scores,	44.4	11.2
Boys		
Change in Attitude Scores,	-0.80	3.7
Girls		
Change in Attitude Scores,	4.0	3.1
Boys		

Table 3. Mean and Standard Deviation of data sets used for parametric tests comparing questionnaire answers of primary and intermediate grades separately.

Category	Mean	Standard Deviation
Total Pre-Camp Content	4.2	1.6
Knowledge Scores, Primary		
Total Pre-Camp Content	6.5	3.0
Knowledge Scores,		
Intermediate		
Pre-Camp Lab Scores,	2.8	1.3
Primary		
Pre-Camp Lab Scores,	4.0	1.7
Intermediate		
Pre-Camp Exhibit Room	1.4	0.9

Scores, Primary		
Pre-Camp Exhibit Room	2.5	1.9
Scores, Intermediate		
Total Post-Camp Content	7.2	3.6
Knowledge Scores, Primary		
Total Post-Camp Content	8.8	2.2
Knowledge Scores,		
Intermediate		
Post-Camp Lab Scores,	4.8	2.2
Primary		
Post-Camp Lab Scores,	5.5	1.4
Intermediate		
Post-Camp Exhibit Room	2.4	2.1
Scores, Primary		
Post-Camp Exhibit Room	3.3	1.0
Scores, Intermediate		
Change in Content	3.0	3.7
Knowledge Scores, Primary		
Change in Content	2.3	2.3
Knowledge Scores,		
Intermediate		
Change in Lab Scores,	2.0	2.5
Primary		
Change in Lab Scores,	1.5	1.1
Intermediate		
Change in Exhibit Room	1.0	1.6
Scores, Primary		
Change in Exhibit Room	0.8	1.5
Scores, Intermediate		
Pre-Camp Attitude Scores,	45.0	3.1

Primary		
Post-Camp Attitude Scores,	48.0	5.0
Primary		
Change in Attitude Scores,	3.0	2.6
Primary		
Change in Attitude Scores,	0.67	4.8
Intermediate		

Table 4. Median values for categories that were used for non-parametric tests.

Category	Median
Pre-Camp Attitudes, Primary	44.0
Pre-Camp Attitudes, Intermediate	45.5
Post-Camp Attitudes, Primary	48.0
Post-Camp Attitudes, Intermediate	45.5
Change in Attitudes, Intermediate	-0.50
"Science is important in daily life"	0.000
(differences in scores Post-Camp minus Pre-	
Camp)	
"I want to be a scientist when I grow up"	0.00
(differences in scores Post-Camp minus Pre-	
Camp)	
"I enjoy doing science experiments"	0.00
(differences in scores Post-Camp minus Pre-	
Camp)	
"I enjoy doing experiments with a chemical	-1.0
reaction" (differences in scores Post-Camp	
minus Pre-Camp)	
"I enjoy learning about bugs" (differences in	0.00
scores Post-Camp minus Pre-Camp)	

"I enjoy learning about animals" (differences	0.00
in scores Post-Camp minus Pre-Camp)	

The total content knowledge scores were higher on the post-camp questionnaire than the precamp questionnaire (t = -3.08, p = 0.006, n = 11). For the lab-based questions, the paired ttest showed that the scores were higher on the post-camp questionnaire when compared to the pre-camp scores (t = -3.30, p = 0.004, n = 11). The exhibit room based questions also showed that the scores were higher on the post-camp questionnaire (t = -2.09, p = 0.032, n = 11).

The paired t-test comparing the pre-camp questionnaires found that the scores for the labbased questions were higher than the exhibit room based questions (t = 2.19, p = 0.020, n = 11). For the post-camp questionnaire, the paired t-test also found that the scores were higher on the lab-based questions than the exhibit room based questions (t = 3.23, p = 0.002, n = 11).

The results showed that there was no statistical difference between the change in scores for the lab portion of the questionnaire and the change in scores for the exhibit room portion (t = -1.20, p = 0.244, n = 11).

For the total scores on the attitude questions, the paired t-test found that the scores were not significantly different before and after the camp (t = -1.24, p = 0.247, n = 10).

After analyzing six of the attitude questions individually, I found that there was no evidence of an increase in positive attitudes on the post-questionnaire when compared to the prequestionnaire for the following five questions: "Science is important in daily life" (W = 2.0, p = 0.395, n = 10), "I enjoy doing science experiments" (W = 2.0, p = 0.181, n = 10), "I enjoy learning about bugs" (W = 10.5, p = 0.542, n = 10), "I enjoy learning about animals" (W = 0.0, p = 0.186, n = 10), "I want to be a scientist when I grow up" (W = 2.0, p = 0.395, n = 10). The only question that showed a more positive attitude towards science on the postcamp questionnaire was "I enjoy doing experiments with a chemical reaction" (W = 0.0, p = 0.018, n = 10).

Next I analyzed the scores for girls and boys separately, starting with the girls. The girls had higher scores on the post-camp questionnaire than the pre-camp questionnaire for both the lab (t = 2.60, p = 0.024, n = 6) and the exhibit room (t = 2.67, p = 0.022, n = 6) portions. The change in lab scores were not significantly different from the change in exhibit room scores for the girls (t = 0.66, p = 0.522, n = 6). Total content knowledge scores were higher on the post-camp questionnaire than the pre-camp questionnaire (t = 3.12, p = 0.013, n = 6). The girls' attitudes did not change after attending the camp (t = -0.48, p = 0.543, n = 6).

For the boys, the scores on the lab portion of the questionnaire did not change after attending the camp (t = 2.06, p = 0.109, n = 5) and the same was found for the exhibit room scores (t = 0.34, p = 0.749, n = 5). As with the girls, there was no difference between the change in lab scores and change in exhibit room scores (t = 1.21, p = 0.260, n = 5). The total content knowledge scores for the boys did not change after the camp (t = 1.25, p = 0.280, n = 5). However, the boys did have higher attitude scores on the post-camp questionnaire (t = 2.90, p = 0.022, n = 5).

After looking at the scores of the girls and boys separately, I compared questionnaire answers between the genders. There was no difference between the pre-camp lab scores (t = -2.11, p = 0.064, n = 11), post-camp lab scores (t = -0.72, p = 0.491, n = 11), or change in lab scores (t = 0.91, p = 0.386, n = 11) when comparing girls and boys. The pre-camp exhibit room scores were higher for boys than girls (t = -3.23, p = 0.004, n = 11). However, there was no difference between boys and girls with respect to the exhibit room scores on the post-camp questionnaire (t = -0.94, p = 0.374, n = 11) and there was not a difference in the change in exhibit room scores (t = 1.60, p = 0.145, n = 11). However, there was a difference between genders for the total pre-camp content knowledge scores, with the boys having higher scores than the girls (t = -3.65, p = 0.003, n = 11 Post-camp content knowledge scores of girls did not differ from those of boys (t = -0.94, p = 0.372, n = 11) and the change in content knowledge scores did not differ (t = 1.38, p = 0.202, n = 11).

With regard to attitudes, girls and boys did not have different attitude scores on the pre-camp questionnaire (t = 1.00, p = 0.345, n = 10) or on the post-camp questionnaire (t = 0.15, p = 0.885, n = 10). There also was no difference between the change in attitude scores of the girls and the boys (t = -2.23, p = 0.056, n = 10).

Finally, I analyzed the questionnaire results after separating the campers by age into "intermediate" (entering grades 5-6) and "primary" (entering grade 4 and homeschool). First I analyzed the primary campers' scores. There was no difference between the pre- and post-camp lab scores (t = 1.83, p = 0.142, n =5) or between the pre- and post- camp exhibit room scores (t = 1.41, p = 0.230, n = 5). The total content knowledge scores also were not difference in the pre- and post-camp questionnaire (t = 1.83, p = 0.142, n = 5). There was no difference in the change in lab scores and change in exhibit room scores (t = 0.77, p = 0.465, n = 5). Attitude scores also did not differ pre- and post-camp for the primary campers (t = 2.32, p = 0.103, n = 4).

For the intermediate campers, the exhibit room scores did not differ pre- and post-camp (t = 1.39, p = 0.224, n = 6). However, the lab scores were higher on the post-camp questionnaire (t = 3.50, p = 0.009, n = 6). The total scores pre- and post- camp were very close to being significantly different, but did not make the standard 5% significance threshold (t = 2.54, p = 0.052, n = 6). The change in lab scores did not differ significantly from the change in exhibit room scores (t = 0.90, p = 0.388, n = 6). There was no difference in the attitude scores pre- and post camp for the intermediate campers (W = 9.0, p = 0.834, n = 6).

When comparing the primary campers to the intermediate campers, there was no difference in the pre-camp lab scores (t = -1.30, p = 0.225, n = 11), post-camp lab scores (t = -0.65, p = 0.531, n = 11), or change in lab scores (t = 0.46, p = 0.659, n = 11). The same results were found when comparing pre-camp exhibit room scores (t = -1.20, p = 0.262, n = 11), postcamp exhibit room scores (t = -0.97, p = 0.355, n = 11), and change in exhibit room scores (t = 0.18, p = 0.860, n = 11) of primary and intermediate campers. Total content knowledge scores did not differ in the pre-camp questionnaire (t = -1.52, p = 0.163, n = 11) or in post-
camp questionnaire (t = -0.92, p = 0.382, n = 11). The change in content knowledge scores was not different for primary and intermediate campers (t = 0.37, p = 0.719, n = 11).

Pre-camp attitudes did not differ between the two age groups (W = 22.0, p = 1.0000, n = 10). The same result was found for the post-camp attitude scores (W = 26.0, p = 0.4555, n = 10). There was no difference in the change in attitudes between the primary and intermediate campers (t = 0.87, p = 0.408, n = 10).

## Short Answer Results

The short answer questions on the questionnaire (Appendix D) were administered to see if the campers related science to everyday life and if they could give an example of a science experiment they had done. Answers were reviewed and categorized based on whether it was a good answer or not.

For the question related to science in everyday life, all of the campers who responded gave good examples on the pre- and post-camp questionnaire. The only exception was one post-camp response that did not quite make sense (denoted with a \* in Table 5). Some of them were harder to follow than others, but their apparent train of thought was on the right track. The responses are shown, in no particular order, in Table 5.

Table 5. Responses given by campers to the question "Can you give an example of using science in everyday life?" on the pre- and post-camp questionnaire. \* denotes response that did not make sense.

Pre-camp Responses	Post-Camp Responses
- Lights. Fish tank.	- Computer.
- To make metal.	- I use electricity.
- To make oxygen.	- * They use science in everyday life
- When you turn the lights on and off.	because we could find this out.
- Doing the weather.	- The Weather.
- Cooking, you bake food and mix food	<ul> <li>When you watch TV you are using</li> </ul>

together	something called electricity.	
	- Da weather sucka!!!!!	
	- Cooking and baking.	

On the pre-camp questionnaire, ten campers responded to the question about a science experiment they had done before. Nine campers responded to the question on the post-camp questionnaire. Three of the responses on the pre-camp questionnaire and two responses on the post-camp questionnaire were not examples of science experiments. The responses are shown in Table 6. As with the previous short answer question, some of the responses were difficult to decipher but I could figure out what the campers meant most of the time.

Table 6. Responses to the question "Can you give an example of a science experiment you have done before?" on the pre- and post-camp questionnaire. Answers are sorted based on the quality of the example.

Pre-Camp	Responses	Post-Camp Responses		
Good Examples Not Examples		Good Examples	Not Examples	
- Researching	<ul> <li>Never done a</li> </ul>	- I have done	- Yes in school.	
animals.	science	the Mento		
<ul> <li>I have mixed baking soda and vinegar.</li> </ul>	experiment before. - No.	test. - I put Mentos in a coco bottle.	- No.	
- Thave done me				
without a	bubbets.	- About water.		
thumb.		Life without a		
- Growing		thumb.		
mediworms.		- Growing		
- When I made a		mealworms.		
bridge out of		- Putting		
straws and		Mentos in a		
tested the		Coke bottle.		
stability.		- A chemical		

- Animals and	reaction.	
habitats.		
	<ul> <li>I know what</li> </ul>	
- Drop water on	fish have in	
penny to see	them.	
how much		
would fit.		

# **Engagement During Each Lab**

## Notes on Video Transcriptions

For each video transcription, the time the excerpt starts in the video recording is given. The time is shown with number of minutes, followed by a period and then the number of seconds. For example, an excerpt that starts at 2 minutes and 43 seconds into a recording would be labeled 2.43. Some recordings were broken up into multiple clips so the clip number is also shown. Since only certain excerpts were transcribed rather than the entire video recording, lines are numbered individually for each excerpt. Some lines may have been removed if they were not relevant to the incidence of engagement. For example, if a student yells out an answer and the instructor tells them to put his or her hand hand up, those lines in the transcription are not shown. When someone is gesturing, for example when the instructor is pointing to a camper who has their hand up, these gestures are shown in brackets. If something needs to be added to give more context to a transcription, the information is placed in square brackets to denote that this was not something the speaker actually said.

## pH Lab

This lab was the first activity during the camp and there was minimal chatting throughout. A few campers were not showing signs of engagement right away. The entire camp group was not showing signs of engagement with the pre-lab talk until around four minutes into the activity. During this time, some of the campers were not focused on the teacher or were fidgeting with the equipment instead of paying attention. After this point, all the campers showed signs of engagement by facing the instructor and paying attention. Some campers showed disciplinary engagement by answering questions posed by the instructor. For example, Campers 3, 5, 7, and 9 are all showing signs of disciplinary engagement in the excerpt below, in which instructor is talking about acids and bases in daily life.

5.51, clip 1 of 2.

- 1 Instructor: Where do you find Hydrochloric acid?
- 2 Instructor: What liquid are you touching right now?
- 3 Camper 7: Water!
- 4 Instructor: Yeah that's on the outside but what's inside ya?
- 5 Camper 3: Sweat!
- 6 Camper 7: Blood.
- 7 Instructor: Not sweat. Not Blood.
- 8 Camper 5: Blood, oh, no.
- 9 Instructor: What's in your stomach?
- 10 Camper 9: Stomach acid.
- 11 Instructor: (points to student indicating correct answer) Hydrochloric Acid.

The only outward sign of productive disciplinary engagement in the pH lab occurred during the pre-lab talk. In the excerpt below, the instructor is relating the number of bugs in local lakes to the basic pH of the water. Camper 5 is then able to make the connection between the bugs in the lake and this area being good for fishing.

10.38, clip 1 of 2.

- 1 Instructor: Our lakes grow good bugs. What eats bugs?
- 2 Camper 5: Fish.
- 3 Instructor: Fish, yes. So do you know why Kamloops is famous for fish?
- 4 Camper 5: Because of the bugs.

Since Camper 5 is able to make this connection without being told outright, it is considered to be an example of productive disciplinary engagement.

Once the pre-lab talk ended and the lab began, all of the campers showed signs of disciplinary engagement. Each of them was working on the lab and following the directions. Some of them asked the instructor and camp helpers questions about the lab which is also a sign of disciplinary engagement.

During the post-lab talk, all of the campers were engaged. They were facing the instructor and paying attention to what was being said. As with the pre-lab talk, some showed signs of disciplinary engagement by answering questions posed by the instructor. In the following excerpt, Campers 5 and 10 are reporting some of their findings. I would say that Camper 7 is also showing disciplinary engagement because he or she volunteered to answer in line 2.

10.20, clip 2 of 2.

- 1 Instructor: Okay so now what was the most basic one?
- 2 (Campers 7 and 5 put hands up)
- 3 (Camper 5 seems very excited to answer)
- 4 Instructor: Okay camper 5, before you explode
- 5 Camper 5: Uh, sodium hydroxide (struggles with pronunciation)
- 6 Instructor: Sodium hydroxide, yeah.
- 7 (Camper 10 puts hand up)
- 8 Instructor: (points to camper 10) Yeah?
- 9 Camper 10: Lime juice, I mean lime water
- 10 Instructor: Yeah, lime water was another one.

Overall, the campers were engaged throughout this lab. All of them showed signs of disciplinary engagement during the lab activity, while only some of them showed these signs during the pre- and post-lab talks. Only one outward sign of productive disciplinary engagement was found in the video recording for this lab.

### **Chemical Reactions Lab**

The campers were very engaged in this lab from the start. They all showed signs of engagement throughout the lab. Since this lab is composed of many parts (see Appendix E for details), the pre-lab talk was brief. This talk mostly included instructions on how to perform the chemical reactions on the spot plates and safety information. The pre-lab talk did not include any questions posed to the campers by the instructor due to the lengthy instructions needed for the activity, so no signs of disciplinary engagement were shown. However, during the first part of the lab when the campers are mixing chemicals on a spot plate, many examples of disciplinary engagement were shown. The campers were all on task and following the directions while working on their chemical reactions. Many campers also showed signs of disciplinary engagement by talking about their observations out loud. Some examples of observations heard in the video recording are listed below.

-It's magenta, cool!

- It's fuzzy.

- Woah, dude! Look at my copper (shows partner).
- Bubbles!

These observations stated by the campers are considered disciplinary engagement rather than productive disciplinary engagement because they are talking about the reactions but they aren't having an "aha!" type moment in which they seem to be learning something specific.

Once all the campers were finished with their spot plate reactions, there was a brief post-lab talk. This mostly discussed what happened in some of the reactions and what happened when some of them did not read the labels on the chemicals correctly.

The next portion of the lab included three chemical reactions that produced a gas that the campers tested to determine what kind of gas it was. For this portion of the lab, the instructor would tell them which two chemicals to mix and how to test for the gas. The campers would

then perform the experiment and then the instructor would talk to them about what kind of gas was produced. This was repeated for all three reactions, each producing a different gas. During each of the talks about the gas produced, there were signs of disciplinary engagement when the instructor asked questions and the campers responded. An example of this is given in the excerpt below. The instructor asked what the campers saw when they tested for oxygen.

8.30, clip 2 of 3.

- 1 Instructor: Can somebody tell me what they saw when they did that?
- 4 (Campers 3, 7, 10, put up hands)
- 5 Instructor: Okay, uh. (Points to camper 10)
- 6 Camper 10: Um, when I lit the, um stick, when I put in [the test tube], like I blew it
- 7 out then I put it in, it re lit.

This is a good example of disciplinary engagement because Camper 10 was reporting what he or she saw during the experiment. There were other similar instances of disciplinary engagement similar to this during the various discussions about the gases.

In this lab there were six instances of productive disciplinary engagement that could be easily identified. All of the excerpts are shown below.

This first example of productive disciplinary engagement occurred after the reaction that produced oxygen. The instructor wants the campers to figure out what gas was produced, but first he had to get them to figure out that a gas was produced.

9.25, clip 2 of 3.

- 1 Instructor: Do you guys know a chemical that helps makes things burn?
- 5 Instructor: ... when you're making bubbles in there, what do those bubbles tell us we
- 6 are making?
- 7 Camper 9: Gas

Camper 9 is showing a sign of productive disciplinary engagement because he or she is relating bubbles being produced to a gas being formed, which was something discussed in the spot plate portion of the chemical reactions lab. This camper is relating something he or she learned in the previous portion of the lab to what is being seen now.

In this next excerpt, there are two instances of productive disciplinary engagement shown by different campers. This conversation occurred after the campers made and tested for carbon dioxide.

13.10, clip 2 of 3.

- 1 Instructor: So you saw bubbles, didn't you?
- 2 (Many campers say yes)
- 3 Instructor: So there was a gas in there. Was the gas oxygen?
- 4 Camper 5: No!
- 5 Instructor: No, it wasn't or else it would have burned more right? So was it something
- 6 that stops fire maybe?
- 7 Camper 7: Yeah.

Camper 5 is definitely showing a sign of productive disciplinary engagement here because he or she is relating what happened in this experiment to what happened in the previous one. The previous one produced oxygen, which re-lit a glowing splint. In this reaction, the gas made the fire go out so oxygen must not have been produced. Camper 7 is also showing a sign of productive disciplinary engagement because he or she is relating what they observed in the reaction to the properties of the gas produced.

The following excerpt is similar to the first example of productive disciplinary engagement in this lab because Camper 7 is also making the connection between bubbles forming and a gas being produced.

18.28, clip 2 of 3.

1 Instructor: (points to jar [containing the reaction]) What do bubbles tell us?

- 2 Camper 7: Carbon dioxide.
- 3 Instructor: No, could have made...
- 4 Camper 7: (Cuts off instructor mid-sentence) Gas!

Even though another camper already answered a similar question earlier in the lab, Camper 7 is still showing signs of productive disciplinary engagement. The camper answers the question first with carbon dioxide (line 2) relating it to one of the previous reactions. When the camper is told that the answer is wrong, he or she is then able to relate bubbles being produced to the production of a gas, just like he or she saw in the previous reactions.

The next incidence of productive disciplinary engagement occurred after the instructor made some hydrogen explode after collecting it in jar.

19.04, clip 2 of 3.

- 1 Instructor: what does that tell us about the gas in there?
- 2 Camper 5: That it's....flammable?
- 3 Instructor: Exactly! Is it a little bit flammable?
- 4 Camper 5 shakes head

Camper 5 is definitely showing a sign of productive disciplinary engagement because he or she was not told that the gas was flammable beforehand. This camper was able to relate an explosion to something being flammable based only on previous knowledge.

The final example of productive disciplinary engagement during this lab occurred after the campers found out that the flammable gas was hydrogen.

0.05, clip 3 of 3.

1 Instructor: So what do you think the fuel was in the space shuttle?

2 Camper 7: Wha?

3 Instructor: That big thing that flew off to space, but doesn't go anymore. They had two 4 big canisters and they mixed them together and lit them on fire. What do you think

- 5 they were mixing there?
- 6 Camper 5: Hydrogen.

Productive disciplinary engagement is being shown here by Camper 5 since he or she is relating what they saw during the experiment to a real life application.

Overall, this lab was very engaging. The campers all showed signs of disciplinary engagement during the entire lab. There were also many examples of productive disciplinary engagement found, which is promising since these instances can be difficult to find.

#### **Salmon Dissection**

The campers were eager to participate in this lab and they were paying attention the whole time. The only exception was one camper who did not participate in the lab at all because he or she was uncomfortable with doing a dissection. This camper was allowed to sit out and this camper was not included in the video analysis. This could be considered a lack of engagement, but under the circumstances it was not considered when measuring engagement during this lab.

There were lots of questions during the dissection and the campers were excited for the entire time. Campers often looked at other groups' salmon to compare it to theirs and see "cool things" that others may have found. This would definitely be an example of disciplinary engagement, since the campers are getting very involved in the lab. Disciplinary engagement was also evident during some of the discussions between the instructor and campers throughout the dissection. A great example of this was when the instructor was getting the campers to think about what external parts of the salmon were different from people and if there is anything that salmon and people have in common. Many of the campers got involved in the discussion which is transcribed below.

8.00, clip 1 of 2.

1 Instructor: Is there any parts on there that people don't have?

- 2 Camper 5: Uh yeah lots.
- 3 (Camper 8 raises hand)
- 6 Instructor: (Points to camper 8)
- 7 Camper 8: Fins.
- 8 Instructor: Fins, yeah. (Points to camper 6)
- 9 Camper 6: Scales.
- 10 Instructor: Scales. (Points to camper 3)
- 11 Camper 3: Tail.
- 12 Instructor: Tail, that's a fin yup. (Points to camper 10)
- 13 Camper 10: They're different mouthed
- 14 Instructor: They're different, their mouth is kinda different yup. (Points to camper 8)
- 15 Camper 8: Gills
- 16 Instructor: Gills, do people have gills?
- 17 Camper 5: No!
- 18 Instructor: Nope. Okay so is there anything on the outside of this fish, when we look
- 19 at it, that people might have?
- 20 (No campers speak or raise their hands.
- 21 Instructor: That are the same as people. Hands please.
- 22 Camper 7: Skin
- 23 Instructor: They have skin, yes people have skin

This is an excellent example because six of the campers are all participating in the conversation. Disciplinary engagement was shown here because the campers are comparing a fish to what they know about people.

Only one example of productive disciplinary engagement was found in this lab, but it is one of the best examples. This occurred when campers first opened the salmon and found the eggs (female) or milt (male) inside, transcribed below.

28.20, clip 1 of 2.

1 Camp Helper: Oh that's a female! (Points to Camper 5 and Camper 8's salmon).

- 2 Camper 5: Ours is a female.
- 3 Camper 8: How do you tell?
- 4 Camper 5: Because of the eggs.
- 5 Main Instructor: Now look at this. You guys have one with white stuff (points to one
- 6 group's salmon) and this one as red stuff. (Points to demonstration salmon).
- 7 Main Instructor: What's different? This one's got these lumpy red things (pointing
- 8 to eggs in demonstration salmon) and that one's (points to one group's salmon) got
- 9 smooth white stuff. So have a look around. Look at that one (points to a different
- 10 group's salmon).
- 11 (Campers move about the room. Looking at the salmon at each table.)
- 12 Camper 8: We have a female
- 13 Main Instructor: (Points to Camper 8's salmon) That is a female with eggs. These
- 14 (points to two male salmon) are males with milt.
- 15 Camper 7: Where's the eggs? (walks over to Camper 8's salmon)
- 16 Camper 8: These are eggs (shows Camper 7 the eggs).
- 17 Camper 5: (Walks over to another group) Let's see yours, is yours a female?
- 18 (looks) Nope. (Looks at different salmon) No. There's only two females.

In this instance of productive disciplinary engagement, Campers 5, 7, and 8 were able to compare their salmon and talk about the differences. This is a positive outcome because it shows that the campers really learned about this difference between male and female salmon

Overall, all of the participating campers were excited about the salmon during the whole lab. They discussed their salmon with fellow group members and with the instructors. The campers seemed the most excited during this lab, but it did not show the most productive disciplinary engagement.

# **Investigating Pond Invertebrates**

The campers were well engaged in this lab, but more so during the actual activity; not every camper was engaged during the pre-lab talk. This lab required lots of equipment so there was a bit of distraction during the pre-lab talk due to the amount of items on the table. Some campers showed signs of disciplinary engagement during the pre-lab talk. They were able to answer questions about insects based on knowledge they had from previous experience outside of camp. An example is given below from the pre-lab talk. The instructor is in the process of drawing an insect on the board and is asking the campers about insect characteristics.

4.00, clip 1 of 2.

- 1 Instructor: Do bugs have heads? (Draws head on chalkboard)
- 2 Many campers say yes.
- 3 Instructor: Then what?
- 4 Campers 5 and 10: Body
- 5 Camper 3: Yes
- 6 Instructor: Okay (draws body) we got eyes, a body. Do they have any other parts?
- 7 Camper 5: They have legs.
- 8 Instructor: Legs. So if we are looking at insects, how many legs do they have?
- 9 Camper 5: Six
- 10 Camper 3: Six
- 11 Instructor: Not eight?
- 12 Camper 5: No.
- 13 Camper 10: That's a spider.

Here, the campers are able to discuss insects based on their previous knowledge. I would categorize this as disciplinary engagement because they were not learning these facts during this lab. They were answering questions based on what they knew already.

There were not any outward signs of productive disciplinary engagement in this lab. I had originally categorized the following two examples as productive disciplinary engagement

because the campers were talking about the number of legs on an insect, which is something they talked about in the discussion transcribed above.

9.55, clip 1 of 2.

- 1 Instructor: Are they an insect?
- 2 Camper 5: Yes
- 3 Instructor: How do you know?
- 4 Camper 5: Because of the six legs.
- 5 Instructor: That would be a good indication.

12.30, clip 1 of 2.

- 1 Instructor: (Draws eight legs on a drawing of a mayfly) Is that right?
- 2 Camper 10: No.
- 3 Instructor: It's not right. A mayfly's an insect. Too many legs right?

When I first looked at these transcriptions alone, I thought they were examples of productive disciplinary engagement. However, when looking back at the previous transcription talking about insect morphology, I realized that the campers talking in that excerpt were the same as in the two excerpts above. This means that they already knew that an insect has six legs before the lab, since they were talking about it in the opening discussion. Therefore, these two above excerpts are examples of disciplinary engagement rather than productive disciplinary engagement. This demonstrates that finding examples of productive disciplinary engagement can be very difficult since it is difficult to collect evidence that indicates it is occurring.

Once the pre-lab talk was completed, the campers were all engaged in their invertebrate activity. They showed signs of disciplinary engagement in various ways such as using an insect information sheet to figure out what kind of insects they found. Even though this lab did not show any outward signs of productive disciplinary engagement, the campers were very enthusiastic and engaged during the activity.

# **Engagement During Exhibit Room Activities**

### **Pulleys**

The pulley activity was the most engaging of the three exhibit room activities studied. Every camper went to this activity at some point during the three sessions spent in the exhibit room. One camper went to the activity twice. Campers worked with the activity alone or with one other camper. There were nine instances when campers were at the pulley activity. Of these nine instances, one of them was categorized as engagement, two were disciplinary engagement, and six were productive disciplinary engagement.

The one instance of simple engagement was categorized as such because the camper only read the directions but did not try the activity. Reading the directions shows they were engaged, but not actually trying the activity means they did not interact with the activity fully and were not, therefore, showing signs of disciplinary engagement.

In both of the examples of disciplinary engagement, the campers just pulled all three strings at once. Doing this could potentially lead the campers to realize that changing the number of pulleys in the system also changes the distance the string must be pulled. However, it did not appear from the videos that these campers were making this connection since they were only there for a brief period. There was no evidence to demonstrate learning was occurring, which is why these interactions were not categorized as productive disciplinary engagement.

Two of the examples of productive disciplinary engagement involved campers working together at the activity while the remaining four involved a camper trying the activity alone. In both of the instances when campers were working together, one of the campers demonstrated that they figured out which pulley system was easier to pull because they told the other camper. The second camper would either try the second pulley to see for his or herself or watch the first camper compare the two. Both campers in each situation are

showing signs of productive disciplinary engagement since they both understand the concept by the end of the interaction.

When productive disciplinary engagement occurred while the camper was working alone, the first thing each camper figured out was which pulley was easiest to lift. In three of the four instances, the campers appeared to figure out the connection between the ease of lifting the load and the length the string must be pulled. In the other instance, it was hard to tell if the camper understood this connection.

## Lever

Five of the campers went to the lever activity during the exhibit room sessions. Three campers interacted with the activity on their own and there was one instance of two campers working together. All four of these instances can be categorized as productive disciplinary engagement. By the time the campers were finished interacting with the activity, they had made the lever balance, which shows they understood the concept of the activity.

The best example of productive disciplinary engagement occurred when one of the campers was able to make the lever balance by putting weights at different distances from the pivot. This shows that the camper really understood the concept since he or she was doing more than just placing the weights at the same distance on each side of the pivot.

## Mirrors

The mirror activity was definitely the least engaging of the three exhibit room activities studied. Only two campers went to the activity, and one of them only looked in the mirror and then left. This instance would be categorized as engagement because the camper looked at the activity, but did not do anything with it. In the second instance, the camper did move the mirror and the object. However, the camper got distracted by another camper and left the activity. I would categorize this as disciplinary engagement because it cannot be determined for certain if the camper understood the concept since I do not know what they are thinking.

# **Relating Engagement to Questionnaire Answers**

## Labs

Of the many instances of productive disciplinary engagement observed during the labs, only three of them could be related directly to a specific question on the content knowledge portion of the questionnaire. All three of these instances occurred during the chemical reactions lab and are transcribed fully in Appendix F. Instances one and two both involve campers relating the formation of bubbles to the production of a gas, which is the basis of question five on the content knowledge portion of the questionnaire (Appendix D). In both cases, the campers got this question right on the pre- and post-camp questionnaire.

Instance three involved a camper connecting the observation that hydrogen is explosive to what kind of gas might be used to fuel the space shuttle. This camper was able to connect the explosive nature to the practical use of hydrogen as fuel. The camper involved must have understood that hydrogen was explosive, which was the basis of question 2 on the content knowledge portion of the questionnaire (Appendix D). However, the camper got the question right on the pre-camp questionnaire, but surprisingly then got it wrong on the post-camp questionnaire.

These results found when comparing instances of productive disciplinary engagement to questionnaire answers are summarized in Table 7.

Table 7. Summary of results found when comparing instances of productive disciplinary engagement during labs related to content knowledge questions to questionnaire answers.

Instanc	Camper	Lab	Associated Content	Pre-	Post-
e	Involve		Knowledge Question	Camp	Camp
	d			Answer	Answer

1	9	Chemical	5	Correct	Correct
		Reactions			
2	7	Chemical	5	Correct	Correct
		Reactions			
3	5	Chemical	2	Correct	Incorrect
		Reactions			

# **Exploration Room Activities**

In the exploration room portion of the video recordings, ten instances of productive disciplinary engagement were observed. Four of these instances occurred while a camper was interacting with the lever activity while the remaining six instances occurred with the pulley activity. The instances are transcribed in chronological order in Appendix G.

Two of the content knowledge questions on the questionnaire were based on the lever activity, so pre- and post-camp answers could be compared for each camper who showed productive disciplinary engagement while interacting with the lever. Both of these questions were asking whether the lever pictured was balanced or not (Appendix D).

There were also two questions about the pulley activity in the questionnaire, but they were on slightly different topics relating to the pulley activity. Question 12 on the content knowledge portion (Appendix D) asks which block would be easier to lift based on the pulley system pictured. In each instance of productive disciplinary engagement involving the pulleys, the campers appear to understand which pulley system makes it easier to lift the load. Therefore, I can compare the pre- and post-camp answers to this question for campers involved in each instance. Question 13 on the other hand, asks whether the number of pulleys changes how far you need to pull the string. I only compared pre- and post-camp answers on this question for the campers who appear to investigate this concept during the instance of productive disciplinary engagement. Results of the comparison of pre- and post-camp content knowledge answers to instances of productive disciplinary engagement are summarized in Table 8.

Table 8. Summary of results found when comparing instances of productive disciplinary engagement at exhibit room activities to content knowledge questionnaire answers.

Instance	Camper(s) Involved	Activity	Associated Content Knowledge Question(s)	Pre-Camp Answer	Post-Camp Answer
1	3	Pulley	12	Incorrect	Incorrect
1	5	Pulley	12	Incorrect	Correct

2	8	Lever	10	Correct	Correct
			11	Correct	Correct
3	10	Pulley	12	Incorrect	Correct
3	11	Pulley	12	Incorrect	Correct
4	10	Lever	10	Incorrect	Correct
			11	Incorrect	Incorrect
4	2	Lever	10	Incorrect	Correct
			11	Incorrect	Incorrect
5	1	Pulley	12	Incorrect	Incorrect
			13	Incorrect	Correct
6	8	Pulley	12	Correct	Correct
			13	Correct	Correct
7	1	Lever	10	Correct	Correct
			11	Incorrect	Incorrect
8	9	Lever	10	Correct	Correct
			11	Correct	Correct
9	9	Pulley	12	Incorrect	Incorrect
			13	Correct	Correct
10	4	Pulley	12	Incorrect	Incorrect
			13	Incorrect	Incorrect

As shown in the summary table (Table 8), none of the instances of productive disciplinary engagement resulted in a camper who answered the pre-camp question correctly, then answering the post-camp question incorrectly. There were six occurrences of a camper answering the pre-camp question wrong and then getting the post-camp question right. However, there were eight occurrences when the camper answered the question wrong on both the pre- and post-camp questionnaire. Campers answered the question correct on both the pre- and post-camp questionnaire during seven occurrences.

# DISCUSSION

#### Questionnaire Answers by the Group as a Whole

The results of the questionnaire showed that the campers' science knowledge increased after attending the camp. This was true for both the lab based questions and the exhibit room based questions. I expected this to happen based on my previous experience working with campers at the Science Centre. Learning is happening during the course of the camp.

The scores for lab-based questions were higher than scores for exhibit room based questions. After observing the entire camp, this makes sense. The lab portions of the camp are structured and similar to a classroom setting. Information is presented to the campers in the pre-lab talk and then they get to do an experiment based on the information given. In this situation the information is presented in more than one way which is beneficial for children with different learning styles (Mayer 1997). The labs also include very specific learning outcomes, which the campers can use to direct their learning. This contrasts with the exhibit room sessions, in which campers are free to complete activities as much or as little as they want. Learning is less directed in this situation and campers may not always be as focused.

Changes in scores from pre-camp to post-camp were not different when comparing the lab questions to the exhibit room questions. This demonstrates that the two types of activities offer potential for learning.

In the attitudes portion of the questionnaire, the children's scores did not change. This surprised me at first because it seems logical that attending a science camp should cause children to have a more positive attitude towards science. However, when looking back at the original questionnaire answers, the attitude scores were highly positive to begin with. After further thought, these results make sense. These children are between the ages of eight and eleven. This is a time when parents or guardians may give their children a choice of what they want to do during the summer. The campers most likely aren't attending camp because their parents or guardians are forcing them to, but because they want to be there. If the kids

want to attend a science camp during the summer, it is highly likely that they already have positive attitudes towards science.

When looking at some of the attitude questions individually, one question did show a more positive attitude after the camp. This question was "I enjoy doing experiments with a chemical reaction". Attitudes may have shown improvement for this question because there were many labs involving chemical reactions and the campers had lots of opportunities to see what a chemical reaction really is. They may not have known what is considered a chemical reaction before the camp or they may not have been exposed to chemical reactions in a fun and interactive way.

#### Questionnaire Answers When Separated by Gender

Once the girls and boys were analyzed separately, there were some trends that emerged. The girls showed all the same trends as the group as a whole. For example, the girls showed an increase in lab scores after attending the camp, which was also found when looking at the camp group as a whole. The boys, however, showed somewhat different trends. None of their content knowledge scores showed a significant change. No change was shown in the exhibit room scores, lab scores, or in the content knowledge scores as a whole. However, their attitudes did improve significantly, unlike the girls or the group as a whole. These results may seem surprising at first, but they should be reviewed with caution. The sample size in this experiment is low, which may reduce the power of the. When looking at the boys alone, there are only five scores being analyzed. This low sample size could have skewed the results. To find out if these trends in the boys are valid, future experiments could be done that have a higher sample size.

I was hoping to find that there was no difference between scores of boys and girls because it would reinforce the idea that gender does not influence a child's ability to learn (Spelke 2005). This result was found for most of the comparisons between boys and girls, but not for all. Boys were shown to have higher pre-camp exhibit room scores and higher total pre-camp content knowledge scores than the girls. As with the analysis of the boys alone, these results

need to be analyzed closely. Again, future studies could be completed with a higher sample size to see if these results are a trend or just an artifact of the small sample size.

The attitudes of the boys did not differ from the girls either before or after the camp. Both genders showed highly positive attitudes towards science.

#### Questionnaire Answers When Separated by Grade

The primary campers (entering grade 4 or homeschool) did not show a difference in scores for any of the comparisons. This is somewhat surprising because it shows that the younger campers did not significantly increase any of their scores. Once again, there were only five campers in this category so the small sample size may have explained why the primary campers did not follow the general trend of the camp.

The intermediate campers (entering grades 5 and 6) showed almost the same results. Most of their scores did not significantly change after attending the camp. Lab scores were the only ones that showed an increase on the post-camp questionnaire. If the sample size had been higher (here, n = 6), the changes in scores may have been statistically significant.

When comparing the primary campers to the intermediate campers, there were no differences shown in their scores. This surprised me a bit, since I expected the primary campers to have lower scores than the intermediate campers, at least on the pre-camp questionnaire. I thought this originally because the intermediate campers simply have had more exposure to science in school. They have completed more of the elementary school curriculum than have the younger campers, so it would be reasonable to expect them to have higher pre-camp scores. However, it is definitely good to see that the post-camp scores did not differ because that means the camp allowed the campers to get to the same level regardless of their age and how much science they have completed in school.

## **Questionnaire Short Answers**

The short answer questions on the questionnaire were included more for curiosity than for analysis purposes. It was encouraging that all but one of the responses to "Can you give an example of using science in everyday life?" were good examples. Only six of the campers responded to the question on the pre-camp questionnaire and seven responded on the post-camp questionnaire. An increase of one response is significant because it shows the camp may have at least got the child thinking about science in everyday life. However, it was disappointing that all the campers did not give an answer on the post-camp questionnaire.

For the question "Can you give an example of a science experiment you have done before?" more campers responded. On the pre-camp questionnaire, ten of the eleven campers wrote an answer. Seven of the responses were good examples, whereas only three were either a bad example or stated they had not done a science experiment before. For the post-camp questionnaire, only nine campers responded to the question. This response rate is still significant, but it was disappointing that not all of the campers responded. Again, the post-camp questionnaire had seven good responses. There were only two responses that were not an example of an experiment. This is important because one less camper gave an example that was not correct.

## **Engagement During Labs**

Based on the results, it is hard to determine which lab showed the highest amount of engagement. There are many components to consider when trying determining the engagement level displayed by students in the labs.

For each of the four labs, all of the campers eventually got to the point of disciplinary engagement. Each of them participated in the lab and completed the activities, with the exception of the single camper during the salmon lab who chose not to participate. When looking at the ability for the labs to foster participation in science, all the labs are equal. If I look at each lab's ability to enable science dialogue, it is also hard to pick a single lab that is the best. Each lab included a pre-lab talk and most included a post-lab talk. This suggests that all the labs have equal opportunity to enable science dialogue between the campers and the instructor. However, not all the campers participated in the conversation during these lab talks. Here, I do not mean some campers were not paying attention or engaged in the talks. Some of the campers simply did not reach the level of disciplinary engagement by answering questions in these lab talks, which is not necessarily an issue with the lab itself. Some campers are shy and less willing to answer questions out loud, while others are very extroverted and love contributing to the conversation.

The salmon dissection and pond invertebrates lab both showed lots of camper participation during the pre-lab talk as well as during the activities. The chemical reactions lab had little participation during the initial pre-lab talk, but during the talks throughout the lab, many campers were participating in science dialogue. Investigating pH showed the least science dialogue of the four labs. This may be attributed to the complexity of the topic, since pH may not be something the campers have been exposed to before. The pH lab was also the first activity of the camp so campers may not have been fully comfortable with the group yet and, therefore, may have been less willing to participate in group discussions. When it comes to fostering science dialogue, I would consider the chemical reactions lab, salmon dissection, and pond invertebrates lab to be equal during this camp situation. It is important not to make generalizations because though the pH lab may not have created as much science dialogue compared to the other labs, but it is still a vauluable lab. If this lab had been conducted with campers who had more experience with pH, there may have been more science dialogue occurring. Having this lab occur later on in the camp might also have increased the level of science dialogue associated with it because the campers were then comfortable with each other and the instructor.

If I were to look at the number of instances of productive disciplinary engagement in each lab, it is easy to pick which one is the most engaging. The chemical reactions lab showed six instances of outward productive disciplinary engagement while the pH lab and salmon dissection each had one, and the pond invertebrates lab had none. Based on these results, it would be easy to say that the chemical reactions lab is the best because it showed the most instances of productive disciplinary engagement. However, it is not this simple. As stated previously, it is very difficult to categorize productive disciplinary engagement and it is also difficult to catch these events on film. I do not know what the campers are thinking so it was impossible to know if they had an "aha!" learning moment unless they showed it outwardly. Therefore, I do not think it is appropriate to rank the labs based on the number of instances of productive disciplinary engagement seen since this may not accurately measure the ability of the lab to engage campers. In fact, the chemical reactions lab may simply have had more chances for the campers to show instances of productive disciplinary engagement. This might be attributed to the flow of this lab. The instructor would explain what to do, the campers did the activity, everyone talked about the activity, and then they moved on to the next portion of the lab. This may foster outward signs of disciplinary engagement because the campers have a chance to discuss what happened in the lab right after they complete the activity.

Considering all these factors involved in engagement in the labs, I would say that all the labs are equally engaging. Each of the labs engaged the campers in the activity at hand which is important. Some of the labs had more science discussions or instances of productive disciplinary engagement than others, but these factors may not be powerful at predicting the total engagement during a lab. It is important to stress that the results of this study do provide insight into this specific camp, but not everything found during the study will result in an overarching conclusion about the Science Centre or science camps in general.

## **Engagement During Exhibit Room Activities**

When it comes to the exhibit room activities, I think it is a bit easier to comment on the engagement level associated with each activity. It is easier to determine if a camper is having a moment of productive disciplinary engagement while interacting with these activities because they have very specific learning outcomes.

The pulley activity was the most engaging of the three activities studied. All of the campers interacted with this activity and it was the only activity that a camper went to twice. This activity also had six instances of productive disciplinary engagement, more than the other two combined.

Engagement in the lever activity was lower than in the pulley activity based on the fact that only 5 campers interacted with it. However, all of the interactions showed signs of productive disciplinary engagement. This can be compared to the pulley activity for which had three of the nine interactions did not show signs of productive disciplinary engagement.

It is clear that the mirror activity was the least engaging of the three chosen. Only two campers went to the activity at all and none of the interactions with the activity showed signs of productive disciplinary engagement. This does not surprise me, since this activity is smaller and more inconspicuous than the other two, so campers often pass it by. In my previous experience at the Science Centre, I have noticed that this activity is not often completed often despite its useful learning outcomes. Also, the topic of this activity is more advanced than the other two, which may have contributed to the campers' lack of interest.

#### Comparing Productive Disciplinary Engagement to Questionnaire Answers

The results of comparing instances of productive disciplinary engagement to specific questions on the questionnaire are somewhat unexpected. For the three instances of productive disciplinary engagement during the chemical reactions lab, none of them resulted in a camper going from an incorrect answer to a correct answer. In instance 3 (Table 7, Appendix F), the camper got the question correct on the pre-camp questionnaire but incorrect on the post-camp questionnaire. This might mean that the camper was guessing the answer to the question or did not read the question properly. As for instances 1 and 2 (Table 7, Appendix F), during the lab the campers got the answer correct on the pre- and post-camp questionnaire. This makes me wonder whether the campers were actually showing productive disciplinary engagement since it appears they already knew the answer before starting.

For the exhibit room activities, a greater proportion of the instances of productive disciplinary engagement coincided with a camper changing their response from an incorrect answer on the pre-camp questionnaire to a correct answer on the post-camp questionnaire. However, this still did not occur in a majority of the cases. In only six out of the twenty-one cases of productive disciplinary engagement did the camper change their answer from incorrect to correct on the questionnaire. For the remaining fifteen instances of productive disciplinary engagement, comparisons of pre- and post-camp questionnaire showed no changes in answers. Campers either got the answer correct or incorrect on both the pre- and post-camp questionnaires. For those instances where the camper already had the correct answer on the pre-camp questionnaire, we would not be expecting a change in response on the post-camp questionnaire.- However for those instances where the camper had the answer incorrect on both pre- and post – camp questionnaires this brings up the question of whether these campers were actually showing signs of productive disciplinary engagement during these occurrences. Perhaps some of the interactions that were categorized as productive disciplinary engagement were incorrectly labeled. It is hard to determine if the campers got the question wrong on the post-camp questionnaire because they were not learning anything from the interaction, or if they forgot what they learned by the time they answered the postcamp questionnaire. This conundrum further demonstrates that it is very difficult to observe and categorize instances of productive disciplinary engagement. This is mostly due to the fact that I do not know what the children are actually thinking. I can only pick out instances of productive disciplinary engagement if a child says something outright. Children do not necessarily say something out loud every time they learn something new. The learning may be occurring in their head so I cannot see it.

However, it should be pointed out that even though only six of the twenty-one instances categorized as productive disciplinary engagement resulted in an incorrect answer going to a correct answer, it is significant that there were no cases when a correct answer resulted in an incorrect answer after interacting with the activity. This indicates that even though not all the interactions necessarily directly resulted in learning, they never hindered learning or reversed

what was previously learned. These results can help reinforce that these kinds of activities set up a positive learning environment.

# **FUTURE WORK**

Though the results of this study were good, there is certainly more work that could be done in the future. This study could act as a model for future studies relating to the topic of hands-on learning during summer science camps, or these methods could even be used to study other hands-on learning environments.

Subsequent studies with the same design could be conducted in order to increase the sample size and therefore produce more powerful results. More studies could be done looking at the same camp at this particular science centre that I looked at in this research project. Future work could also incorporate participants from other camps at this particular science centre. Science camps at other locations could also be looked at to help build a larger sample size.

More work can also be done with the data collected for this study. Due to time limits, I was not able to analyze the videos in as much depth as possible. In the future, the video recordings could be analyzed further. Things like number of instances of students asking questions or length of dialogue between students and the instructor could be measured. Since the methods I used for determining instances of learning (by picking out instances of productive disciplinary engagement and comparing those to questionnaire answers) did not really work out, these methods could be modified. Instead of working from the instances from the videos to the questionnaire, future researchers could look for changes in questionnaire answers and then try to pick out the instance when that learning may have occurred. If this method appears to be more effective, it could be used in similar studies done in the future.

Future work could also compare the various activities in the exploration room at this particular science centre. Questionnaires and video recordings could be used to determine the

effectiveness of each activity as a teaching tool, how children interact with the different activities, and which activities children are drawn to first. This could help this science centre to determine what works in terms of these exploration room activities and what improvements or enhancements could be made. Similar work could also be done looking at various lab activities at this science centre to determine which lab formats work best. For example, length of pre- or post-lab talks could be related to children's learning during the activity.

Finally, future work could address the notion mentioned in the discussion that children at camps are less focused during their time in the exploration room than visitors from the general public. It would be interesting to look at whether there really is a difference in the engagement and learning that occurs during public drop in visits versus camp time. Questionnaires and video recordings could be used in this kind of study in a similar way to how they were used in the current research project. If this research found that the exploration room activities are more effective when public drop in visitors are participating rather than campers, this could help give insight into how the exploration room could become a stronger learning environment during camps. Positive results from this kind of study could also help reinforce that these kinds of science learning centres are for learning and not just for fun alone.

# CONCLUSION

Overall, I believe the set up of science camps at the Science Centre is productive for learning. It is not expected that children will learn something from every learning opportunity provided at the camp. This is reflected in the diversity of answers to the content knowledge questions. The labs at this particular Science Centre are specially designed for fun and structured hands-on learning which is important for fostering a positive learning environment in the camp setting. Time in the exhibit room allows children to learn independently. This can also foster learning, but this learning style appears to be less effective in the camp setting. The campers did not increase their content knowledge for the exhibit room based questions as much as the lab based questions. I think this is a fair conclusion based on my previous experience working with camps at the Science Centre. The labs are very structured and the campers are told exactly what to do. This makes it easy for them to know exactly what they should be getting out of the activity. In contrast, time in the exhibit room during camp is when campers are more focused on having some fun free time than participating in science learning.

I want to stress that these conclusions are based on the camp setting alone. I do not want to devalue the exhibit room at the Science Centre. All the activities in the exhibit room are great tools for people to use when learning about science. I think if a similar study were to be conducted with people from the public coming to this Science Centre with the purpose of coming to the exhibit room, the results would be very different. It is likely that those people would show an increase in their content knowledge on topics based on the exhibit room activities since they would be focused on learning. Parents often accompany children to the exhibit room and discuss activities with the children. This is in contrast to the camp setting where the campers are more focused on fun in the exhibit room rather than learning science.

The results of this study provide insight into how well camps at the Science Centre are running. These findings may be applied to science centres and science camps as a whole since it was shown that, contrary to what others have suggested (Griffin 1994 and Johnston and Rennie 1994, both in Gardner 1994), learning does occur at science centres. I think The Science Centre should continue to expose children and adults alike to science in a hands-on fashion. This experience is effective in fostering science learning, which is important no matter what a person's past, present, or future holds.

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# APPENDIX A



**Thompson Rivers University** 

900 McGill Road Box 3010 Kamloops, BC V2C 0C8 Telephone (250) 828-5000

Dear parent/guardian,

By way of this letter I would like to introduce to you the research project that I am working on for my Honours thesis project entitled: *Investigating the effect of a summer science camp on elementary children's content knowledge and attitudes towards science*. I would like to ask your consent to allow your child to be a part of this research project.

I am a third year student completing an Honours degree in Biology (B.Sc.) at Thompson Rivers University. The purpose of my research is to investigate children's learning of science in a summer science camp. This research will help the science camp directors designing future summer science camps and it may help other camp directors in different locations develop their science camps as well.

In my research project I specifically want to find out how the kind of hands-on science learning that children do at the Big Little Science Centre science camp (Senior Science Camp – July 22- 26, 2013) helps them develop 1. Positive attitudes to science 2. Science content knowledge, 3. Science skills and process knowledge.

There are two parts to the research study:

- The first is a pre- and post- questionnaire that I would like your child to complete. The questionnaires should take no more than about twenty minutes for your child to complete. I will be giving the pre-questionnaire to the children on Monday morning July 22<sup>nd</sup>
- , before camp activities begin and the post- questionnaire on Thursday July 25<sup>th</sup> after camp activities are complete and before Friday, which is filled with preparations for parent joining us.
- The second part of the study is to observe your child's science activities at the camp by video and audio recording and observational notes.

The only people who will have access to the questionnaire are myself, Dr Rees and Dr Flood (my supervisors at TRU). After completion you child's name will be removed and replaced

by a number. The questionnaires will be kept in a private location in Dr Rees's office. The observational notes, video and audio recordings will only be viewed by myself Dr Rees and Dr Flood and will be stored securely in the office of Dr Rees at TRU for seven years as per TRU policy. All information will remain confidential. Students' names will not be used in any publications resulting from the study. A newsletter with a summary of the findings from the study will be sent to you upon the project's completion, but it will not include specific information on individual students.

If you decide that you do not want your child to take part there will be no negative effects for your child. If you decide to allow your child to take part and then later change your mind you can withdraw permission for your child to participate at any time. If you decide that you do not want your child to participate I will not include them in the video recording and audio recording and I will not take notes on your child's activities. Should you first decide to grant permission for your child to participate and then change your mind I will not use your child's work in the study and will not refer to the words or actions of your child in my research.

Thank you for your time and consideration. If you have any questions, please do not hesitate to call me at 250-819-6302 or email me at morrans10@mytru.ca. If you have any questions for my supervisor, Dr Carol Rees, you can contact her at 250-828-5004 or email her at crees@tru.ca. If you have questions regarding the conduct of this study please contact the Research Ethics Board at TRU Please keep this information letter for your records, and return the consent form provided in the next page.

Sincerely,

Spencer Morran Honours Biology Student Thompson Rivers University

# **APPENDIX B**



Thompson Rivers University

900 McGill Road Box 3010 Kamloops, BC V2C 0C8 Telephone (250) 828-5000

# Informed Consent for Minors by Parent or Guardian to Participate in a Research Project or Experiment

**Note:** The University and those conducting this project subscribe to the ethical conduct of research and to the protection at all times of the interests, comfort, and safety of participants. This form, and the information it contains, is given to you for your own protection and full understanding of the procedures, risks and benefits involved.

Having been asked by Spencer Morran (telephone number 250-819-6302) supervised by Dr Carol Rees (telephone number 250-828-5004) School of Education, Faculty of Human Social and Educational Development and Dr Nancy Flood (telephone number 250-828-5436) Faculty of Biological Sciences of Thompson Rivers University, to consent on behalf of (name of child) \_\_\_\_\_\_\_, to participate in a research project entitled: *Investigating the effect of a summer science camp on elementary children's content knowledge and attitudes towards science.* The purpose of the project is to investigate learning that occurs through hands on activities during a week-long summer science camp. The results of this research will give camp directors insight into how their science camps can improve. This knowledge can be used to make improvements on how camps are run to be sure the children are learning as well as having fun. Children will be asked to complete a questionnaire before and following the camp and some of their activities will be observed, video and audio recorded. This project is considered to be of minimal social, physical and emotional risk. Participants will be given a \$10 discount on the camp fees. I certify that I understand the procedures to be used. I have tried as fully as possible to explain the procedures to (name of child): \_\_\_\_\_\_\_ and to obtain the participant's consent. If the participant displays any sign of distress or reluctance to participate in any aspect of this research she/he will be asked if they would like to be withdrawn from the research procedure, and this will be brought to my attention.

I also understand that I may ask any questions or register any complaint I might have about the project with Spencer Morran (chief researcher), Dr Carol Rees (supervisor), Dr Nancy Flood (supervisor), or with Dr Charles Webber Dean of Faculty of Human, Social and Educational Development, TRU.

Copies of the results of this study, upon its completion, may be obtained by contacting Spencer Morran. The results will be presented at the TRU Undergraduate Conference in March of 2014. Results may also be submitted to an academic journal. Children's names will not be used for any public use.

Camp participants are not obligated to participate in the study. If you do not wish to have your child participate in the study, please circle "do not consent" below. Parents/Guardians who choose to allow their child to participate in the study can choose to participate in all aspects of the study (video, audio and questionnaire) or to participate in specific portions.

I **consent** / **do not consent** (circle one) that my child will participate in the study by completing the questionnaire and agreeing to be audio and video recorded.

as described above, during the period: July 22-26 2013, at The BIG Little Science Centre. NAME (Please print):

#### ADDRESS:
I have read and understood the above information regarding this project, voluntarily agree that my child can participate in the project and understand that I have the right to withdraw my consent at any time. I understand that the participant's identity and any information obtained will be kept confidential through the following processes: The questionnaires of each child will be assigned a number and will be identified by that number. Video and audio recordings will be viewed and listened to only by the research team in the office of Dr Carol Rees. Once the video and audio data has been analyzed, the files will be saved on USB keys and along with test scores and written observations, will be stored in a secure location in the office of Dr. Rees for seven years as per TRU policy. I have received a copy of this consent form and a participant feedback form.

I agree to have **audio** data collected of my child's participation in selected activites in summer science camp and will be used for research purposes only and will be destroyed by wiping USB keys clean after seven years as per TRU policy.

SIGNATURE: \_\_\_\_\_

DATE\_\_\_\_\_

**RELATIONSHIP TO PARTICIPANT:** 

I agree to have **visual** data collected of my child's participation in selected activites in summer science camp and will be used for research purposes only and will be destroyed by wiping USB keys clean after seven years as per TRU policy.

SIGNATURE: \_\_\_\_\_\_ DATE

**RELATIONSHIP TO PARTICIPANT:** 

I agree to have my child participate in the **questionnaire** portions of the study and the information collected will be used for research purposes only and will be destroyed by wiping USB keys clean and shredding written questionnaires after seven years as per TRU policy.

SIGNATURE: \_\_\_\_\_\_
DATE\_\_\_\_\_

**RELATIONSHIP TO PARTICIPANT:** 

# **APPENDIX C**



Thompson Rivers University

900 McGill Road Kamloops, BC V2C 0C8 Telephone (250) 828-5000

Dear Participant:

The Research Ethics Board would like to thank you for participating in this study.

**Participant Feedback Form** 

If you would care to comment on the procedures involved you may complete the following form and send it to the Chair, The University Research Ethics Board. Completion of this form is optional, and is not a requirement of participation in the project. All information will be treated in a strictly confidential manner.

Name of Principal Investigator: Spencer Morran supervised by Dr Carol Rees and Dr Nancy Flood.

Title of Project: Investigating the effect of a summer science camp on elementary children's content knowledge and attitudes towards science

Department: School of Education, Faculty of Human, Social and Educational Development and Faculty of Biological Sciences.

Did you sign an informed Consent Form before participating in the project?

Were you given a copy of the Consent Form? \_\_\_\_\_

Were there significant deviations from the originally stated purpose, procedures and time

commitment:

I wish to comment on my involvement in the above project which took place:

(Date)	(Place)	(Time)
Comments:		
Is it permissible for the Research E	Cthics Board to contact you regarding this form?	Yes
Completion of this section is opti	onal	
Your Name:		
Address:		
Telephone:		

This form should be sent to Chair, Thompson Rivers University, Research Ethics Board, 900 McGill Road, TRU, Kamloops, B.C. V2C 0C8

# **APPENDIX D**



Thompson Rivers University 900 McGill Road Box 3010 Kamloops, BC V2C 0C8 Telephone (250) 828-5000

As discussed with your parents/guardian, you have been asked to complete this questionnaire by Spencer Morran an Honours Biology at Thompson Rivers University for her study entitled *Investigating the effect of a summer science camp on elementary children's content knowledge and attitudes towards science*. Your parents/guardian has allowed you to participate in this study. The questionnaire is short and should take less than 20 minutes. When you have finished completing the questionnaire, please give it to Spencer Morran who will keep it in a safe place where only the researchers will see it. Your name will be removed from the questionnaire so no one will know who you are.

Child's Name			
Age Grade a	s of September 2013	Gender	
Have you visited the B	IG Little Science Ce	ntre before during sc	hool time? $\Box$ Yes $\Box$ No
If Yes, how many time	s? Dust once	☐5 times or less	☐More than 5 times
Have you visited the B	IG Little Science Ce	ntre outside of schoo	l time? 🗆Yes 🗆No
If Yes, how many time	s? Dust once	☐5 times or less	☐More than 5 times

If Yes, please list the camp(s) you have attended.							
Have you been to a EUREKA	! Scien	ce camp	before	?		□Yes	□No
Have you been to another scie	ence car	np befo	re?			□Yes	□No
Do you attend Bert Edwards S	School o	of Scien	ce and '	Fechnol	ogy?	□Yes	□No
In scho	ol I hav	e done s	science	experin	nents of	ten.	
Strongly Disagree	1	2	3	4	5	Strongly Ag	ree
Ins	school I	never d	lo scien	ce expe	riments		
Strongly Disagree	1	2	3	4	5	Strongly Ag	ree
In school I learn science from books.							
	1	2	2	4	~		
Strongly Disagree	1	2	3	4	3	Strongly Ag	ree
In school I learn science from watching videos.							
Strongly Disagree	1	2	3	4	5	Strongly Ag	ree

Visits to the BIG Little Science Centre were the only time I learned science during the school year.

Strongly Disagree	1	2	3	4	5	Strongly Agree
		<u>A</u>	<u>ttitude</u> :	<u>s</u>		
	Scienc	e is im	portant	in daily	life.	
Strongly Disagree	1	2	3	4	5	Strongly Agree
	I enjoy	doing	science	experin	nents.	
Strongly Disagree	1	2	3	4	5	Strongly Agree
	I enj	oy read	ing abo	out scien	ce.	
Strongly Disagree	1	2	3	4	5	Strongly Agree
I enjoy watching science shows on TV.						
Strongly Disagree	1	2	3	4	5	Strongly Agree
I enjoy doing experiments with a chemical reaction.						
Strongly Disagree	1	2	3	4	5	Strongly Agree

I enjoy learning about bugs.						
Strongly Disagree	1	2	3	4	5	Strongly Agree
I enjoy learnin	g about	science	and do	ing exp	eriments	s outdoors.
Strongly Disagree	1	2	3	4	5	Strongly Agree
	I enjoy	learning	g how tl	nings wo	ork.	
	i enjoj		5			
Strongly Disagree	1	2	3	4	5	Strongly Agree
I enjoy learning about animals.						
Strongly Disagree	1	2	3	4	5	Strongly Agree
I want to be a scientist when I grow up.						
Strongly Disagree	1	2	3	4	5	Strongly Agree
I do not want to be a scientist when I grow up.						
Strongly Disagree	1	2	3	4	5	Strongly Agree

When I am older,	I would like to take	more science classes.
------------------	----------------------	-----------------------

Strongly Disagree 1 2 3 4 5 Strongly Agree

Can you give an example of using science in everyday life?

Can you give an example of a science experiment you have done before

(Circle the Answer You Think is Correct)

1. Is vinegar an acid, a base or neutral?

Acid Base

Neutral

2.	Which of these	gases will cause	an explosion?
----	----------------	------------------	---------------

3. Which of these gases will re-light a fire that has been blown out?

Oxygen

Hydrogen Carbon Dioxide Oxygen

4. If you mix two things together and there is a colour change, is a chemical reaction happening?

Yes No

5. What is being made if you mix two chemicals together and see bubbles?

Solid Gas Nothing Special

6. Why don't fish chew their food?

They are rude They Don't Want To Lose Any They Don't Have Teeth

7. Which body parts do fish and humans NOT have in common?

Blood Lungs Heart Mucus/Slime Liver

8. Which of these creatures is an insect?



9. Which set up will show more red pegs in the mirror?





10. Is this lever balanced?



Yes No

11. Is this lever balanced?



No

12. Which block will be easier to lift?



13. When using pulleys to lift a block, does the number of pulleys used change how far you need to pull the string?

Yes No

# **APPENDIX E**

## pH Lab

In this lab the students learn about the pH scale and what acidic, basic, and neutral mean. They are given various chemicals and allowed to test the pH of each one. A piece of litmus paper is placed in each well of a spot plate. Students then add three drops of a chemical to a well on the spot plate. The litmus paper changes colour depending on how acidic or basic the chemical is. Students are given a chart with all the possible colours of the litmus paper with its corresponding number on the pH scale. The students compare what their litmus paper looks like to the chart to see what the pH is. They write down the pH for each chemical and determine if it is acidic, basic, or neutral.

### **Chemical Reactions Lab**

In this lab the students learn about what a chemical reaction is and what some signs are that a chemical reaction has occurred. This lab consists of two parts. The first part has the students mixing two chemicals together in the well of a spot plate. Two drops of each chemical are added to the well and the students observe what happens. They write down their observations and determine if a chemical reaction has occurred and how they know. In the second part of this lab the students used chemical reactions to make gases in a test tube and they then test what kind of gas was made. The first gas they make is carbon dioxide which is created by mixing acetic acid (vinegar) and sodium bicarbonate (baking soda). They test for the carbon dioxide by lighting a splint on fire and putting it into the test tube which will cause the splint to stop burning. For the second gas the students mix hydrogen peroxide and yeast to produce oxygen. To test for oxygen the students light a splint and then blow it out so there are just embers left. When they put the glowing splint into the test tube the splint will reignite because oxygen provides fuel for the fire. The last gas they make is hydrogen by mixing calcium metal and water together. This gas is tested for by lighting a splint and putting it into the test tube. Hydrogen is explosive so the flame will cause the hydrogen to explode with a loud pop.

### Salmon Dissection

In this lab the students work in groups of three or four and dissect a salmon. The instructor goes through the external morphology of the salmon first and then walks the students through the entire dissection. Internal organs such as the stomach, gills, liver, kidneys, and spleen are

observed. The brain is hard to get to so the instructor finds the brain on their own fish as a demonstration for the whole group.

## **Investigating Pond Invertebrates**

This lab begins with a discussion of what an insect is and what an invertebrate is. The instructor discusses the kinds of things the students may see during the lab. Groups of four students share a bucket of pond scum filled with invertebrates. The students are asked to catch some of the invertebrates and sort them based on how they look. They are also asked to identify some of the invertebrates they find using pictures provided.

# Appendix F

Transcriptions of instances of productive disciplinary engagement observed in the lab recordings directly relating to specific content knowledge questions on the questionnaire.

# Instance 1

9.30 Chemical reactions lab. Clip 2 of 3.

- 1 Instructor: ... you're making bubbles in there, what do those bubbles tell us we are
- 2 making?
- 3 Camper 9: Gas

# Instance 2

18.28 Chemical reactions lab. Clip 2 of 3.

- 1 Instructor: (Points to jar) What do bubbles tell us?
- 2 Camper 7: Carbon dioxide.
- 3 Instructor: No, could have made...
- 4 Camper 7: (Cuts instructor off mid-sentence) Gas!

## **Instance 3**

0.05 Chemical reactions lab. Clip 3 of 3.

- 1 Instructor: So what do you think the fuel was in the space shuttle?
- 2 Camper 7: Wha?
- 3 Instructor: That big thing that flew off to space but doesn't go anymore. They had two
- 4 big canisters and they mixed them together and lit them on fire. What do you think
- 5 they were mixing there?
- 6 Camper 5: Hydrogen.

# Appendix G

Instances of productive disciplinary engagement occurring in the exhibit room are shown below. Not all instances involved the campers speaking so a list of their actions is given when needed. These instances are listed in chronological order.

#### **Instance 1**

7.26 Exhibit Room Session 1, clip 1 of 1

Campers 3 and 5 at Pulleys

1 Camper 3: This is easier

2 Camper 5 Figures out which one is easiest.

### **Instance 2**

8.17 Exhibit room Session 1, clip 1 of 1

Camper 8 at lever -Followed the directions -Made it balance -Understands the set up

#### **Instance 3**

9.06 Exhibit Room Session 2, clip 1 of 1.

Camper 10 at pulleys (Reads instructions while trying each one) Camper 10: (pulls the hardest one) this one is the hardest. Camper 11 comes over and pulls them with camper 10 Camper 10: This one is hardest (while pulling it)

## **Instance 4**

9.52 Exhibit Room Session 2, clip 1 of 1.

Camper 10 and Camper 2 at lever -working on it together -Got it to balance -Reading directions and following them -Did not talk to each other at all

#### **Instance 5**

0.58 Exhibit Room Session 3, clip 1 of 1.

Camper 1 at pulleys

-Pulls middle one, then one on the right (hardest)

-Appears to be able to tell it's easier

-May have got the length thing but it's hard to tell

### **Instance 6**

1.07 Exhibit Room Session 3, clip 1 of 1

Camper 8 with pulleys

-Watches Camper 1 try it (previous instance)

- Tries it themselves

-Starts in middle

-Compares each combination

-Possibly comparing length

-Keeps them at same level in hands, watching weights go up at different levels

-Likely gets the length thing

#### **Instance 7**

1.01 Exhibit Room Session 3, clip 1 of 1.

Camper 1 at levers

-Set it up to balance with weights at various distances from fulcrum (i.e. isn't just putting the same on each side).

#### **Instance 8**

6.54 Exhibit Room Session 3, clip 1 of 1.

Camper 9 -Begins at lever -Balances it by placing weights at same distance on each side

#### **Instance 9**

(Continuation of Camper 9's activity in Instance 8)

-Moves on to pulleys

-Tries each one, definitely got the easier/harder part

-Not sure if they got the length concept

#### **Instance 10**

11.59 Exhibit Room Session 3, clip 1 of 1.

Camper 4 at pulley

-Did not read directions

-Tries each

-Seems to get the easier/harder part

-Compares how heavy the weights are by lifting them with their hand. Likely

checking to see if they weight the same

-Not sure if they noticed different number of pulleys in each set up

-Reads instructions now

-Appears to get the length component, but not positive

-Spent approximately 3.5 minutes at this activity

# ETHICS APPROVAL CERTIFICATE



June 05, 2013

Ms. Spencer Morran Faculty of Science Thompson Rivers University

File Number: 100401 Approval Date: June 05, 2013 Expiry Date: June 04, 2014

Dear Ms. Spencer Morran,

The Research Ethics Board has reviewed your application titled 'Investigating the effect of a summer science camp on elementary children's content knowledge and attitudes towards science'. Your application has been approved. You may begin the proposed research. This REB approval, dated June 05, 2013, is valid for one year less a day: June 04, 2014.

Throughout the duration of this REB approval, all requests for modifications, renewals and serious adverse event reports are submitted via the Research Portal. To continue your proposed research beyond June 04, 2014, you must submit a Renewal Form before June 04, 2014. If your research ends before June 04, 2014, please submit a Final Report Form to close out REB approval monitoring efforts.

If you have any questions about the REB review & approval process, please contact the Research Ethics Office via 250.852.7122. If you encounter any issues when working in the Research Portal, please contact the Research Office at 250.371.5586.

Sincerely,

Malipden

Chair, Research Ethics Board