

THE EFFECTS OF SELF TOURS ON SCHOOL GROUPS
IN THE *DINOSAURS UNDER THE BIG SKY* SCIENCE EXHIBIT
AT THE MUSEUM OF THE ROCKIES

by

Angela L. Hewitt

A professional paper submitted in partial fulfillment
of the requirements for the degree

of

Master of Science

in

Science Education

MONTANA STATE UNIVERSITY
Bozeman, Montana

July 2010

STATEMENT OF PERMISSION TO USE

In presenting this professional paper in partial fulfillment of the requirements for a master's degree at Montana State University, I agree that the MSSE Program shall make it available to borrowers under rules of the program.

Angela L. Hewitt

July 2010

ACKNOWLEDGEMENTS

This project could not have been completed without the assistance and collaboration of several individuals. My advisors, John Graves, Jamie Cornish, and Jim Schmitt, all played a crucial role in the development, execution, and analysis of this study. More than forty classroom teachers generously agreed to participate, dedicating valuable classroom time to completing the quizzes and surveys required for this project making this study possible. My co-worker, Nikki Dixon, and other Museum staff members made it possible to carry out this study through their support. James Weikert contributed dinosaur drawings to the Student Attitude Surveys, helping make this data collection instrument usable for younger students. And of course, this project would not have been possible without the support of my family.

TABLE OF CONTENTS

INTRODUCTION AND BACKGROUND	1
CONCEPTUAL FRAMEWORK.....	2
METHODOLOGY	8
DATA AND ANALYSIS	18
INTERPRETATION AND CONCLUSION	38
VALUE.....	42
REFERENCES CITED.....	46
APPENDICES	48
APPENDIX A: Self Tour Project Participation Agreement	49
APPENDIX B: Self Tour Project Instructions.....	52
APPENDIX C: Content Quiz: Level 1	55
APPENDIX D: Content Quiz: Level 2.....	58
APPENDIX E: Content Quiz: Level 3.....	61
APPENDIX F: Student Attitude Survey: Grades K – 5.....	64
APPENDIX G: Student Attitude Survey: Grades 6 – 12	67
APPENDIX H: Self Tour Observation Form	70
APPENDIX I: Teacher Interview Questions	73
APPENDIX J: Teacher Survey	76
APPENDIX K: Self Tour Project Teacher Resources Letter	80
APPENDIX L: Teacher Talking Points	82
APPENDIX M: Scavenger Hunt: Level 1.....	91
APPENDIX N: Scavenger Hunt: Level 2.....	96
APPENDIX O: Scavenger Hunt: Level 3.....	101
APPENDIX P: Scavenger Hunt: Level 4.....	107

LIST OF TABLES

1. Data Triangulation Matrix	16
2. Statistical Means of Percentages of Engagement and Off-task Behavior of Self Touring Students with and without an Activity and Students Receiving Guided Tours	21
3. Statistical Means and Standard Deviations for Content Quizzes of Students Participating in Guided Tours and Self Tours with and without an Activity	24
4. Statistical Means and Standard Deviations for Student Attitude Surveys of Students Participating in Guided Tours and Self Tours with and without an Activity	28
5. Statistical Means for Pre- and Post-Visit Content Quiz Results of All Types of School Groups Including Students Using Developed Educational Tools	36
6. Statistical Means for Pre- and Post-Visit Scores and Changes in Student Attitude Surveys for Students who Participated in a Self Tour using Developed Educational Resources	37

LIST OF FIGURES

1. Box-and-Whisker Plot of Student Engagement by Minute during Guided Tours	19
2. Box-and-Whisker Plot of Student Engagement by Minute during Self Tours with an Activity	20
3. Box-and-Whisker Plot of Student Engagement by Minute during Self Tours without an Activity	21
4. Differences in Content Quiz results for students receiving a guided tours, participating in self tours with an activity, and participating in self tours without an activity	25
5. Box-and-Whisker Plot of the Statistical Mean Including Pre-Visit and Post-Visit Responses of Each Question of the Student Attitude Survey Completed by Students who Received a Guided Tour	29
6. Box-and-Whisker Plot of the Statistical Mean Including Pre-Visit and Post-Visit Responses of Each Question of the Student Attitude Survey Completed by Students who Participated in a Self Tour with an Activity	30
7. Box-and-Whisker Plot of the Statistical Mean Including Pre-Visit and Post-Visit Responses of Each Question of the Student Attitude Survey Completed by Students who Participated in a Self Tour without an Activity	31
8. Numeric Changes in Student Attitude Survey Responses for Students Receiving a Guided Tour, Participating in a Self Tour with an Activity, and Participating in a Self Tour without an Activity	32
9. Percentages of Engagement for School Groups using Developed Educational Tools By minute during Self Tours	34
10. Percentages of Engagement for All School Groups by Minute by Tour Type	35

ABSTRACT

This project evaluated the effects of self tours on school groups visiting the Museum of the Rockies' Dinosaurs under the Big Sky exhibit. School groups that visited the Museum between January and May of 2010 were divided into three categories including those self touring using an activity, those self touring without an activity, and those receiving a guided tour with a docent. Each student was asked to complete a Content Quiz and a Student Attitude Survey before and after their visit to the Dinosaurs under the Big Sky exhibit to measure changes in student understanding of major exhibit concepts and changes in attitudes towards dinosaurs, museums, and science in general. Visiting school groups were observed during their tour time to evaluate student engagement, off-task behavior, methods used to keep students engaged, and attitudes towards the tour. After their visit, each participating teacher completed a survey to gather data on the purpose of school group visits, perceptions of student engagement, and instructional techniques used during touring. This project generated evidence that students have an increased understanding of major exhibit concepts and are more engaged when receiving a guided tour or self touring with an activity than students who self tour without an activity.

INTRODUCTION AND BACKGROUND

I teach early and elementary education for the Museum of the Rockies (MOR) in Bozeman, Montana. Founded in 1957, the Museum has grown to become the largest and most heavily visited cultural and natural history museum in Montana today, and the fifth most frequented destination statewide. The Museum is renowned for its work in dinosaur paleontology and seeks to become a preeminent dinosaur museum. The Museum also conducts research in Western history, manages collections of approximately 280,000 objects, operates a Digistar planetarium and a fully interpreted living history farm, mounts engaging exhibits both permanent and temporary, conducts dynamic educational programs for children and adults, and is a state-wide partner in Montana's "Indian Education for All" initiative. The Museum is accredited by the American Association of Museums and is a Smithsonian Affiliate. The Museum welcomes over 125,000 general visitors and nearly 7,000 Montana schoolchildren annually (S. Dickerson, personal communication, May 17, 2010).

In addition to standard programming for the public, the Museum provides guided tours and other lessons for visiting schoolchildren throughout the year. The Museum encourages school groups to visit by providing free admission to all Montana schoolchildren through grants and private donations. With the free admission, students have the opportunity to see a planetarium show and receive a guided tour of one of the Museum's permanent or traveling exhibits in addition to self touring the entire Museum.

A constant concern for MOR's Education Department is the quality of self tour time for visiting school groups. Museum staff has witnessed a lack of control and focus during self tours with some visiting school groups. Teachers have also given feedback,

both formally and informally, that they would appreciate more resources to use for self tours. As a result of this concern, the purpose of this study was to determine the effects of self tours on students with school groups visiting the Museum of the Rockies' *Dinosaurs under the Big Sky* exhibit.

School groups visiting MOR's *Dinosaurs under the Big Sky* exhibit between January 1 and May 14, 2010 were asked to participate in the study. Out of the 56 school groups that were invited to join the study, 39 completed enough data to be used for the study, 2 participated in the study but did not provide usable data, 14 groups did not respond to requests for participation, and 1 group declined to participate because the students were only in kindergarten. Over 1,450 students participated in this study through school groups. Group sizes ranged from 3 to 122 students and were led by 1 to 6 teachers. Groups represented a wide range of grades including one preschool group, two first grade groups, five second grade groups, three fourth grade groups, five fifth grade groups, ten sixth grade groups, four high school groups, and nine groups with students in a range of grades from kindergarten through eighth grade. This study will not discuss variables caused by student ages.

CONCEPTUAL FRAMEWORK

Introduction

Museums are rich learning and teaching environments. Classrooms of school-aged children, families, self-touring adults, and eager toddlers visiting with their pre-schools are drawn to museums because of potential learning. While some groups experience a museum through volunteer and paid museum staff serving as guides, many schools explore museums independently. Like all visitors, school groups will spend at

least some portion of their visit touring exhibits without a guide. In the case of school groups, the teacher then becomes responsible for facilitating learning while touring exhibits independently.

Definition of free-choice and self-directed learning

Independent learning in museum environments can be labeled as free-choice learning (Falk, 2001). Falk introduced the concept of free-choice learning as an alternative to the terms formal and non-formal learning. According to Bamberger and Tal (2006), “the idea of free-choice emphasizes the unique nature of out-of-school environments that allows the learner to identify several learning options, in a variety of spaces, and finally, choose a specific option, theme, or space for learning” (p. 76). In this environment, the learner must have perceived choice and control. Falk (2005) states, “to qualify as free-choice learning the learner must perceive... that s/he possesses the freedom to select (or not to select) from amongst choices” (p. 273). Museums overflow with opportunities for free-choice learning. While visitors explore exhibits, even on guided tours, they have the freedom to choose which exhibit panels and content to stop and explore, or continue past without reading.

Free-choice learning is inherently different from formal classroom-like settings. While learning in the classroom requires sequential lessons relying upon prior knowledge, free-choice learning does not require students to build their knowledge in a specific order. Instead, short learning experiences relying on curiosity and intrinsic motivation guide students to new understandings. In addition to the benefits of short educational experiences, learning in free-choice environments also enhances idiosyncratic learning experiences and encourages nonhierarchical relationships between

facilitators and learners (Bamberger & Tal, 2006). Researchers have found that the nature of free-choice educational environments promote and nurture learning (Tran, 2006).

Free-choice learning can also be considered synonymous with other terminologies or competing concepts, one of these being self-directed learning (SDL). Though similar to free-choice learning, Banz (2008) suggests self-directed learning differs in adult education contexts. While free-choice learning can happen incidentally and takes place in an informal learning environment, SDL has been thoroughly researched in formal and non-formal environments. Banz argues self-directed learning uniquely requires the learner to assume control of his or her learning process. However, Falk (2005) uses this same definition, including the underlying motivation and interest of the learner, as an argument to use the term free-choice learning which has been accepted by other researchers (Tran, 2006, Bamberger & Tal, 2006, Kisiel, 2007). Regardless of the terminology used, free-choice and self-directed learning situations where learners are responsible for their own learning are both present in museums.

Role of exhibit components

A museum's exhibit components greatly influence both the free-choice and self-directed learning that takes place in museum environments. Museum educators are not always involved in the process of creating exhibits. However, the exhibit labels, components, and exhibit interaction all greatly influence how visitors and students learn in museum environments. One of the first educational theorists to explore museum education, John Dewey, labeled some museum learning as 'educative' because the learning enhanced the making of further experiences, and other experiences as 'mis-

educative' because the learning had no further influence upon later experience (Van Moer E., De Mette, T. & Elias, W., 2008). Exhibits that are based solely on information often generate reactions without personal engagement. Experienced-based exhibits, however, encourage engaging experiences. Without personal engagement, visitors are not likely to take control of their own thinking or open up to further growth. Exhibits, therefore, need interactive and experience-based features to promote quality learning experiences (Van Moer et al.).

Throughout museums, exhibit labels serve as a guide during free-choice and self-directed learning experiences. In a study evaluating the effects exhibit labels have on museum learning, researchers concluded that labels which asked questions and provided their explanations turned exhibit features into small lessons (Atkins et al., 2009). The same researchers also suggested that "exhibit designers need to pay attention to not only what is said, but how" (p. 182). Through choices in exhibit design, informal education environments show visitors what they expect them to learn (Atkins et al.). Indirectly, the scientists and educators who write the labels and design exhibits teach the visitors who eventually explore their exhibitions (Tran, 2006).

Classroom group visitors

Classroom teachers visit museums with their students to teach subject matter that cannot be covered in the classroom or to enhance classroom learning while introducing students to resources in their community (Tran, 2006). Classroom teachers also visit and value museum field trips because of their educational benefits (Kisiel, 2005). Teachers supplement formal science education with museum field trips, a method recommended by

the U.S. National Research Council (1996), which states that “the school science program must extend beyond the walls of the classroom to the resources of the community” (p.45).

During field trip visits, students sometimes have the opportunity to tour exhibits with paid or volunteer educators. With numerous studies supporting, explaining the importance of, and quantifying student learning during these guided tours, it is well known in the world of museum education that a short, educator-led lesson has a positive effect on the content students remember from museum visits (Tran, 2006).

School-aged children that do not participate in a guided tour with a museum educator have the opportunity to explore museum exhibits in a more independent manner. Bamberger & Tal (2006) studied student learning with three levels of choice ranging from structured learning to complete learning freedom: no choice, limited choice, and free-choice. The study found that activities that allowed limited choice, where students were given an individual or small-group learning task in order to explore the exhibition according to the topic of the visit, enhanced the learning process more than free-choice or no choice experiences (Bamberger & Tal, 2006). A previous study also found that school group visitors without clearly programmed objectives or effective teaching strategies may have a meaningless museum visit (Guisasola, Morentin, & Zuza, 2005).

Educational materials for school groups

In addition to free-choice learning, studies related to museum education have also evaluated the role of educational materials that guide learning within exhibits. Studies prior to Bamberger and Tal (2006) revealed the effectiveness of teacher-created educational materials to direct and improve student learning. Although educators have mixed opinions of the learning potential for one particular educational tool, worksheets,

research shows that “properly constructed worksheets may enhance the learning process” (Kisiel, 2007, p.30). Here teacher feedback revealed that more than 40% of teachers would use some sort of structured engagement, such as a worksheet, during field trips. Guisasola et al. (2005) found that “the incorporation of educational materials centered on school-museum learning allows greater and better student learning of science and its methods” (p. 549). However, Kisiel later found that teachers may not know the effective pedagogy used within a museum setting and therefore may not use the best practices in designing worksheets. In museum learning environments, students on class field trips can enhance learning with carefully constructed educational materials.

Unanswered Questions

Informal educational environments, like museums, encourage and support independent learning. Depending upon the context in which school-aged children visit museums, initial research regarding learning has shown both successes and ways to improve. In school group visits, Palmquist & Crowley (2007) suggest museum educators lack the knowledge of current research on free-choice learning environments, which has led to inadequate touring techniques. At the same time, Kisiel (2007) suggests classroom teachers need a greater understanding of museum education techniques in order to develop effective worksheets used during museum learning. While there is no question that school-aged children are learning something during self-directed tours, more research needs to be done on how children learn most effectively in these environments. The roles of classroom teachers, museum educators, and parents can be evaluated to reveal the most effective techniques for helping students learn in free-choice environments. With the abundance of research conducted of guided tours in museum

settings, more studies on self-directed and free-choice learning could help museum educators understand how to better serve school-aged children.

METHODOLOGY

During the project, observations and questionnaires were used to determine the degree that students understand major exhibit concepts and engagement in the learning process during self tours. In addition to self touring students, students receiving guided tours of the *Dinosaurs under the Big Sky* exhibit were also evaluated to uncover the frequency of engaged behavior and student understanding of major exhibit concepts. The study period started on January 1, 2010 and continued until May 14, 2010. Data collection strategies included content quizzes (administered before and after school group visits), teacher interviews and an online survey, observational data, and student surveys. School groups visiting the Museum of the Rockies during the study period were contacted prior to their visit and asked to participate in the study.

The school groups that participated in this study had a wide variety of group sizes ranging anywhere from 3 to 122 students. For each group to be represented equally in analyzing, one set of statistical data was generated for each school group. These single data sets representing each group were then used for data analysis. Therefore, in this study, sample sizes indicate the number of groups participating, not individual students. Only students with both pre- and post-visit data for each data set were included in generating their group's representative data set.

Participating teachers with students using both self touring and guided tour methods were sent a Letter of Introduction (Appendix A), Pre-Visit Instructions (Appendix B), Content Quizzes (Appendices C, D, and E) without the answer keys, and

Student Attitude Surveys (Appendices F and G) to administer in their classroom before their museum visit.

Three different Content Quizzes, designed to evaluate student understanding of major exhibit concepts, were developed to address different academic levels. Teachers were asked to choose which quiz to administer based on their expectations of students' base knowledge of dinosaurs. All Content Quizzes contained ten questions using matching, multiple-choice, and true or false question types. The Level One Content Quiz was designed for students who had never studied dinosaurs (Appendix C) and included one matching, three multiple-choice, and six true or false questions. The Level Two Content Quiz was designed for students with a basic understanding of dinosaurs (Appendix D) and included one matching, four multiple choice, and five true or false questions. The Level Three Content Quiz was designed for students who have studied dinosaurs extensively (Appendix E) and included one matching, three multiple choice, and six true or false questions. Teachers were not given the answer keys to any of these quizzes to prevent influencing student data.

The Level One Content Quiz and the Level Two Content Quizzes each had one question that was confusing and misleading for students. As a result, the second question on the Level One Content Quiz and the fifth question on the Level Two Content Quiz were eliminated from scoring. The Level One Content Quiz was scored without question two with the highest score possible being nine points. The Level Two Content Quiz was scored without question five with the highest score possible being nine points. The Level Three Content Quiz remained in its original scoring format with all questions included and the highest possible score being ten points.

One school group's data set for Content Quiz results was eliminated from the study since more than half of the students in this group, who participated in a self tour of the *Dinosaurs under the Big Sky* exhibit with an activity, answered one of the questions in the post-visit Content Quiz in the same unusual manner. On the Level One Content Quiz, more than half of this group of students circled both "True" and "False" on question seven, "Dinosaurs dragged their tails." Half of these students also wrote in, "Some did." It is likely that this group's teachers discussed possible answers before students submitted their quizzes; therefore, results from this school group was not used in this study for this data set.

Most teachers participating in this study chose to administer the Level One Content Quiz to their students for unknown reasons. Out of 35 school groups who submitted both pre- and post-visit quizzes, 24 used the Level One Content Quiz (including 13 groups receiving guided tours, five groups participating in self tours with an activity, and six groups participating in self tours without an activity). The Level Two Content Quiz was used by eight school groups (including four groups receiving guided tours, three groups participating in self tours with an activity, and one group participating in a self tour without an activity). The Level Three Content Quiz was only used by three school groups (including one group receiving a guided tour, one group participating in a self tour with an activity, and one group participating in a self tour without an activity); therefore, the results of the Level Three Content Quiz were not included in the analysis due to the small size of the sample.

Two different Student Attitude Surveys were also developed to meet the academic levels of different age groups. Although the questions were the same, the Grades K-5

Student Attitude Survey (Appendix F) for students in kindergarten through fifth grades includes pictures to represent student feelings. Older students in sixth through twelfth grade were asked to respond using descriptive words using the Grades 6-12 Student Attitude Survey (Appendix G). These surveys were used to assess how students perceived their self touring time. Using a Likert scale, students using the Grades 6-12 Student Attitude Survey could respond to each statement by selecting, *strongly agree*, *agree*, *disagree* or *strongly disagree*. Students using the Grades K-5 Student Attitude Survey selected a picture of a dinosaur expressing these four attitudes. Teachers were asked to bring the ungraded Content Quizzes and Attitude Surveys taken before their museum visit to the Museum on the day of their field trip.

Data collected on the post-visit Student Attitude Survey regarding student perceptions of their tour time and activities during self tours was not often completed. Those groups that did provide answers to these questions had a wide variety of responses. Students often left questions blank in this area indicating confusion regarding the statements given. Questions regarding self tours were completed even by students on guided tours. As a result, this portion of the Student Attitude Survey was eliminated for data analysis.

At the Museum, each participating school group was asked to identify one small group (consisting of six to ten students and one chaperone) to be observed during their self tour or guided tour of the *Dinosaurs under the Big Sky* exhibit. Each teacher was asked to include a variety of students in this group, mixing both academic and behavioral abilities. In many cases the participating teacher did not identify a group to study. In this

case, I chose four to ten students, trying to include students that exhibited different behaviors and attitudes.

The selected small group was observed to evaluate engagement in the learning process. During the observation, this project used a direct observation code which separates academic engagement into two categories: *active* and *passive engagement*. This code, developed by Shapiro (1996), was designed to observe student engagement during instructional activities. Active engagement (AE) occurs when a student is actively attending and responding to a true academic task and includes activities such as writing, reading aloud, and talking to a teacher or peer about the academic material. Passive engagement (PE) occurs when students are focused on assigned academic work by listening to a lecture, looking at a worksheet, or silently reading a book.

During the self tour, off-task behavior was also recorded as one of three types: *off-task motor*, *off-task verbal*, and *off-task passive behavior* (Vile Junod, R. E., DuPaul, G. J., Jitendra, A. K., Volpe, R. J., & Cleary, K. S., 2005). Off-task motor behavior (OT-M) was defined as a motor task which is not part of the academic task and interferes with attention to, or completion of, the assigned academic task (i.e., wandering, drumming with a pencil, lounging on seating areas). Off-task verbal behavior (OT-V) was defined as any verbal actions that were not related to the academic task (i.e., humming, conversations with peers not related to the task). Off-task passive behavior (OT-P) was defined as any activity in which a student was not talking or acting out, but not engaged in the academic task (i.e., daydreaming, looking around the room).

For consistency and to match current psychological study standards, students were not observed until ten minutes into their tours. After this ten minute period, I then

recorded academic engagement on one minute intervals for the chosen study group for the next ten minutes using the Tour Observation Form (Appendix H). The number of students demonstrating each type of engagement (AE and PE) and off-task behavior (OT-M, OT-V, OT-P) were recorded at each interval using tally marks. Only one type of behavior was recorded for each student. Any actions before or after this ten minute observational period were not recorded for this project.

Because of the winding design of the *Dinosaurs under the Big Sky* exhibit, only one of the four halls that make up the Complex can be seen at one time. With smaller groups that toured the Complex together during both self tours and guided tours, the observations of engaged and off-task behavior recorded can be considered accurate. However, larger groups that allowed students to spread out through all four halls during self tours decreased the accuracy of the recorded behaviors since I could not visually evaluate all self touring students at the exact moment needed for each interval. Each selected student's data was recorded on one minute intervals for these situations; however, not all students' behavior was noted at the same exact time.

In addition to recording academic engagement, I also made note of chaperone and docent methods used to maintain student focus, methods used to teach exhibit content during the self tour, and student and chaperone comments that reflect attitudes towards the exhibit, self tour or guided tour, and major exhibit concepts. I noted if self touring students used an educational activity, student attitudes towards the use and difficulty of the educational activity, how the activity was utilized, and techniques chaperones used to encourage comprehension of concepts while self touring. All of these comments were recorded with written notes. I also made note of the lengths of tour times. However, this

data was not included in analysis because there was not a correlation between tour length and student engagement. I intended to not interact with self tour or guided tour groups. This was not always possible because students often approached me with questions regarding the exhibit, exhibit content, or what I was doing.

Percentages for each demonstrated behavior were generated for each minute of data collection from raw data (tallies) to equally compare different group sizes. Groups that toured less than twenty minutes were still used in data analysis. These groups had less than ten individual moments of data collection; therefore, overall means for student engagement during tour time were calculated with fewer than ten individual percentages. When more than one small group was observed from the same visiting school group, data was combined to generate one single set of data for the group.

Due to the time constraints of museum visits, participating teachers were asked to complete Content Quizzes, Student Attitude Surveys, and teacher interviews in their classroom within one week of their visit to the Museum of the Rockies. Some teachers completed post-visit quizzes and surveys immediately, while others waited over a week. Although it would have been more ideal to have a specific date that all post-visit data was completed to limit variables, it was a challenge to receive simply receive the data. Therefore, teachers were asked, but not required, to complete post-visit quizzes and surveys in this time frame. Each student was asked to complete a second Content Quiz to gather data on student understanding of major exhibit concepts. Students were required to take the same level Content Quiz before and after their visit to the Museum of the Rockies. Content Quizzes taken after school group visits were compared to the Content Quizzes completed before the Museum visit to measure the knowledge students gained

during their tour. Student Attitude Surveys taken after the visit were compared to the surveys taken before their visit to measure how student perceptions about dinosaurs and science have changed as a result of self tours or guided tours.

Teacher attitudes, concerns, and educational needs for self tours at the Museum of the Rockies were evaluated using Teacher Interview Questions (Appendix I) and the Teacher Survey (Appendix J). The Teacher Interview Questions were administered to the first three participating teachers. Because of difficulties scheduling and facilitating interviews in a timely manner, an alternative online survey was created through Google Documents. The remaining teachers participating in the study were emailed a link to complete the survey within a week of their visit. Twenty-three of the forty-two participating teachers contributed feedback in the form of Teacher Interviews and an online Teacher Survey. Eleven of these teachers received a guided tour of the *Dinosaurs under the Big Sky*. The remaining twelve teachers that provided feedback had their students participate in a self tour. Of these twelve teachers, seven provided an activity for their students while five did not.

It was imperative that data collection processes remained consistent throughout the period of study in order to ensure consistent, valid, and reliable data among a large number of visiting school groups. Consistency was achieved by a single observer to keep subjective interpretations of engagement consistent and using the same data collection instruments for all school groups.

The Triangulation Matrix for this study is presented in Table 1.

Table 1
Data Triangulation Matrix

Focus Questions	Data Source 1	Data Source 2	Data Source 3
<i>Primary Question:</i> 1. What are the effects of self tours on school-aged children in the Museum of the Rockies' <i>Dinosaurs under the Big Sky</i> science exhibit?	Structured teacher interviews and teacher survey	Student Attitude Surveys	Comparison of Content Quiz results
<i>Secondary Questions:</i> 2. To what degree do students understand major exhibit concepts after self touring?	Comparison of Content Quiz results	Student Attitude Surveys	Structured teacher interviews and teacher survey
3. How much of the self tour time are students engaged in the learning process?	Field notes and observational records	Structured teacher interviews and teacher survey	Student Attitude Surveys
4. What tools are teachers currently using to encourage learning during self tours?	Structured teacher interviews and teacher survey	Field notes and observational records	Student Attitude Surveys

After receiving just over half of the collected data, evidence suggested that students who were self touring with an activity were more engaged and scored higher on the Content Quizzes after their visit than the students who self toured the *Dinosaurs under the Big Sky* exhibit without an activity. As a result of this evidence, the eight remaining teachers with students that would be self touring the *Dinosaurs under the Big Sky* exhibit during the study period and who had already agreed to participate in the study

were given educational resources to use during their tour time. Only three of the eight teachers tested the educational resources.

The feedback teachers provided up to this point and observations of how teachers facilitated learning during self tours dictated the type of resources created. It was clear that many teachers did not want or would not have chose to facilitate a free choice learning experience during self tour time. Instead, teachers were more comfortable with and preferred more traditional tools like scavenger hunts or worksheets. To encourage the use of an activity for students during self tour times, I chose to produce educational resources that reflected what the teachers preferred instead of what researchers have found to be successful, including free-choice learning.

The educational resources created included Teacher's Talking Points (Appendix L), highlighting important areas of the exhibit that focus on the main educational goals of the *Dinosaurs under the Big Sky* exhibit. With pictures and a map, teachers were given two to five bullet points to inform their students at each of the 26 highlighted exhibit features. Using these talking points did not require a teacher to lead a tour. Instead, they provided quick information to those teachers that did not have background knowledge of dinosaurs.

Also included in the educational resources was a set of four scavenger hunts for students of varying ages and abilities. The Level One Scavenger Hunt (Appendix M) and Key had no writing requirements. The Level Two Scavenger Hunt (Appendix N) required students to provide written one-word answers, but required no complete sentences. The Level Three Scavenger Hunt (Appendix O) required complete sentences

and some higher order thinking skills. The Level Four Scavenger Hunt (Appendix P) required short essays and higher order thinking skills for most questions.

These three teachers were responsible for formatting their tours using the educational resources provided. They were not instructed to administer any particular scavenger hunt, nor were they required to use the Teacher's Talking Points. Participating teachers had to read through the educational resources and select the tools that would work best for them. Only two of these three groups were observed because of overlapping schedules of these schools.

DATA AND ANALYSIS

Student Engagement through Tour Observations

All school groups observed while touring the *Dinosaurs under the Big Sky* exhibit demonstrated both engaged and off-task behaviors. Students on guided tours were actively engaged 4.2% of the time and passively engaged 78.4% of the time, with a mean of 82.7% engagement throughout the tour. These same students demonstrated off-task motor behavior 2.6% of the time, off-task verbal behavior 2.5%, and off-task passive behavior 12.5% of the time, with a mean for off-task behavior of 17.6%. The statistical median, mean, minimum, maximum, and lower and upper quartile for school groups receiving guided tours of the *Dinosaurs under the Big Sky* exhibit at the Museum of the Rockies can be seen in the box plot shown in Figure 1. Medians, means, minimums, maximums, and lower and upper quartiles were calculated individually. Therefore, means for individual engaged and off-task categories may not equal the overall statistical mean for engaged and off-task behavior.

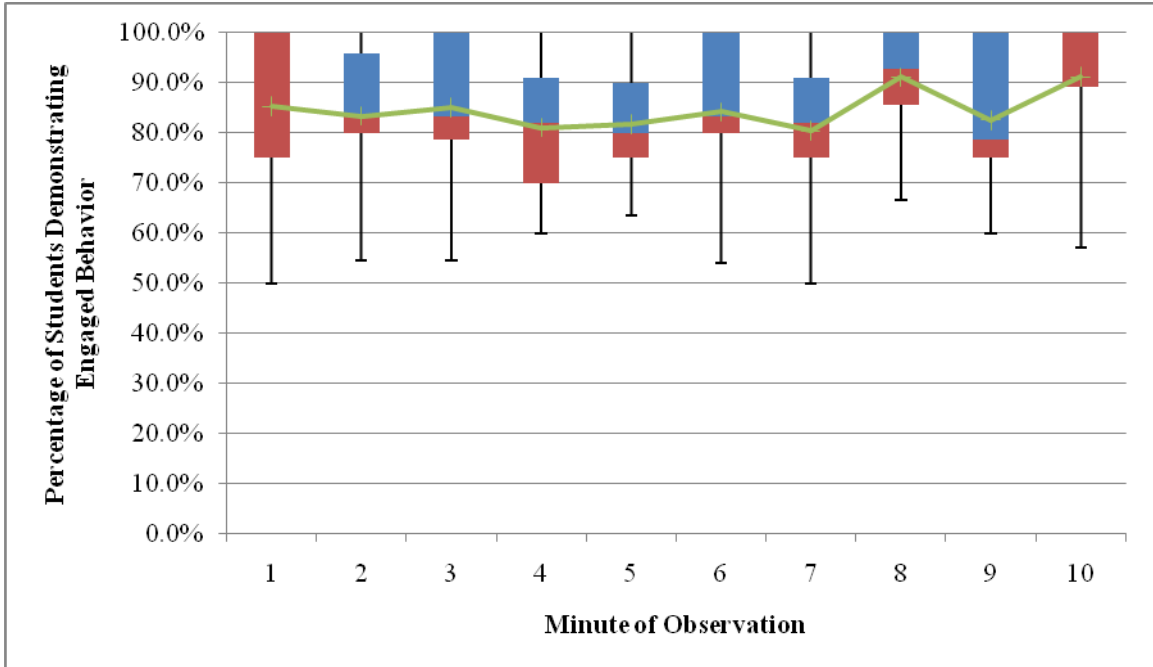


Figure 1. Box-and-Whisker Plot of Student Engagement by Minute during Guided Tours ($N=14$) in the *Dinosaurs under the Big Sky* exhibit at the Museum of the Rockies. Boxes represent the inter-quartile range (25th to 75th percentile), and whiskers indicate the minimum and maximum values. The statistical median is represented by the point where the red and blue boxes meet. The green line with markers indicates the statistical mean for each minute.

Self touring students with an activity were actively engaged 44.9% of the time and passively engaged 34.3% of the time, with a mean of 79.2% engagement throughout the tour. These same students demonstrated off-task motor behavior 5.2% of the time, off-task verbal behavior 8.5%, and off-task passive behavior 6.9% of the time, with a mean for off-task behavior of 20.6%. The statistical median, mean, minimum, maximum, and lower and upper quartile for school groups participating in self tours of the *Dinosaurs under the Big Sky* exhibit with an activity at the Museum of the Rockies can be seen in the box plot shown in Figure 2.

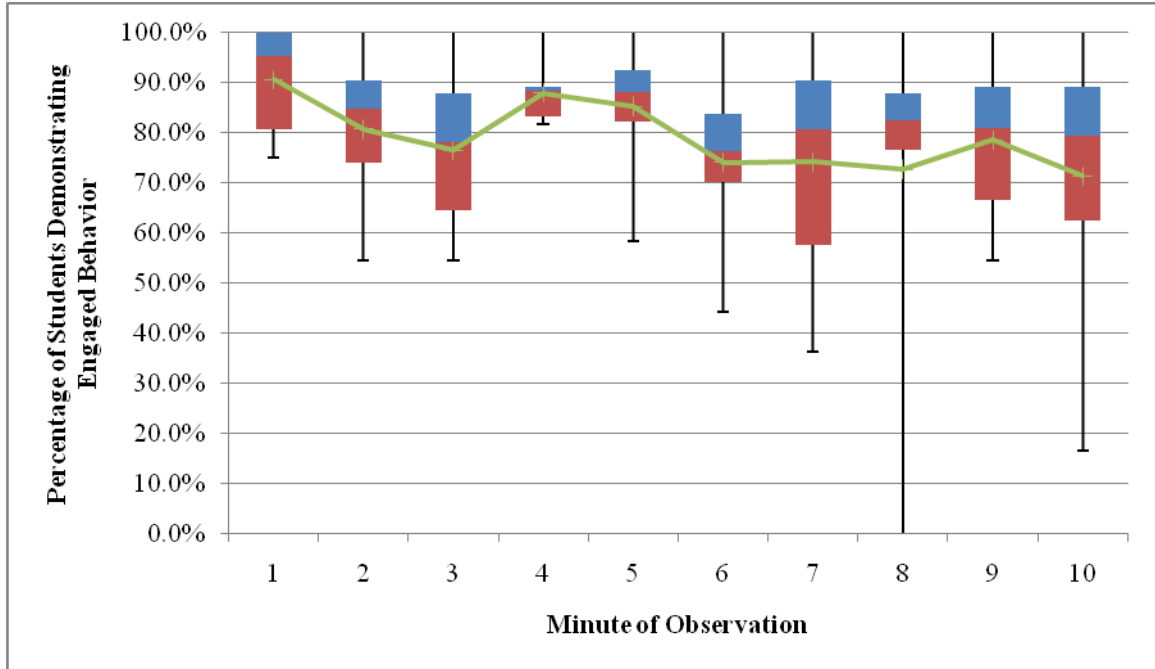


Figure 2. Box-and-Whisker Plot of Student Engagement by Minute during Self Tours with an Activity ($N=7$) in the *Dinosaurs under the Big Sky* exhibit at the Museum of the Rockies. Boxes represent the inter-quartile range (25th to 75th percentile), and whiskers indicate the minimum and maximum values. The statistical median is represented by the point where the red and blue boxes meet. The green line with markers indicates the statistical mean for each minute.

Self touring students without an activity were actively engaged 23.9% of the time and passively engaged 31.3% of the time, with a mean engagement of 69.1% throughout the tour. These same students demonstrated off-task motor behavior 8.7% of the time, off-task verbal behavior 6.5%, and off-task passive behavior 8.8% of the time, with a mean for off-task behavior of 30.0%. The statistical median, mean, minimum, maximum, and lower and upper quartile for school groups participating in self tours of the *Dinosaurs under the Big Sky* exhibit without an activity at the Museum of the Rockies can be seen in the box plot shown in Figure 3.

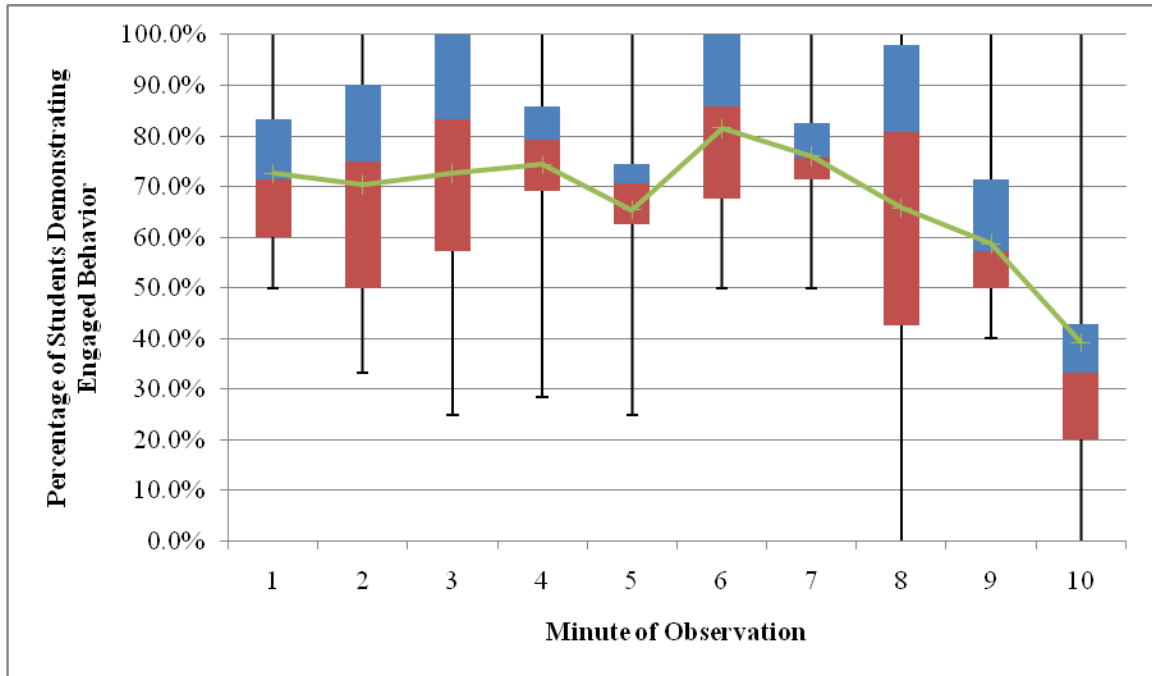


Figure 3. Box-and-Whisker Plot of Student Engagement by Minute during Self Tours without an Activity ($N=9$) in the *Dinosaurs under the Big Sky* exhibit at the Museum of the Rockies. Boxes represent the inter-quartile range (25th to 75th percentile), and whiskers indicate the minimum and maximum values. The statistical median is represented by the point where the red and blue boxes meet. The green line with markers indicates the statistical mean for each minute.

The statistical means for all ten minutes of observation for students receiving guided tours, students participating in a self tour with an activity, and students participating in self tour without an activity are shown in Table 2.

Table 2

Statistical Means of Percentages of Engagement and Off-task Behavior of Self Touring Students with and without an Activity and Students Receiving Guided Tours in the Dinosaurs under the Big Sky exhibit at the Museum of the Rockies

Group Category	Engaged Behaviors	Off-Task Behavior
Guided Tour (n= 14)	82.7%	17.6%
Self Tour with Activity (n=7)	79.2%	20.6%
Self Tour without Activity (n=9)	69.1%	30.0%

Teacher feedback regarding student engagement revealed a variety of reasons why students demonstrate off-task behavior during both guided and self tours. A fifth grade teacher, whose students received a guided tour, clearly listed some of challenges preventing total engagement for students touring the *Dinosaurs under the Big Sky* exhibit at the Museum of the Rockies, saying,

Their age, the rest of the exhibits that were still to be experienced and for those that had the tour at the end of their day, they were getting tired. We were on the road very early that day. It was not the fault of the docents or the information.

Other teachers who visited the dinosaur halls through both self and guided tours added to the list of distractions. A sixth grade teacher whose students self toured shared, “They are easily distracted from the message you'd like them to receive by extraneous stimuli, (eg. graphic displays, extraneous sounds, and of course, one another).” Another sixth grade teacher shared similar distractions that included, “Lack of motivation, other groups touring, [and] messing around with friends.” A second grade teacher whose students received a guided tour agreed stating, “Students (naturally) become disengaged when other tours enter the space, as well as when they listen to concepts that are above their understanding (the explanation of the interconnectivity at the technology center).”

Teacher feedback also suggested that the layout and presentation of information within the *Dinosaurs under the Big Sky* exhibit prevented engagement in addition to typical student distractions. These teacher comments highlight the influence of exhibit components, interactives, and exhibit labels, which museum educators cannot control on student learning. A tenth, eleventh, and twelfth grade teacher whose students self toured stated, “The students were not as engaged in it because of all of the reading involved, but

they really enjoyed it.” A fourth grade teacher whose students self toured agreed. “[The exhibits] mostly involve reading and no other interaction.”

One teacher shared techniques that were successful in keeping students engaged.

A fifth grade teacher stated,

What made it possible for my students to be engaged during their entire tour time was I asked them questions that they had to find the answers to in the exhibit.

The exhibit also had interactive areas that keep kids on task.

A fourth grade teacher shared that her students spent “very little time devoted to wandering due to close assistance of our chaperones and focused students in general.”

Four teachers attributed their students’ engagement to the docent who led their guided tour. “Our docents were VERY knowledgeable,” a sixth grade teacher shared. A second grade teacher elaborated on this benefit of guided tours. “The docent made the tour very interesting. She was very patient and made sure to include all children when asking questions and presenting info.”

Student Knowledge through Content Quizzes

Before their visit, students who would later receive a guided tour of the *Dinosaurs under the Big Sky* exhibit had a mean score of 67.2% on the Level One Content Quiz (raw score of 6.05 out of 9.0, standard deviation of 0.85). After their visit, these same students had a mean score of 79.2% on the Level One Content Quiz (raw score of 7.12 out of 9.0, standard deviation of 0.80). On average, these students scored 12.0% higher after their guided tour (raw score change of 1.08, standard deviation of 0.46).

Students who would self tour the *Dinosaurs under the Big Sky* exhibit with an activity had an mean score of 76.1% on the Level One Content Quiz (raw score of 6.85

out of 9.0, standard deviation of 0.57) before their visit. After their visit, these same students had a mean score of 84.4% on the Level One Content Quiz (raw score of 7.60 out of 9.0, standard deviation of 0.49). On average, these students scored 8.3% higher after their self tour with an activity (raw score change of 0.75, standard deviation of 0.27).

The students who would later self tour the *Dinosaurs under the Big Sky* exhibit without an activity had a mean score of 65.9% on the Level One Content Quiz (raw score of 5.93 out of 9.0, standard deviation of 1.18) before their visit. After their visit, these same students had a mean score of 69.6% on the Level One Content Quiz (raw score of 6.26 out of 9.0, standard deviation of 0.69). On average, these students scored 3.8% higher after their self tour with an activity (raw score change of 0.34, standard deviation of 1.13). Mean scores and standard deviations for Level One and Level Two Content Quizzes for groups receiving guided tours, groups self touring with an activity, and groups self touring without an activity are shown in Table 3.

Table 3
Statistical Means and Standard Deviations for Content Quizzes of Students Participating in Guided Tours and Self Tours with and without an Activity in the Dinosaurs under the Big Sky exhibit at the Museum of the Rockies

Tour Type	Level 1		Level 2	
	Pre-Visit	Post-Visit	Pre-Visit	Post-Visit
Guided Tour	67.2% (9.4%) n=13	79.1% (8.9%) n=13	63.4% (7.8%) n=4	72.2% (4.7%) n=4
Self Tour with Activity	76.1% (6.3%) n=5	84.4% (5.4%) n=5	67.7% (7.1%) n=3	68.0% (4.8%) n=3
Self Tour without Activity	65.9% (13.1%) n=6	69.6% (7.7%) n=6	66.6% (N/A) n=1	64.9% (N/A) n=1

Note. Percentages in parentheses indicate standard deviations.

A comparison of the difference between pre-visit and post-visit scores for Level One and Level Two Content Quiz results for all three categories of school groups is shown in Figure 4.

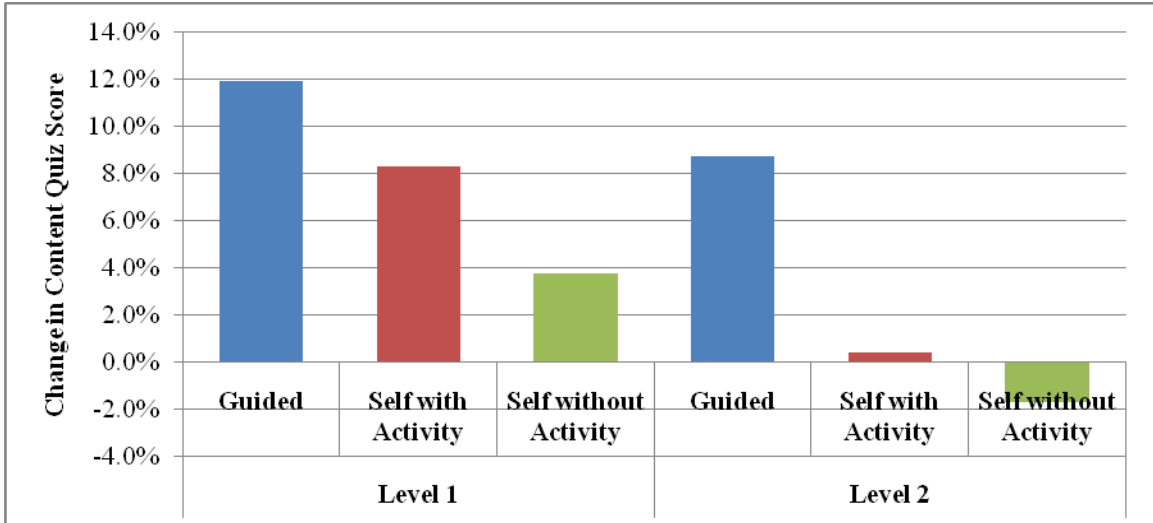


Figure 4. Differences in Content Quiz results for students receiving guided tours, participating in self tours with an activity, and participating in self tours without an activity in the *Dinosaurs under the Big Sky* exhibit at the Museum of the Rockies. A positive change reflects a higher post-visit Content Quiz score than a pre-visit score.

Teacher perceptions of student learning within the *Dinosaurs under the Big Sky* exhibit were unanimous for all but one teacher. Most teachers felt their students gained the knowledge they expected from their tour. The one first grade teacher, who did not agree with her peers, offered an explanation of what would have increased student learning by sharing, “I would have a hunt for specific answers to questions about dinosaurs.” However, even those teachers that felt their students gained all the knowledge they hoped for, offered insight to what they would improve upon for their next visit to the Museum’s dinosaur exhibit. One high school teacher suggested that “It might be nice to work with staff to develop a few age appropriate activities the students could complete after their self guided tour.”

Other teachers shared what techniques they have found to foster student learning. One sixth grade teacher shared, “We do a lot of work prior to visiting the museum.” A second grade teacher whose students received a guided tour stated, “Reading stories, viewing exhibits, touching fossils, questioning and then receiving great answers, and the tour guide really kept their attention with pictures of where the fossils came from.” A fifth grade teacher shared, “the display itself was very engaging. The dino hall is very appealing and the docents were extremely knowledgeable. They were also great with the kids and engaged them with questions and interesting information.”

Six teachers indicated the positive influence of docents on student learning. These teachers described the docents who led their guided tour as “knowledgeable,” and cited their tours and the hands-on teaching materials they used as reasons why their students gained the knowledge they were hoping for during their tour times.

Student Attitudes through Student Attitude Surveys

Students that received a guided tour, self toured with an activity, and self toured without an activity had a positive statistical mean for all four statements relating to dinosaurs before and after their visits. However, students that received a guided tour or who self toured without an activity had a less positive mean response to “I want to learn more about dinosaurs” after their visit. All three categories of school groups also had a positive statistical mean for four of the five statements relating to science before and after their visits. Nevertheless, students on guided tours had a less positive mean response to “Science is cool” after their visit, students who self toured without an activity had a less positive mean response to “I like science” after their visit, and all three groups of students had a less positive mean response to “I want to learn more about science” after their visit.

All groups of students revealed positive and negative reactions to the statement, “I want to be a scientist when I grow up.” Students’ responses to this statement had a high standard deviation and near neutral mean for all types of touring school groups.

Mean scores and standard deviations for the Student Attitude Survey for groups receiving guided tours, groups self touring with an activity, and groups self touring without an activity completed before and after school group visits are shown in Table 4.

Table 4
Statistical Means and Standard Deviations for Student Attitude Surveys of Students Participating in Guided Tours and Self Tours with and without an Activity in the Dinosaurs under the Big Sky exhibit at the Museum of the Rockies

Survey Question	Guided Tour (n=11)		Self Tour with Activity (n=5)		Self Tour without Activity (n=6)	
	Pre-Visit	Post-Visit	Pre-Visit	Post-Visit	Pre-Visit	Post-Visit
I like dinosaurs.	80.7% (15.3%)	85.7% (10.7%)	67.0% (10.3%)	74.7% (10.3%)	65.3% (18.3%)	78.3% (9.0%)
Dinosaurs are cool.	79.0% (11.7%)	84.0% (9.7%)	68.0% (10.0%)	74.7% (11.3%)	65.7% (15.7%)	75.7% (8.0%)
My friends think dinosaurs are cool.	76.3% (8.7%)	82.3% (11.3%)	58.0% (9.3%)	66.0% (10.3%)	60.3% (18.7%)	67.3% (14.3%)
I want to learn more about dinosaurs.	76.7% (14.3%)	74.3% (18.7%)	74.7% (10.7%)	76.0% (9.7%)	77.7% (10.7%)	76.0% (10.7%)
I like science.	77.7% (14.7%)	77.0% (15.0%)	73.3% (9.7%)	74.7% (11.7%)	82.0% (14.0%)	74.0% (10.0%)
Science is cool.	83.3% (13.3%)	79.3% (15.0%)	65.0% (17.0%)	68.0% (14.3%)	65.7% (18.0%)	72.7% (18.3%)
I want to learn more about science.	74.3% (15.7%)	72.3% (18.3%)	71.7% (12.0%)	71.3% (12.0%)	71.7% (15.7%)	67.0% (15.0%)
My friends think science is cool.	71.7% (14.7%)	73.0% (14.7%)	58.0% (16.0%)	60.0% (11.3%)	62.7% (16.7%)	65.0% (10.0%)
I want to be a scientist when I grow up.	42.3% (22.3%)	44.7% (22.3%)	38.3% (8.3%)	37.7% (10.3%)	45.3% (18.0%)	45.0% (16.7%)

Note. Responses are on a scale with 0% representing the response *strongly disagree* and 100% representing *strongly agree*. Percentages in parentheses indicate standard deviations.

The statistical median, mean, minimum, maximum, and lower and upper quartile for school groups touring of the *Dinosaurs under the Big Sky* exhibit at the Museum of the Rockies can be seen in the box plot shown in Figure 5 for students receiving guided tours, Figure 6 for students participating in self tours with an activity, and Figure 7 for students participating in self tours without an activity.

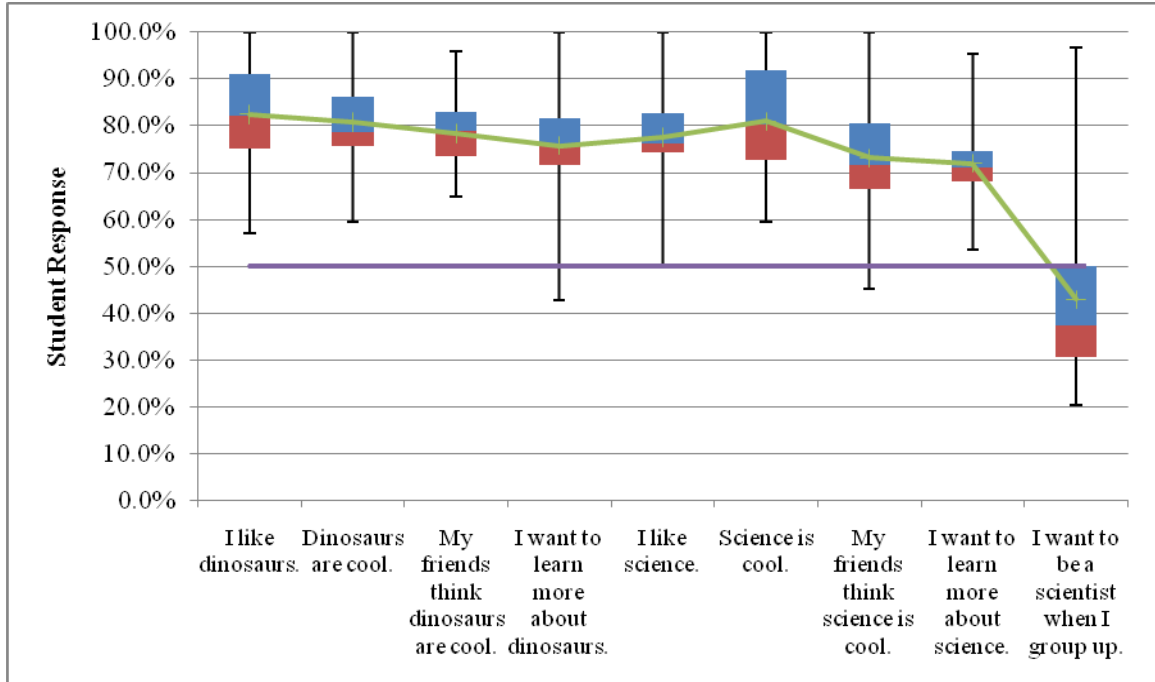


Figure 5. Box-and-Whisker Plot of the Statistical Mean Including Pre-Visit and Post-Visit Responses of Each Question of the Student Attitude Survey Completed by Students who Received a Guided Tour of the *Dinosaurs under the Big Sky* exhibit at the Museum of the Rockies ($N=12$). Boxes represent the inter-quartile range (25th to 75th percentile), and whiskers indicate the minimum and maximum values. The statistical median is represented by the point where the red and blue boxes meet. The green line with markers indicates the statistical mean for each minute. The purple line is the numeric response equal to neutral.

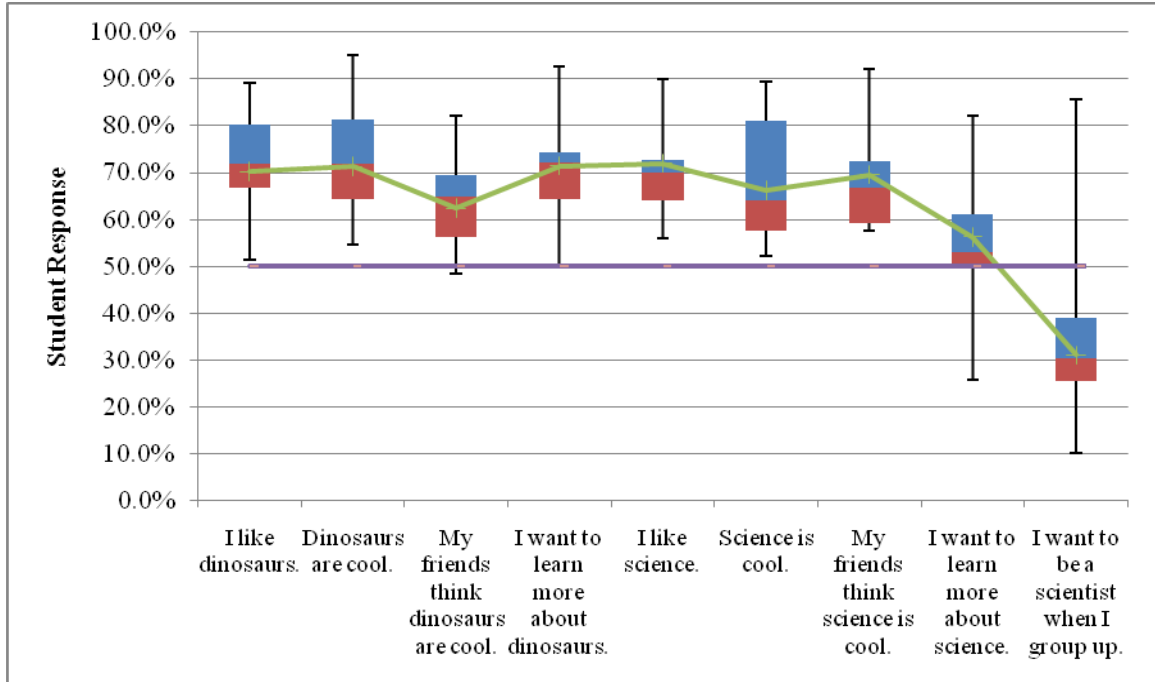


Figure 6. Box-and-Whisker Plot of the Statistical Mean Including Pre-Visit and Post-Visit Responses of Each Question of the Student Attitude Survey Completed by Students who Participated in a Self Tour with an Activity of the *Dinosaurs under the Big Sky* exhibit at the Museum of the Rockies ($N=9$). Boxes represent the inter-quartile range (25th to 75th percentile), and whiskers indicate the minimum and maximum values. The statistical median is represented by the point where the red and blue boxes meet. The green line with markers indicates the statistical mean for each minute. The purple line is the numeric response equal to neutral.

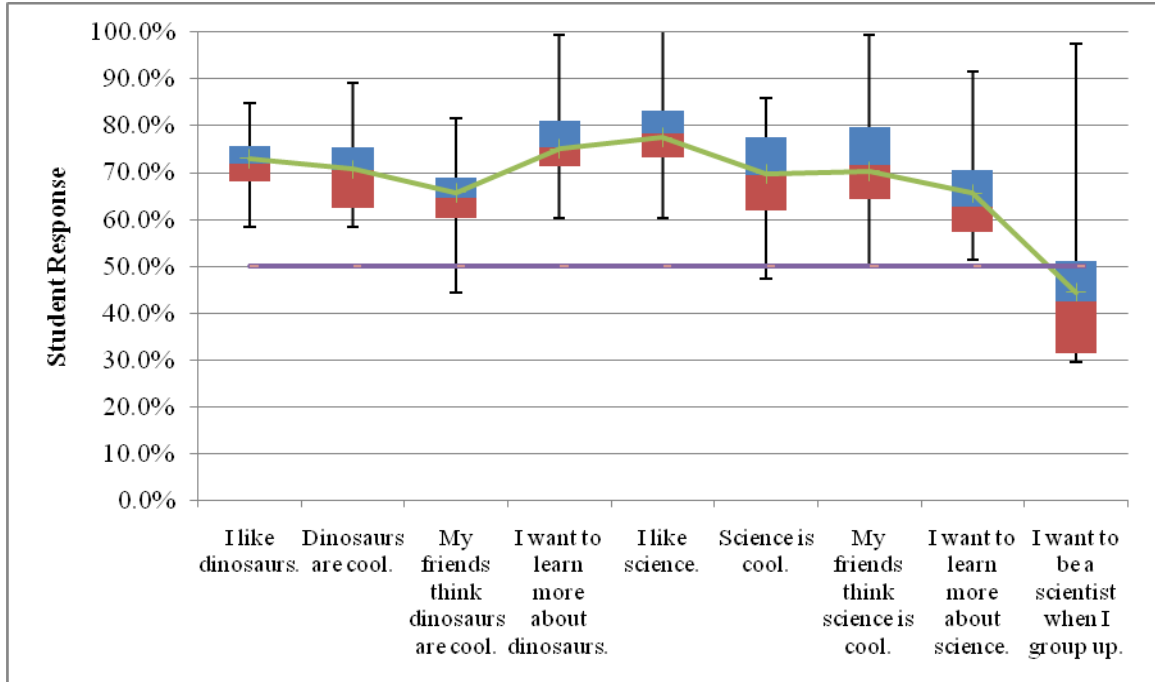


Figure 7. Box-and-Whisker Plot of the Statistical Mean Including Pre-Visit and Post-Visit Responses of Each Question of the Student Attitude Survey Completed by Students who Participated in a Self Tour without an Activity of the *Dinosaurs under the Big Sky* exhibit at the Museum of the Rockies ($N=8$). Boxes represent the inter-quartile range (25th to 75th percentile), and whiskers indicate the minimum and maximum values. The statistical median is represented by the point where the red and blue boxes meet. The green line with markers indicates the statistical mean for each minute. The purple line is the numeric response equal to neutral.

Students that received a guided tour, self toured with an activity, and self toured without an activity had a positive change for three of the four statements relating to dinosaurs before and after their visits. However, these increases in student responses are small. Students receiving a guided tour had a negative change, showing a less positive reaction after their visit to the statement, “I want to learn more about dinosaurs.” Students who participated in self tours, however, had a more positive reaction to this same statement after their visit to the *Dinosaurs under the Big Sky* exhibit. All types of students also responded more positively to the statement, “I want to learn more about science,” after their tour. The changes in the response to each statement in the Student

Attitude Survey for students receiving guided tours and participating in self tours with an activity and without an activity for each survey statement is shown in Figure 8.

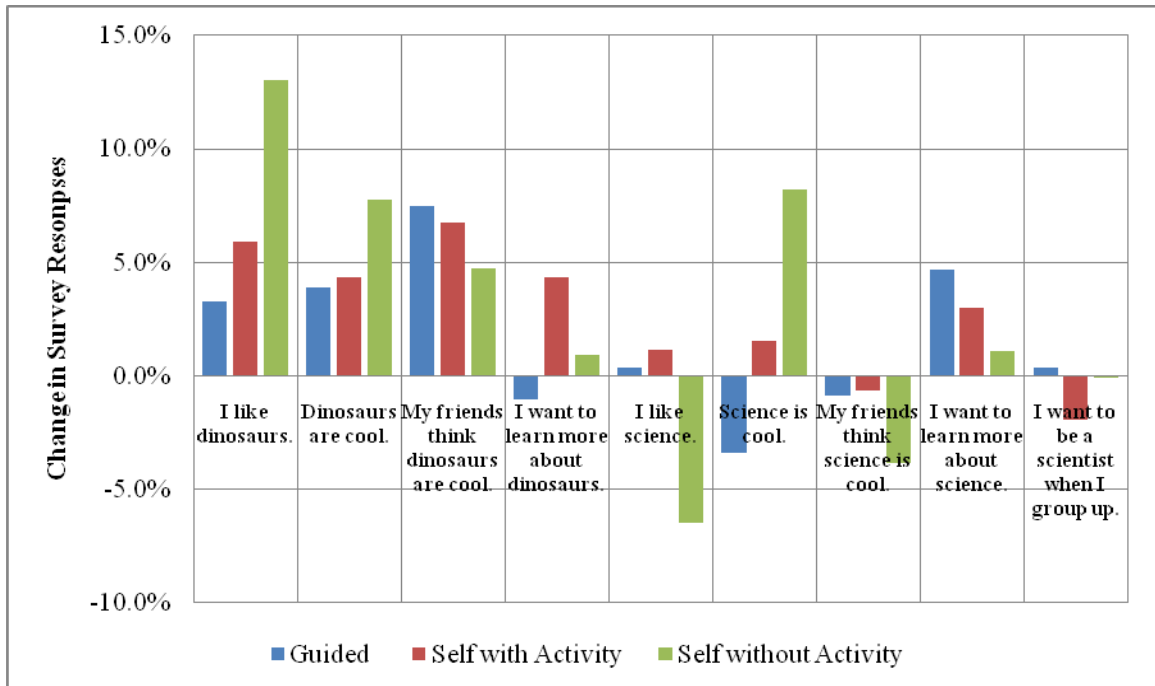


Figure 8. Numeric Changes in Student Attitude Survey Responses for Students Receiving a Guided Tour ($N=12$), Participating in a Self Tour with an Activity ($N=9$), and Participating in a Self Tour without an Activity ($N=8$) in the *Dinosaurs under the Big Sky* exhibit at the Museum of the Rockies. A positive change reflects a higher post-visit response than the pre-visit response.

Student Knowledge, Attitude, and Engagement using Teacher Resources

Despite each teacher's feelings towards how engaged their students were during their tour and what knowledge their students gained as a result of their tour, most teachers attitudes included a desire and need for improvement of tours at the Museum of the Rockies. Most suggestions focused on educational tools.

Of the 12 teachers whose students participated in a self tour, 11 shared that they have used or would like to use an educational activity or worksheet with their students during the self tour of the *Dinosaurs under the Big Sky* exhibit. One of these teachers indicated that he or she would facilitate a hands-on activity in the exhibit, but would not

use a “worksheet.” A sixth-grade teacher stated, “Any tools, ie. worksheets, you could provide which I could modify would of course be appreciated. Thanks for working towards improvement.” Even one teacher whose students received a guided tour of the dinosaur halls shared a desire for educational tools. “In the event I could not schedule a guided tour, I would like to have age appropriate work packets - (like a scavenger hunt?) so that the children would gain accurate info.”

Teachers also shared that any educational tools generated for use in the dinosaur halls must be appropriate and fit individual teacher needs. A first grade teacher stated, “A scavenger hunt for younger children would be great. But the reading level must be appropriate. I would recommend consulting with K-3 teachers to make sure any materials are at the correct reading level.” A sixth grade teacher shared that he would use a Museum worksheet, “if it was in alignment with my class goals.” A first grade teacher stated, “It would be wonderful if someone had the time to write up questions and suggestions for each section based on particular grade levels.” Another first grade teacher echoed the importance of grade level based educational tools sharing that she would use a worksheet the Museum generated, “if it was age-appropriate for my students (reading level).”

A first grade teacher expressed one benefit of classroom teachers that live close to the Museum of the Rockies. “I often go to the museum the weekend before I bring the children and make notes for myself so I know what I want to cover. I was unable to do that this year and it made a difference.” A small rural kindergarten through sixth grade teacher mirrored this comment. “A worksheet or something like that would definitely

help, especially for someone like me who came from out of town I couldn't go tour the Museum before to put together my worksheet before hand."

Students that participated in a self tour and used the educational materials generated as a result of this study were actively engaged 66.8% of the time and passively engaged 21.0% of the time, with a mean of 87.8% engagement throughout the tour. These same students demonstrated off-task motor behavior 2.2% of the time, off-task verbal behavior 3.9% of the time, and off-task passive behavior 6.2% of the time, with a mean for off-task behavior of 12.2%. Individual school group results for engagement of students participating in self tours without an activity can be seen in Figure 9.

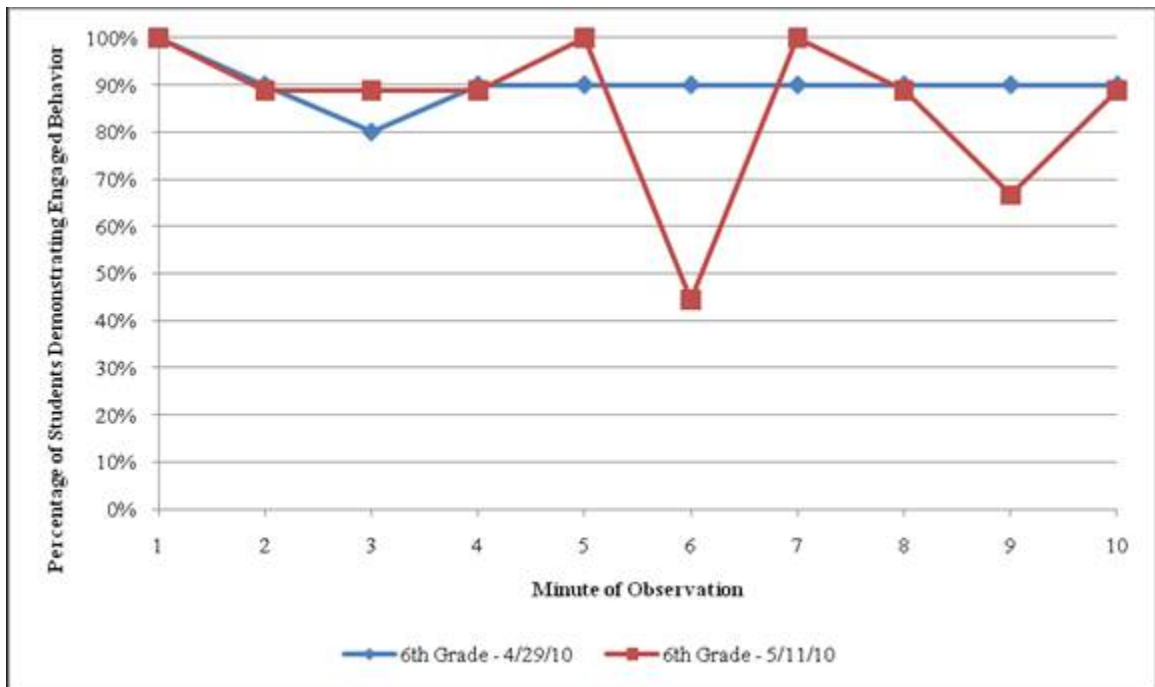


Figure 9. Percentages of Engagement for School Groups using Developed Educational Tools by Minute during Self Tours of the *Dinosaurs under the Big Sky* exhibit at the Museum of the Rockies ($N=2$).

Statistical means for each minute of the study period for students receiving guided tours, self touring with an activity, self touring without an activity, and self touring using the Teacher's Resources developed are shown in Figure 10.

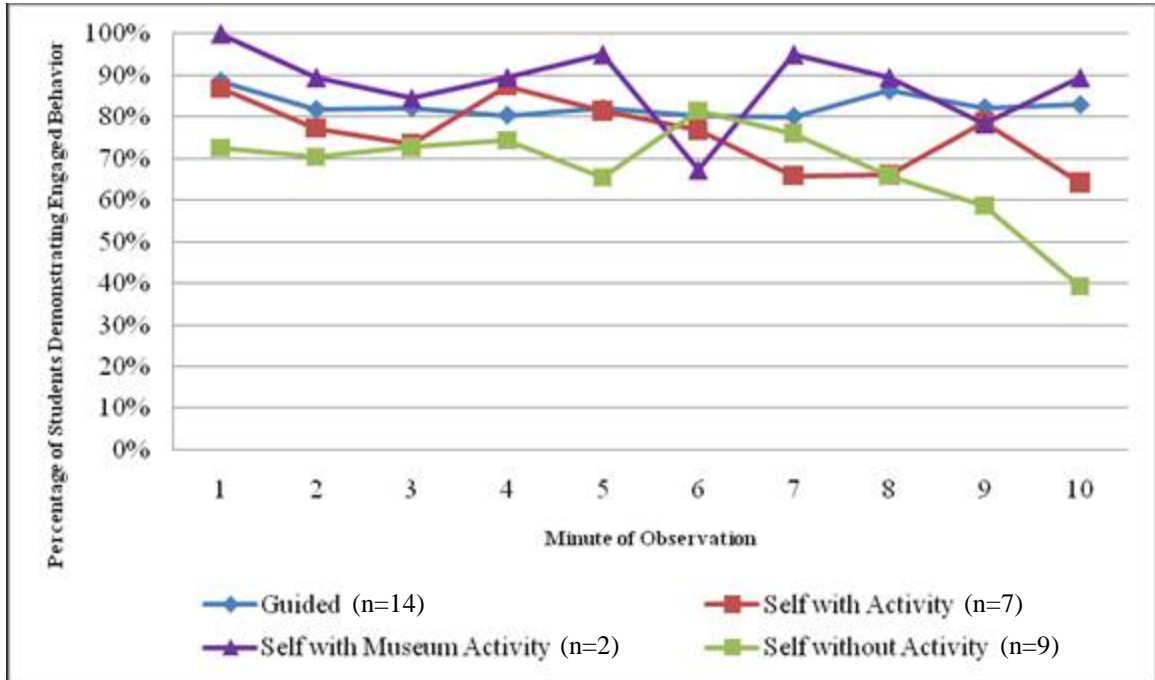


Figure 10. Percentages of Engagement for All School Groups by Minute by Tour Type of the *Dinosaurs under the Big Sky* exhibit at the Museum of the Rockies.

Students that used the developed educational tools during their self tour of the *Dinosaurs under the Big Sky* exhibit had a mean score of 76.0% on the Level One Content Quiz (raw score of 6.84 out of 9.0, standard deviation of 0.12) before their visit. After their visit, these same students had a mean score of 81.9% on the Level One Content Quiz (raw score of 7.37 out of 9.0, standard deviation of 0.12). On average, these students scored 5.8% higher after their self tour using the educational tools generated as a result of this study (raw score of 0.52, standard deviation of 0.00).

Out of the three school groups who tested the educational tools created, only one group completed the Level Two Content Quiz. This group had a mean score of 64.7% on the Level Two Content Quiz before their visit (raw score of 5.82 out of 9.0). After their visit, this group had a mean score of 64.9% on the Level Two Content Quiz (raw score of 5.84 out of 9.0). On average, these students scored 0.2% higher after their self tour using the educational tools generated as a result of this study (raw score change of 0.02).

Results for pre- and post-visit Content Quizzes taken by students receiving a guided tour, students self touring with an activity, students self touring without an activity, and students self touring using the educational resources developed as a result of this study are shown in Table 5.

Table 5
Statistical Means for Pre- and Post-Visit Content Quiz Results of All Types of School Groups Including Students Using Developed Educational Tools

Tour Type	Level 1			Level 2		
	Pre-Visit	Post-Visit	Change	Pre-Visit	Post-Visit	Change
Guided Tour	67.2% n=13	79.1% n=13	12.0% n=13	63.4% n=4	72.2% n=4	8.8% n=4
Self Tour with Activity	76.1% n=5	84.4% n=5	8.3% n=5	67.7% n=3	68.0% n=3	4.4% n=3
Self Tour without Activity	65.9% n=6	69.6% n=6	3.8% n=6	66.6% n=1	64.9% n=1	-1.7% n=1
Self Tour with Developed Educational Resources	76.0% n=2	81.9% n=2	5.8% n=2	64.7% n=1	64.9% n=1	0.2% n=1

Like all other categories of school group visitors in this study, the results of Student Attitude Surveys for students that used the Teacher Resources generated a result of this study were mixed. Statistical means and standard deviations for the Student Attitude Survey completed by students participating in self tours using the Teacher Resources developed as a result of this study are shown in Table 6.

Table 6
Statistical Means for Pre- and Post-Visit Scores and Changes in Student Attitude Surveys for Students who Participated in a Self Tour using Developed Educational Resources (N=2).

Survey Question	Pre-Visit	Post-Visit	Change
I like dinosaurs.	61.7%	64.3%	3.7%
Dinosaurs are cool.	63.3%	64.3%	2.3%
My friends think dinosaurs are cool.	52.3%	56.3%	3.7%
I want to learn more about dinosaurs.	68.3%	70.0%	1.7%
I like science.	69.0%	65.0%	-0.1%
Science is cool.	58.0%	58.0%	0.0%
I want to learn more about science.	67.7%	62.7%	5.7%
My friends think science is cool.	47.7%	52.3%	4.3%
I want to be a scientist when I grow up.	30.3%	30.0%	0.0%

Note. Responses are on a scale with 0% representing the response *strongly disagree* and 100% representing *strongly agree*.

Teacher responses to the online Teacher Survey indicate a positive attitude towards the educational resources generated as a result of this study. When a sixth grade teacher who used the educational tools was asked if she was satisfied with the level of student engagement during her group's self tour, she responded, "Yes. The scavenger hunt kept the students on task." The other teacher who used the educational resources and provided feedback agreed, though stated that it kept the students only "somewhat" focused. The feedback from these two teachers echoed earlier educator feedback regarding a variety of options, levels, and tools to meet a range of educational goals and

the needs of many teachers. One of the teachers recognized the levels created and shared, “Yes, I liked that there were four options that could be used at different grade levels.”

The other teacher suggested another way the educational resources could be modified to fit the needs of more teachers. “The scavenger hunt was a great idea, although a shorter version would be helpful. Most of our kids were not able to finish.”

INTERPRETATION AND CONCLUSION

School groups that visit the Museum of the Rockies to learn more about dinosaurs and paleontology typically chose to receive a guided tour of the *Dinosaurs under the Big Sky* exhibit. Guided tours give students the opportunity to ask questions, touch real fossils, and learn about dinosaurs through inquiry and discussion. This study verified that students who receive guided tours demonstrate a high level of engagement (82.7%) and the largest increase in student knowledge (12.0% on Level One Content Quiz). Data collected through this study on students that received guided tours provided a standard by which to compare other school group visitors, including those students that self toured with and without an activity to complete.

Students who self toured the *Dinosaurs under the Big Sky* exhibit using an activity demonstrated a higher frequency of engagement (79.2%) than self touring students without an activity to complete (69.1%). The students that used the educational resources generated as a result of this study had the highest frequency of engaged behavior of all school groups (87.8%). The sample size for students using the educational resources generated from this study, however, was significantly smaller than the other categories of students used in this study. Because of the small sample size being used for analysis, these results may or may not be an indication of how these tools

would affect all students. Data collected regarding student engagement during tours clearly indicated that students who self tour without an activity were not as engaged in the learning process as students who completed an activity while self touring.

Students who self toured with an activity also had a greater increase in understanding of major exhibit concepts than students who self toured without an activity. These students who completed an activity had an average increase of 8.3% on the Level One Content Quiz. Students who used the educational resources while self touring had an average increase of 5.8% on this quiz. Again, data for students who participated in a self tour using the developed educational resources was generated using a significantly smaller data set than the other groups. The students who participated in a self tour without an activity only had an increase of 3.8%. This data indicated that using an activity while participating in a self tour, including the educational resources generated as a result of this study, did not lead to student learning comparable to students receiving guided tours. However, the students who completed an activity while participating in a self tour learned more than students who did not use an activity during their self tour. For those students that do not have the opportunity to receive a guided tour of the *Dinosaurs under the Big Sky* exhibit, providing teachers with an activity for their students to complete during their tour could increase student learning during school group visits to the Museum.

Data collected on student attitudes towards dinosaurs and science indicated that students who visited the *Dinosaurs under the Big Sky* exhibit at the Museum of the Rockies had positive attitudes towards dinosaurs and science in general regardless of the type of tour they participated in during their visit. Student responses to eight out of nine

statements regarding dinosaurs and science had above neutral mean values for all types of school group tours.

All types of students, including those who used the educational resources developed, also revealed an increased positive attitude towards paleontology through small positive changes for three of the four statements relating to dinosaurs before and after their visits. These increases may have indicated a greater interest in dinosaurs as a result of touring. However, these increases in student responses were small and other statements regarding science had both positive and negative changes that revealed inconsistencies in student attitudes. Therefore, this data may or may not have been an indication of the overall effects of the educational tools developed or student attitudes towards science and dinosaurs. Data from the Student Attitude Surveys regarding science in general not just dinosaurs, suggested the tours and educational resources developed may have had little to no effect on student attitudes towards science in general.

Even though student responses to these eight statements were positive before and after visiting the Museum, there were some surprising changes in statistical means regarding student attitudes. A negative change in student attitudes for self touring students without an activity regarding “I like science,” guided tour students regarding “Science is cool,” and all students regarding “I want to learn more about science,” could lead to multiple conclusions. Student responses ranged greatly, even from just one student. Multiple students would show large differences in attitudes between similar questions. This may indicate that the Student Attitude Survey questions were confusing and needed to be modified.

Negative changes for two of the three groups regarding “I want to learn more about dinosaurs” was also surprising. As with the other negative changes in this data set, reasons for these changes are unknown, as students were not asked to comment on their experience. These surprising changes could be an indication of a negative experience at the Museum, or simply confusing questions. During observations of student engagement, however, very few negative comments, attitudes, or behaviors were observed from all three groups of students. Most students demonstrated behaviors reflecting a positive attitude towards their experiences. This data was not collected formally though and cannot be used to confirm or challenge the results of the Student Attitude Survey.

This study has shown that students who received guided tours of the *Dinosaurs under the Big Sky* exhibit demonstrated a high level of student engagement and the largest increase in learning of all types of tours. Students that did not receive a guided tour demonstrated an increased level of engagement and learned more by completing activities while participating in a self tour. Students that used the educational tools developed as a result of this study for their self tour of the *Dinosaurs under the Big Sky* exhibit at the Museum of the Rockies had similar results to their peers who used other types of activities.

Limited teacher feedback and minimal student data prevent drawing conclusions regarding the effects of the educational resources created as a result of this study. Instead, the suggestions of the two teachers who provided feedback and the limited data collected can and will lead to modifications of the educational tools and further studies of the effects of educational resources for self tours. This data reaffirmed that students with

an activity to complete demonstrate a higher level of engagement during self tours than students without an activity.

VALUE

As the Early and Elementary Education Specialist at the Museum of the Rockies, I directly teach close to 2,500 students annually, but indirectly the Museum's educational programming reaches more than 7,000 school children and 150,000 visitors each year. I educate numerous groups of visitors and volunteers including babies, toddlers, elementary students, families, school groups, and the Museum's core of volunteer docents. This project focused on a group of visitors I had not spent much time with in my two years at the Museum – school children. School groups continue to visit the Museum of the Rockies regardless of the traveling exhibits the Museum hosts, the Planetarium shows offered, or how many times they have toured the *Dinosaurs under the Big Sky* exhibit. School groups are a loyal population that in recent history the Museum's Education Department has overlooked. I chose this study because it allowed me to spend more time with these school children that I knew so little about.

Before this study I was aware that our visiting school groups needed more attention. However, I never made the time to evaluate how I, as an educator, could help these students get more from their museum visit. In the hours I spent watching school children tour the *Dinosaurs under the Big Sky* exhibit, I developed an understanding of student behavior and needs within the Museum's dinosaur exhibit. I could see students lose focus and speed past key dinosaur fossils. I observed teachers present inaccurate information within the dinosaur halls because of a lack of contact and comfort with the

exhibit's content. Once I understood the challenges these school groups faced, I then began to appreciate this group's unique needs – needs that I had previously overlooked.

As a museum educator I play a critical role in conveying the Museum's content to all visitors, including those with whom I do not have direct contact. School groups visiting the Museum need resources regardless of their itinerary during their visit. As a direct result of this study I have developed an appreciation for collaboration with teachers and the importance of museum visits for school children. Teachers who frequent the Museum need to be included in the process of generating resources. The teachers who agreed to be involved in the process of developing and testing the educational resources I created as a result of this study were eager and excited to contribute to and provide feedback for tools for visiting teachers.

Because each school group has different needs, teacher resources need to be flexible, adaptable to different ages and abilities, and cover a wide range of educational goals. There is no perfect educational resource that will work well for any classroom. Collaboration with teachers to discover their needs is vital to facilitating successful school field trips. I cannot generate activities and expect teachers to use them nor can I read research and decide to implement just free-choice learning. As a museum educator, I need to listen to visiting teachers, learn their goals and objectives, and lead them towards adaptable resources. Prior to this study, I expected teachers to adapt to the resources we had available. With a new appreciation for these educators' constraints and needs, I now know that I am the one that needs to show flexibility.

Throughout the course of this study, I was also able to observe the effects school group visits have on the students that come with their school. Visiting the Museum of the

Rockies is a big deal to most of the students that go to the Museum with their class. The Museum has the potential to impact thousands of students' lives each year. Providing these students with meaningful experiences through engaging activities and tours can make a larger impact on school children in Montana than classes I directly teach for the Museum of the Rockies. Without observing school group tours through this study, I would not have understood or appreciated the excitement and enthusiasm for paleontology and science these young learners experience as soon as they see the "Big Mike" bronze *T.rex* outside MOR. Although Student Attitude Surveys indicate otherwise, the majority of students I observed the Museum's *Dinosaurs under the Big Sky* exhibit are eager to observe and learn more.

In addition to direct impacts this study has had on me, this project has also affected and will affect thousands of students and teachers. The educational resources I created through this study will be edited by paleontology staff and/or volunteers, modified based on teacher feedback, and shared with all teachers visiting the Museum of the Rockies starting in the fall of 2010. Teachers will receive information about these resources when they plan their Museum visits and will be encouraged to find dinosaur and science-based activities that would meet their students' needs. These resources have the potential to reduce preparation time for teachers for school group visits to the Museum of the Rockies, relay clear educational objectives for the dinosaur halls, and provide background information on paleontology for those teachers that are looking to enhance student learning through pre- and post-lessons. Additionally, teachers from outside the Gallatin Valley will have resources that only local teachers were able to generate for their classes in the past.

This new resource for school teachers will in turn positively affect their students. Activities and an increased understanding of exhibit content amongst teachers has the potential to increase student engagement and, as a result, increase student learning and interest in science. With 7,000 school children visiting the Museum from all around the state each year, the educational impact of this study could be significant.

Outside of the impact on school children at the Museum of the Rockies, this study will also affect other non-traditional educational institutions. The Museum's Education Department often serves as a model for smaller Montana museums. These museums base their educational programming, outreach materials, and teacher's resources on what MOR offers. By sharing the findings of this small study with educators at other regional museums, I have the opportunity to increase a regional understanding of the effects of self tours on school groups and extend the impact of this project to thousands more learners.

This project has undoubtedly changed my awareness of the needs of school groups into a deeper appreciation of the impact the Museum of the Rockies has on thousands of Montana school children annually. It has also shaped my outlook and goals as a museum educator responsible for meeting visiting school group and teacher needs. With continual teacher collaboration, development of teacher resources, and communication with other regional museums and non-traditional learning institutions, this study has the potential to affect thousands of educators, teachers, and school children.

REFERENCES CITED

- Atkins, L., Velez, L., Goudy, D. & Dunbar, K. (2009). The unintended effects of interactive objects and labels in the science museum. *Science Education* 93(1), 161-184.
- Bamberger, Y. & Tal, T. (2006). Learning in a personal context: Levels of choice in a free choice learning environment in science and natural history museums. *Science Education* 91(1), 75-95.
- Bamberger, Y. & Tal, T. (2008). Multiple outcomes of class visits to natural history museums: The students' view. *Journal of Science Education and Technology* 17(3), 274-284.
- Banz, R. (2008). Self-directed learning: Implications for museums. *Journal of Museum Education* 33(1), 43-54.
- Falk, J. H. (2001). *Free-choice science education: How we learn science outside of school*. New York: Teachers College Press.
- Falk, J. H. (2005). Free-choice environmental learning: Framing the discussion. *Environmental Education Research* 11(3), 265-280.
- Guisasola, J., Morentin, M., & Zuza, K. (2005). School visits to science museums and learning sciences: a complex relationship. *Physics Education* 40(6), 544-549.
- Kisiel, J. (2005) Understanding Elementary Teacher Motivations for Science Fieldtrips. *Science Education*, 89, 936-955.
- Kisiel, J. (2007). Examining teacher choices for science museum worksheets. *Journal of Science Teacher Education* 18(1), 29-43.
- National Resource Council. (1996). *National Science Education Standards*. Washington, DC: National Academy Press.
- Palmquist, S. & Crowley, K. (2007). From teachers to testers: How parents talk to novice and expert children in a natural history museum. *Science Education* 91(5), 783-804.
- Tran, L. (2006). Teaching science in museums: The pedagogy and goals of museum educators. *Science Education* 91(2), 278-297.
- Van Moer, E., De Mette, T. & Elias, W. (2008). From obstacle to growth: Dewey's legacy of experience-based art education. *International Journal of Art & Design Education* 27(1), 43-52.

REFERENCES CITED CONTINUED

- Vile Junod, R. E., DuPaul, G. J., Jitendra, A. K., Volpe, R. J., & Cleary, K. S. (2005). Classroom observations of students with and without ADHD: Differences across types of engagement. *Journal of School Psychology 44(2006), 87-104.*

APPENDICES

APPENDIX A

SELF TOUR PROJECT PARTICIPATION AGREEMENT

Appendix A Self Tour Project Participation Agreement

MUSEUM OF THE ROCKIES
Montana State University



touch history

RE: Museum of the Rockies Self Tour Study Participation Agreement

Dear Teacher,

You are being asked to participate in a project that seeks to understand the effects of self tours on school-aged children in the Museum of the Rockies' *Dinosaurs under the Big Sky* exhibit. The purpose of this study is to gain an understanding of and improve the use of exhibit based education materials for visiting school groups within the *Dinosaurs under the Big Sky* exhibit. You have been selected because your class will be visiting the Museum of the Rockies' *Dinosaurs under the Big Sky* exhibit for a guided tour or self tour during the study period.

If you agree to participate you will be asked to administer a Content Quiz and Student Attitude Survey to your students before your visit. While you are at the Museum, I will be observing your students during your guided or self tour. After your visit, you will be asked to administer the same Content Quiz and Student Attitude Survey to your students and answer questions about the effect of touring and student attitudes towards touring using an online survey. The survey will take ten to fifteen minutes of your time.

You may choose not to participate or to withdraw your consent at any time without penalty. Your decision to participate/ not to participate in this study will not result in any benefits or disadvantages.

There are no costs for participating in this project.

Any personal information collected with the survey or interview will be deleted, masked, and/or otherwise changed to ensure confidentiality consistent with professional standards for this kind of research. The data will be kept confidential and secured in locked offices or in password protected computers. No one outside the principal investigator will have access to the data. In research papers, funding proposals, or other public presentations resulting from this study, your name will not be used and any identifying characteristics or personal information that could be used to identify you will be deleted or masked. Your responses will be tallied and combined with all other respondents as summative/cumulative data.

Please feel free to ask any questions regarding this study prior, during, or after your participation. Your participation in this study is confidential and voluntary.

Thank you in advance for your help and participation!

Angie Hewitt
Early/Elementary Education Specialist
angela.hewitt@montana.edu
406.994.6618

600 WEST KAGY BOULEVARD • BOZEMAN, MONTANA 59717
P 406.994.2251 F 406.994.2682 museumoftherockies.org

Please sign and return the following form to confirm your participation in this project.

AUTHORIZATION:

I have read the above and understand the discomforts, inconvenience and risks of this study. I, _____ (name of subject), agree to participate in this study. I understand that I may later refuse to participate, and that I may withdraw from the study at any time. I have received a copy of this consent form for my own records.

Signed: _____

Date: _____

APPENDIX B

SELF TOUR PROJECT INSTRUCTIONS

Appendix B Self Tour Project Instructions



RE: Museum of the Rockies Self Tour Study Instructions

Dear Teacher,

Thank you for agreeing to participate in a project that seeks to understand the effects of self tours on school-aged children in the Museum of the Rockies' *Dinosaurs under the Big Sky* exhibit. Please review the following expectations for your participation.

Before your visit:

Please administer a content quiz before your visit. These quizzes are designed to evaluate what students learn during their time at the Museum. Therefore, students are not expected to know the answers before their visit. There are three content quizzes to choose from. If your students have never studied dinosaurs please use Level 1. If your students have studied dinosaurs extensively before, please use Level 3. The quiz you choose should reflect what the students' knowledge level will be after their visit, not before.

Please administer the Student Attitude Survey appropriate for your students' grade level as well. The Content Quiz and Student Attitude Survey can be copied back-to-back to save paper if desired.

To accurately compare the results of the Content Quiz and Student Attitude Survey before and after your students' visit, please have students complete the information at the top right corner of the Content Quiz and Attitude Survey. All information given (including student names, teacher names, and school names) will be masked by the investigator. Names are used only for matching each student's Content Quizzes and Student Attitude Surveys.

During your visit:

The purpose of this study is to determine the effects of self tours on school groups. Therefore, you and/or your docent (tour guide) do not need to change your methods of touring. The study will look at every technique used to determine what is most effective for touring groups.

When you divide your students into small groups for their guided or self tour, please identify one group to be observed by the investigator. This group should be a good sample of your students and include a wide-range of academic abilities and maturity levels. You do not have to be the chaperone that accompanies this group; however, the chaperone should manage the group (and guide the self tour if applicable) in a style that reflects your expectations.

While touring, the investigator will be taking notes on student engagement by recording academic engagement at one minute intervals for ten minutes for the chosen study group. The number of students demonstrating various types of engagement and off-task behavior will be recorded at each interval using tally marks. Any actions before or after this ten minute observational period will not be recorded.

In addition to recording academic engagement, the observer will also make note of chaperone and docent methods used to maintain student focus, methods used to teach exhibit content during the self tour, and student and chaperone comments that reflect attitudes towards the exhibit, self tour or guided tour, and major exhibit concepts. The observer will note if self touring students used an educational activity, student attitudes towards the use and difficulty of the educational activity, how the activity is utilized, and techniques chaperones use to encourage comprehension of concepts while self touring. Please bring an extra copy of your educational tool for the investigator. All of these comments will be recorded with written notes by an observer that does not interact with the self touring group.

After your visit:

Please administer the same Content Quiz and Student Attitude Survey to your students after your visit. This can be done at the museum or back in your classroom. If you choose to administer the quiz and survey in your classroom, please do this the next time your class meets to reduce the impacts time may have on student memory. Please return the ungraded sets of Content Quizzes and Student Attitude Surveys to the investigator within a week of your visit using the provided envelope with postage paid. (You will receive this envelope during your visit.)

Feel free to ask any questions regarding this study prior, during, or after your participation. Your participation in this study is confidential and voluntary.

Thank you in advance for your help and participation!

Angie Hewitt
Early/Elementary Education Specialist
angela.hewitt@montana.edu
406.994.6618

APPENDIX C

CONTENT QUIZ LEVEL 1

Appendix C
Content Quiz Level 1



Dinosaurs under the Big Sky exhibit
Content Quiz
Level 1

Student: _____
Teacher: _____
School: _____
Circle one: Pre-visit Post-visit

1. Choose the correct definition for the following words:
 - a. Hypothesis _____ A scientific idea that hasn't been proven wrong after many tests
 - b. Theory _____ An educated guess supported by physical evidence like fossils
 - c. Science _____ A process of observing, testing, and learning from mistakes

2. Circle all answers that correctly complete this sentence.
A dinosaur...
 - a. Is cold-blooded and cannot control its body temperature.
 - b. Has legs directly under its body, not sprawled to the side.
 - c. Lived during the time of cavemen.
 - d. Breathes underwater.

Choose the best answer for the following questions.

3. What does a geologist study?
 - a. Rocks and fossils
 - b. Living animals
 - c. Water
 - d. Human history

4. Circle the animal most closely related to dinosaurs.
 - a. Crocodiles
 - b. Lizards
 - c. Birds
 - d. Woolly Mammoth

True or False

5. All extinct animals are dinosaurs. TRUE FALSE
6. Dinosaurs laid eggs in nests like birds..... TRUE FALSE
7. Dinosaurs dragged their tails. TRUE FALSE
8. All dinosaurs ate meat. TRUE FALSE
9. Giant sea monsters lived in parts of Montana millions of years ago. TRUE FALSE
10. Relatives of dinosaurs are still alive today..... TRUE FALSE



Dinosaurs under the Big Sky exhibit
 Content Quiz
 Level 1 - KEY

Student: KEY
 Teacher: _____
 School: _____
 Circle one: Pre-visit Post-visit

1. Choose the correct definition for the following words:
- a. Hypothesis B A scientific idea that hasn't been proven wrong after many tests
 - b. Theory A An educated guess supported by physical evidence like fossils
 - c. Science C A process of observing, testing, and learning from mistakes

2. Circle all answers that correctly complete this sentence.
A dinosaur...

- a. Is cold-blooded and cannot control its body temperature.
- b. **Has legs directly under its body, not sprawled to the side.**
- c. Lived during the time of cavemen.
- d. Breathes underwater.

Choose the best answer for the following questions.

3. What does a geologist study?
- a. **Rocks and fossils**
 - b. Living animals
 - c. Water
 - d. Human history
4. Circle the animal most closely related to dinosaurs.
- a. Crocodiles
 - b. Lizards
 - c. **Birds**
 - d. Woolly Mammoth

True or False

- | | | | |
|-----|--|-------------|--------------|
| 5. | All extinct animals are dinosaurs. | TRUE | FALSE |
| 6. | Dinosaurs laid eggs in nests like birds. | TRUE | FALSE |
| 7. | Dinosaurs dragged their tails. | TRUE | FALSE |
| 8. | All dinosaurs ate meat. | TRUE | FALSE |
| 9. | Giant sea monsters lived in parts of Montana millions of years ago. | TRUE | FALSE |
| 10. | Relatives of dinosaurs are still alive today. | TRUE | FALSE |

APPENDIX D

CONTENT QUIZ LEVEL 2

Appendix D
Content Quiz Level 2



Dinosaurs under the Big Sky exhibit
Content Quiz
Level 2

Student: _____
Teacher: _____
School: _____
Circle one: Pre-visit Post-visit

1. Choose the correct definitions for the following scientific theories:
 - a. Extinction _____ Some elements break down into other materials at known speeds. How much of these elements are left can tell scientists the age of the rocks they make up.
 - b. Darwinian evolution _____ New types of plants and animals come from old types of plants and animals. Animals that have characteristics that give them advantages in their environment will reproduce and pass these successful characteristics onto their offspring. Over time, a group of animals will change to all have these helpful characteristics.
 - c. Radiometric Dating _____ Some plants and animals that once lived are now extinct.
2. Most dinosaur fossils found in Montana are from what two periods?
 - a. Jurassic, Triassic
 - b. Jurassic, Cretaceous
 - c. Triassic, Cretaceous
3. A sauropod is...
 - a. A swimming reptile
 - b. A flying reptile
 - c. A duck-billed dinosaur
 - d. A long necked dinosaur
4. The ARRANGEMENT of fossils in the ground tells paleontologists about
 - a. The color of the fossil.
 - b. What life was like before dinosaurs.
 - c. How old a dinosaur was when it died.
 - d. How a dinosaur lived and died.
5. What piece of physical evidence DOES NOT support the hypothesis that birds are living dinosaurs?
 - a. Some dinosaurs had a wishbone.
 - b. Some dinosaurs had feathers.
 - c. Dinosaurs had a backbone.
 - d. Dinosaurs laid hard-shelled eggs.

True or False

- | | | |
|--|------|-------|
| 6. The size and shape of eggs changes depending on the type of dinosaur that laid them | TRUE | FALSE |
| 7. Scientists make hypotheses without physical evidence based on their opinions. | TRUE | FALSE |
| 8. All dinosaurs walked on four legs..... | TRUE | FALSE |
| 9. Some dinosaurs hunted in packs..... | TRUE | FALSE |
| 10. Regardless of where a fossil is found, it belongs to the federal government. | TRUE | FALSE |



Dinosaurs under the Big Sky exhibit
 Content Quiz
 Level 2 – KEY

Student: KEY
 Teacher: _____
 School: _____
 Circle one: Pre-visit Post-visit

1. Choose the correct definitions for the following scientific theories:
 - a. Extinction C Some elements break down into other materials at known speeds. How much of these elements are left can tell scientists the age of the rocks they make up.
 - b. Darwinian evolution B New types of plants and animals come from old types of plants and animals. Animals that have characteristics that give them advantages in their environment will reproduce and pass these successful characteristics onto their offspring. Over time, a group of animals will change to all have these helpful characteristics.
 - c. Radiometric Dating A Some plants and animals that once lived are now extinct.
2. Most dinosaur fossils found in Montana are from what two periods?
 - a. Jurassic, Triassic
 - b. **Jurassic, Cretaceous**
 - c. Triassic, Cretaceous
3. A sauropod is...
 - e. A swimming reptile
 - f. A flying reptile
 - g. A duck-billed dinosaur
 - h. **A long necked dinosaur**
4. The ARRANGEMENT of fossils in the ground tells paleontologists about
 - a. The color of the fossil.
 - b. What life was like before dinosaurs.
 - c. How old a dinosaur was when it died.
 - d. **How a dinosaur lived and died.**
5. What piece of physical evidence DOES NOT support the hypothesis that birds are living dinosaurs?
 - a. Some dinosaurs had a wishbone.
 - b. Some dinosaurs had feathers.
 - c. **Dinosaurs had a backbone.**
 - d. Dinosaurs laid hard-shelled eggs.

True or False

6. The size and shape of eggs changes depending on the type of dinosaur that laid them TRUE FALSE
7. Scientists make hypotheses without physical evidence based on their opinions. TRUE FALSE
8. All dinosaurs walked on four legs. TRUE FALSE
9. Some dinosaurs hunted in packs. TRUE FALSE
10. Regardless of where a fossil is found, it belongs to the federal government. TRUE FALSE

APPENDIX E

CONTENT QUIZ LEVEL 3

Appendix E
Content Quiz Level 3



Dinosaurs under the Big Sky exhibit
Content Quiz
Level 3

Student: _____
Teacher: _____
School: _____
Circle one: Pre-visit Post-visit

1. Choose the correct definition for the following words:
 - a. Ontogeny _____ The development of an organism from an embryo to adult
 - b. Histology _____ The observation and interpretation of a fossil site
 - c. Taphonomy _____ The study of bone structure

2. Arrange the periods of the Mesozoic Era from OLDEST TO THE MOST RECENT.
 - a. Triassic , Jurassic, Cretaceous
 - b. Jurassic, Cretaceous, Triassic
 - c. Cretaceous, Jurassic, Triassic
 - d. Triassic, Cretaceous, Jurassic

3. Which one of the following traits of dinosaurs do paleontologists NOT have physical evidence for?
 - a. Feathers
 - b. Skin textures
 - c. Colors
 - d. Muscles

4. What best explains the non-extinction hypothesis?
 - a. Animals related to dinosaurs can be found above the Cretaceous-Tertiary boundary; therefore, relatives of dinosaurs still exist.
 - b. At the end of the Cretaceous Period dinosaurs evolved into the large reptiles we see today.
 - c. Although a giant meteor caused the extinction of the dinosaurs, *Ornithomimus* was able to survive.

True or False

- | | | |
|--|------|-------|
| 5. All dinosaurs had similar teeth | TRUE | FALSE |
| 6. Compared to humans, dinosaurs grew slowly | TRUE | FALSE |
| 7. Paleontologists think that some dinosaurs cared for their young. | TRUE | FALSE |
| 8. Western Interior Seaway split North America in two during the Cretaceous Period..... | TRUE | FALSE |
| 9. Regardless of where a fossil is found, it belongs to the federal government. | TRUE | FALSE |
| 10. Some paleontologists think that soft tissue can be preserved for millions of years | TRUE | FALSE |



Dinosaurs under the Big Sky exhibit
 Content Quiz
 Level 3 – KEY

Student: KEY
 Teacher: _____
 School: _____
 Circle one: Pre-visit Post-visit

1. Choose the correct definition for the following words:
 - a. Ontogeny A The development of an organism from an embryo to adult
 - b. Histology C The observation and interpretation of a fossil site
 - c. Taphonomy B The study of bone structure

2. Arrange the periods of the Mesozoic Era from OLDEST TO THE MOST RECENT.
 - a. **Triassic , Jurassic, Cretaceous**
 - b. Jurassic, Cretaceous, Triassic
 - c. Cretaceous, Jurassic, Triassic
 - d. Triassic, Cretaceous, Jurassic

3. Which one of the following traits of dinosaurs do paleontologists NOT have physical evidence for?
 - a. Feathers
 - b. Skin textures
 - c. **Colors**
 - d. Muscles

4. What best explains the non-extinction hypothesis?
 - a. **Animals related to dinosaurs can be found above the Cretaceous-Tertiary boundary; therefore, relatives of dinosaurs still exist.**
 - b. At the end of the Cretaceous Period dinosaurs evolved into the large reptiles we see today.
 - c. Although a giant meteor caused the extinction of the dinosaurs, *Ornithomimus* was able to survive.

True or False

5. All dinosaurs had similar teeth TRUE FALSE
6. Compared to humans, dinosaurs grew slowly TRUE FALSE
7. Paleontologists think that some dinosaurs cared for their young. TRUE FALSE
8. Western Interior Seaway split North America in two during the Cretaceous Period..... TRUE FALSE
9. Regardless of where a fossil is found, it belongs to the federal government. TRUE FALSE
10. Some paleontologists think that soft tissue can be preserved for millions of years TRUE FALSE

APPENDIX F

STUDENT ATTITUDE SURVEY GRADES K – 5



Appendix F
Student Attitudes Survey K-5
Dinosaurs under the Big Sky Exhibit
Student Attitude Survey





























Student: _____

Teacher: _____

School: _____

Circle one: Pre-visit Post-visit

Circle the dinosaur that represents your feelings about the statement.
If you don't know, leave the question blank.

1. I like dinosaurs.				
2. Dinosaurs are cool.				
3. My friends think dinosaurs are cool.				
4. I like science.				
5. Science is cool.				
6. I want to learn more about dinosaurs.				
7. I want to learn more about science.				

8. My friends think science is cool.



9. I want to be a scientist when I grow up.



Please complete these questions after touring the *Dinosaurs under the Big Sky* exhibit.

10. I had fun touring MOR's dinosaur exhibits.



11. It was easy to pay attention during the tour.



12. I learned something new during the tour.



13. I think it would be fun to do an activity during a self tour.



14. I enjoyed the activity my teacher provided during the self tour.



APPENDIX G

STUDENT ATTITUDE SURVEY GRADES 6 – 12



Appendix G Student Attitudes Survey 6-12

Dinosaurs under the Big Sky Exhibit
Student Attitude Survey
Grades 6 – 12

Student: _____
Teacher: _____
School: _____
Circle one: Pre-visit Post-visit

**Circle your feelings about each statement.
If you don't have an opinion, please leave the question blank.**

- | | | | | |
|---|-----------------------|--------------|-----------------|--------------------------|
| 1. I like dinosaurs. | <i>Strongly Agree</i> | <i>Agree</i> | <i>Disagree</i> | <i>Strongly Disagree</i> |
| 2. Dinosaurs are cool. | <i>Strongly Agree</i> | <i>Agree</i> | <i>Disagree</i> | <i>Strongly Disagree</i> |
| 3. My friends think dinosaurs are cool. | <i>Strongly Agree</i> | <i>Agree</i> | <i>Disagree</i> | <i>Strongly Disagree</i> |
| 4. I like science. | <i>Strongly Agree</i> | <i>Agree</i> | <i>Disagree</i> | <i>Strongly Disagree</i> |
| 5. Science is cool. | <i>Strongly Agree</i> | <i>Agree</i> | <i>Disagree</i> | <i>Strongly Disagree</i> |
| 6. I want to learn more about dinosaurs. | <i>Strongly Agree</i> | <i>Agree</i> | <i>Disagree</i> | <i>Strongly Disagree</i> |
| 7. I want to learn more about science. | <i>Strongly Agree</i> | <i>Agree</i> | <i>Disagree</i> | <i>Strongly Disagree</i> |
| 8. My friends think science is cool. | <i>Strongly Agree</i> | <i>Agree</i> | <i>Disagree</i> | <i>Strongly Disagree</i> |
| 9. I want to be a scientist when I grow up. | <i>Strongly Agree</i> | <i>Agree</i> | <i>Disagree</i> | <i>Strongly Disagree</i> |

Please complete these questions after touring the *Dinosaurs under the Big Sky* exhibit.

- | | | | | |
|--|-----------------------|--------------|-----------------|--------------------------|
| 10. I had fun touring MOR's dinosaur exhibits. | <i>Strongly Agree</i> | <i>Agree</i> | <i>Disagree</i> | <i>Strongly Disagree</i> |
| 11. It was hard to pay attention during the tour. | <i>Strongly Agree</i> | <i>Agree</i> | <i>Disagree</i> | <i>Strongly Disagree</i> |
| 12. I learned something new during the tour. | <i>Strongly Agree</i> | <i>Agree</i> | <i>Disagree</i> | <i>Strongly Disagree</i> |
| 13. I would have liked using an activity during the self tour. | <i>Strongly Agree</i> | <i>Agree</i> | <i>Disagree</i> | <i>Strongly Disagree</i> |

14. I enjoyed the activity my teacher provided during the self tour.

Strongly Agree

Agree

Disagree

Strongly Disagree

APPENDIX H

TOUR OBSERVATION FORM

Appendix H Tour Observation Form

Museum of the Rockies
Self Tour Observation Form

School Name: _____ Date: _____

Teacher Name: _____ Chaperone name : _____

Number of students: (M)_____ (F)_____ Number of adults: _____

Grade: _____ Activity sheet: _____

Start time: _____ End time: _____

Time	Behavior	# students	Notes
1 min	AE		
	PE		
	OT-M		
	OT-V		
	OT-P		
2 min	AE		
	PE		
	OT-M		
	OT-V		
	OT-P		
3 min	AE		
	PE		
	OT-M		
	OT-V		
	OT-P		
4 min	AE		
	PE		
	OT-M		
	OT-V		
	OT-P		
5 min	AE		
	PE		
	OT-M		
	OT-V		

	OT-P		
--	------	--	--

Time	Behavior	# students	Notes
6 min	AE		
	PE		
	OT-M		
	OT-V		
	OT-P		
7 min	AE		
	PE		
	OT-M		
	OT-V		
	OT-P		
8 min	AE		
	PE		
	OT-M		
	OT-V		
	OT-P		
9 min	AE		
	PE		
	OT-M		
	OT-V		
	OT-P		
10 min	AE		
	PE		
	OT-M		
	OT-V		
	OT-P		

APPENDIX I

TEACHER INTERVIEW QUESTIONS

Appendix I
Teacher Interview Questions

**Museum of the Rockies
Self Tour Study
Teacher Interview Questions
Post Visit**

Teacher:
School:
Grades:
Date of Visit:
Self/Guided:

Before we get started, I need to let you know this interview is being recorded. Your comments will be used for the study, but will be made anonymous so your name and school's name will not be attached to your comments. If this is ok with you, we'll get started.

1. What were your overall goals for your visit to the Museum of the Rockies?

2. Why did you choose to have your class self tour (or receive a guided tour) of the *Dinosaurs under the Big Sky* exhibit at the Museum?

3. Out of the total time spent in the *Dinosaurs under the Big Sky* exhibit; approximately what percentage of the time do you estimate your students were engaged in the learning process?
 - a. Are you satisfied with this level of engagement? Why or why not?

 - b. What prevented your students from being engaged during their entire tour time? (or) What made it possible for your students to be engaged during their entire tour time?

4. If you self toured the *Dinosaurs under the Big Sky* exhibit... How did you structure your group's self touring time? (i.e. Did you have your groups explore with their chaperone? Did you lead a group tour?)

Why did you choose this method?

Would you use the same method next time? If not, how would you structure your self tour differently?

5. If you self toured the Dinosaurs under the Big Sky exhibit... Did you provide any worksheets or use any educational tools during the self tour?
 - a. If so, what did you use? Did you create this tool yourself? Please describe the types of questions or activities you included in/on your education tool.
 - b. If not, would you have used a worksheet, educational tool, or activity if the Museum provided one?
6. What would an ideal worksheet, activity, or educational tool look like for your students?
7. Specific to the *Dinosaurs under the Big Sky* exhibit, what did you hope your students would learn during the tour?
8. Did your students gain the knowledge you hoped for?
 - a. If so, what helped them achieve these goals? What worked well? What would you change?
 - b. If not, what would you do differently in the future to enhance student learning?
9. Are you satisfied with the educational tools the Museum of the Rockies provides for teachers that choose to self tour? Why or why not?
10. Is there anything else you would like me to know or do you have any other feedback for this study on self tours at the Museum?

APPENDIX J

TEACHER SURVEY

Appendix J

Teacher Surveys

Museum of the Rockies Self Tour Study Survey

Your contact information is needed to match your comments with the other MOR Self Tour Study data collected. All comments from this survey will be made anonymous. Your name and school's name will not be attached to your comments.

* Required

Your Name * _____

School Name: * _____

School City/State * _____

Grade(s): * _____

Did you self tour or receive a guided tour of the Dinosaurs under the Big Sky exhibit? *

- Self Tour
- Guided Tour. _____

Tour Goals and Student Engagement

What were your overall goals for your entire visit to the Museum of the Rockies? *

Why did you choose to have your class self tour or receive a guided tour of the Dinosaurs under the Big Sky exhibit at the Museum? *

Out of the total time spent in the Dinosaurs under the Big Sky exhibit, approximately what percentage of the time do you estimate your students were engaged in the learning process? (Please enter a whole number from 0 - 100.)

* _____

Are you satisfied with this level of engagement? Why or why not? *

What prevented your students from being engaged during their entire tour time? (or)
What made it possible for your students to be engaged during their entire tour time? *

Specific to the Dinosaurs under the Big Sky exhibit, what did you hope your students would learn during the tour? *

Did your students gain the knowledge you hoped for? *

- Yes
- No

If so, what helped them achieve these goals? What worked well? (OR) If not, what would you do differently in the future to enhance student learning? *

Self Tours

Please complete this section if you self toured the Dinosaurs under the Big Sky exhibit. If you received a guided tour, please skip this page and complete the survey on Page 4.

How did you structure your group's self touring time? (i.e. Did you have your groups explore with their chaperone? Did you lead a group tour?)

Why did you choose this method of self touring?

Did you provide any worksheets or use any educational tools during the self tour?

- Yes
- No

If so, what did you use? Did you create this tool yourself? Please describe the types of questions or activities you included in/on your education tool.

If not, would you have used a worksheet, educational tool, or activity if the Museum provided one?

[Back](#) [Continue](#)

Additional Comments

Are you satisfied with the educational tools the Museum of the Rockies provides for teachers that choose to self tour? Why or why not? *

Is there anything else you would like me to know or do you have any other feedback for this study on self tours at the Museum?

[Back](#) [Submit](#)

APPENDIX K

SELF TOUR PROJECT EDUCATIONAL RESOURCES LETTER

Appendix K

Self Tour Project Educational Resources Letter

MUSEUM OF THE ROCKIES
Montana State University



touch history

RE: Museum of the Rockies Self Tour Study Educational Resources

Dear Teacher,

Thank you for agreeing to participate in a research project that seeks to understand the effects of self tours on school-aged children in the Museum of the Rockies' *Dinosaurs under the Big Sky* exhibit.

Early data has shown that students who self tour are more engaged in the learning process and learn more during their tour if they have an activity to work on. To help improve student engagement, I have developed a series of worksheets and Talking Points for teacher for use during school field trips.

Because you have agreed to participate in the study and your group is self touring the *Dinosaurs under the Big Sky* exhibit, your group has been selected to participate in the trial of these educational resources. If you agree to test these materials, you will be asked to have your students complete one of the attached worksheets (or scavenger hunts). In addition, each chaperone with your group would be asked to carry and utilize the Talking Points hand-out. These requirements for testing the teacher resources would be in addition to the Content Quizzes and Attitude Surveys required of the Self Tour Study. Your feedback during the Self Tour Study teacher survey and the results of your students' Content Quizzes and Attitude Surveys will help modify and improve these resources for future use.

Please contact me about your participation in testing the Teacher Resources generated from the Self Tour Study's initial data. Your participation in this study is confidential, voluntary, but greatly appreciated.

Thank you in advance for your additional help and participation!

Angie Hewitt
Early/Elementary Education Specialist
angela.hewitt@montana.edu
406.994.6618

APPENDIX L

TEACHER TALKING POINTS

Appendix L Teacher Talking Points

MUSEUM OF THE ROCKIES
Montana State University



touch history

Museum of the Rockies' Teacher Resources *Dinosaurs under the Big Sky*

Self-Guided Tour

Teacher Talking Points

Overview:

Teachers not receiving a guided tour of the *Dinosaurs under the Big Sky* exhibit are encouraged to review the following talking points for their self guided tour of the Siebel Dinosaur Complex. Information included in this packet is a summary of the most important and interesting features of the exhibit. This guide was created to help teachers answer student questions without reading exhibit panels. Detailed information about each of these Talking Points can be found on exhibit panels within the *Dinosaurs under the Big Sky* exhibit.

Main Themes of the *Dinosaurs under the Big Sky* exhibit:

1. Science is a process through which we can learn more about the natural world by observing physical evidence, testing our ideas about what the physical evidence is telling us, and learning from our mistakes.
2. We find evidence that dinosaurs and birds are related.
3. Different dinosaurs lived at different times and in different places. Not all dinosaurs lived at the same time in the same place.
4. Dinosaurs grew relatively fast and a dinosaur's features changed as it grew.

Vocabulary from the *Dinosaurs under the Big Sky* exhibit:

Cast

Dinosaur (avian, non-avian)

Fossil

Geology

Holotype

Hypothesis

Paleontology

Sauropod

Science

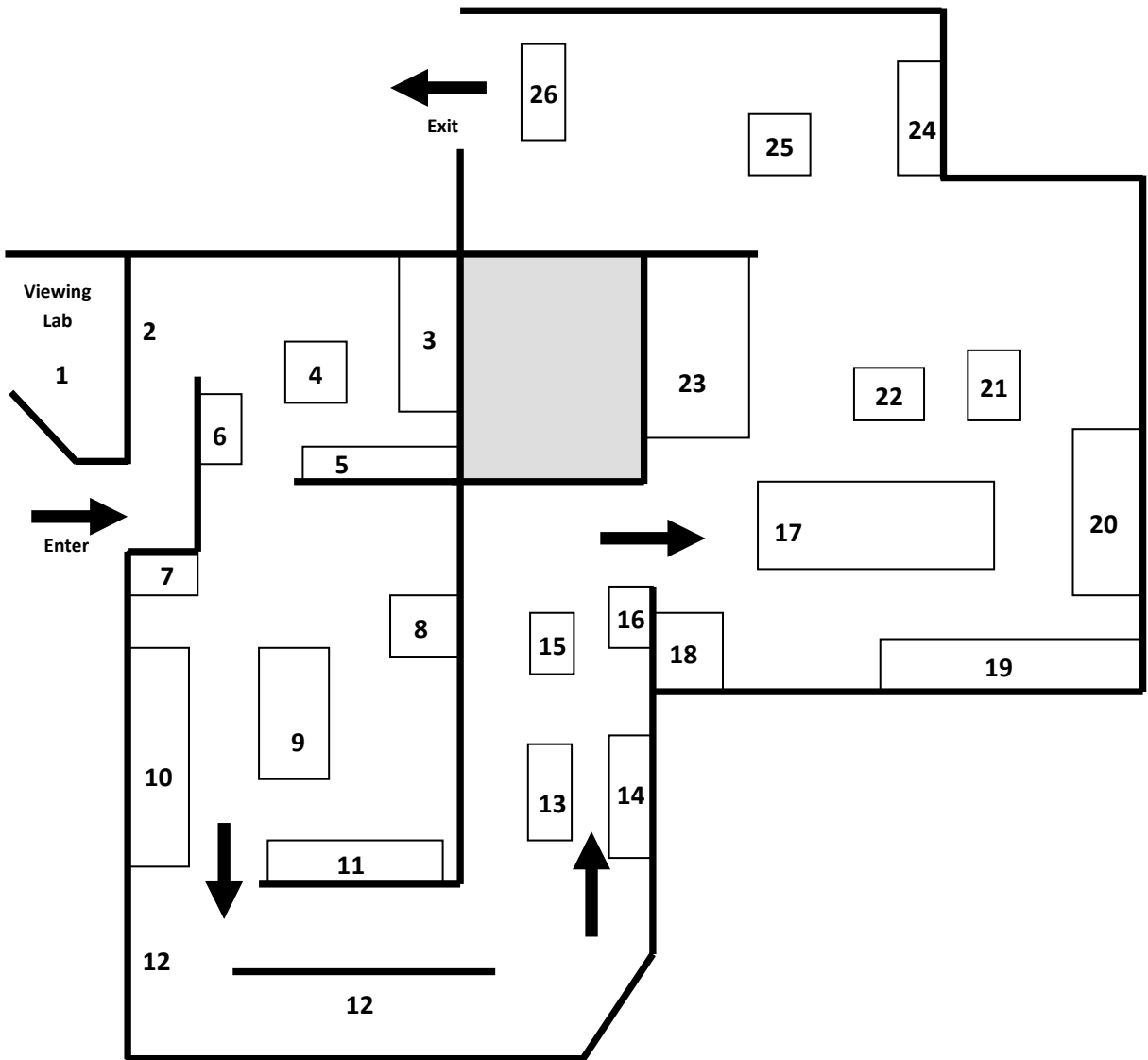
Theory

Vertebrate



Dinosaurs under the Big Sky
Exhibit Map with Talking Points

Note: Not all display cases are represented on this map. This map has been simplified to easily identify the Talking Points included in the following pages.



TALKING POINT 1: Viewing Lab

- **Paleontology** is the study of extinct life. Some paleontologists study dinosaurs.
- **Geology** is the study of rock, the earth's origin, history, and structure.
- **Dinosaurs** were the only group of reptiles that walked with their legs directly under their bodies, not sprawled to the side. They lived on land (terrestrial).
- **Fossils** are preserved remains or traces of once-living animals, plants, and other organisms.
- Fossils are created when a bone (or other organic material) is replaced by minerals and turned to rock.

**TALKING POINT 2: Introduction Panels**

- A **hypothesis** is an idea or educated guess supported by what scientists find (physical evidence).
- A **theory** is a hypothesis that has not been disproved after several tests.
- Montana is a great place to find fossils because the right age of rock is exposed.
- (Non-avian) **Dinosaurs** and humans did not live at the same time. (Non-avian) Dinosaurs lived 230-65 million years ago.

**TALKING POINT 3: Sauropod Growth Series**

- The three leg bones shown here are of a sauropod, or long-necked dinosaur, called a Diplodocus.
 - Baby femur (2 weeks old): *Dinosaur weighed less than 20 lbs.*
 - Juvenile hind leg: *Dinosaur measured 25 feet long and weighed 2 tons (4,000 lbs).*
 - Adult hind leg: *Dinosaur measured 70 feet long and weighed 20 tons (40,000 lbs) or as much as three elephants.*
- If you were proportioned like a sauropod, you would have a body the size you do now, but your head would be the size of a peanut stuck on the end of a neck the size of a three-foot-long straw!
- Apatosaurus rib = one of the largest ribs from any sauropod dinosaur!

**TALKING POINT 4: A Muddy Diplodocus Grave**

- The juvenile sauropods likely got their feet and legs stuck in the mud and couldn't get out.
- Scientists hypothesize that this shows these juvenile diplodocid sauropods traveled together in groups.
- Scientists hypothesize that the rest of the dinosaur's skeleton was washed away.



TALKING POINT 5: Livingston Sauropod

- This sauropod is about 10 years old.
- This sauropod was found near Livingston.

**TALKING POINT 6: *Allosaurus***

- *Allosaurus* was probably the primary predator of sauropods.
- “Big Al” has 19 abnormal bones that show this animal survived multiple injuries, some of which became infected.
- These injuries are likely why Big Al died before reaching adulthood.
- (He/she is estimated to be about 13-15 years old. The life span of an *Allosaurus* is 22 to 28 years.)

**TALKING POINT 7: Dinosaurs and Birds**

- Birds and dinosaurs share the following characteristics:
 - Wishbone
 - Hollow bones
 - Extra-long digit of the hand
 - Oblong, hard-shelled eggs
 - Wrist bone that allows a bird wing to fold to the side of the arm
 - Three-toed foot
 - Feathers
 - Sat on eggs to hatch
- It is widely accepted by paleontologists that birds are the decedents of dinosaurs.

**TALKING POINT 8: Raptor Attack!**

- The skeleton is surrounded by 11 teeth of the small meat-eater *Deinonychus* (a dinosaur closely related to *Velociraptor*).
- Although *Deinonychus* replaced its teeth every 300 days or so, eleven teeth is too many for one *Deinonychus* to lose while feeding on a carcass.
- It is likely that as many as six or eight *Deinonychus* fed on this *Tenontosaurus*.



TALKING POINT 9: *Tenontosaurus* for Dinner

- These are full-scale sculptures of what the *Tenontosaurus* and *Deinonychus* may have looked like.
- Scientists don't know the colors of dinosaurs. They make hypotheses about their color based on other reptiles and birds.
- Skin texture is based on the skin impressions of duck-billed dinosaurs.
- *Deinonychus* has feathers on the areas of the body where feathers are found on other closely related species.

**TALKING POINT 10: Sauropod under Attack**

- These are full-scale sculptures of what a sauropod and *Deinonychus* may have looked like.
- Scientists hypothesize that male and female *Deinonychus* had color variations similar to other known reptiles and birds.
- *Deinonychus* had recurved claws similar to animals that climbed. Because they were meat-eaters, it is unlikely that *Deinonychus* climbed trees, so scientists think that they may have scaled their prey and then used their hind-foot slashing claw to rip into the larger animal's body such as a sauropod.
- *Deinonychus* hunted in packs.

**TALKING POINT 11: Plesiosaur**

- Plesiosaurs are marine reptiles and therefore not dinosaurs. Dinosaurs were terrestrial animals.
- This plesiosaur is an *Edgarosaurus* found in Yellowstone County.
- Unlike most marine reptiles, plesiosaurs did not use their tail to move, but instead relied on two sets of paddle-like arms.
- Plesiosaurs lived in the Western Interior Seaway, a shallow inland sea that split North American in two during the middle to Late Cretaceous, over the Rocky Mountains and what is now Montana.

**TALKING POINT 12: Dinosaur Computer Displays and Games**

- Touch screens can access the Museum's Paleo Video Library, "News from the Field," and Paleo Games.
- Touch screens also show histology images (images taken of the structure of bone).



TALKING POINT 13: Dinosaur Nests

- Dinosaurs laid hard-shelled eggs in nests just like birds.
- Dinosaur eggs come in a variety of sizes, shapes, and textures.
- Not all dinosaurs sat on their eggs. Some covered their eggs with plant debris to keep them warm.
- Field crews from the Museum of the Rockies collected the first clutches of dinosaur eggs in the Western Hemisphere.

**TALKING POINT 14: *Maiasaura***

- *Maiasaura*, Montana's State Dinosaur, is a duck-billed dinosaur whose name means "good mother."
- Baby *Maiasaura* leg bones were too weak for a nestling to walk or run, so scientists hypothesize that adult *Maiasaura* cared for their young.
- *Maiasaura* grew very fast.
 - At birth, it was only 16 inches long and weighed about one-and-a-half pounds.
 - An adult could be 30 feet long and weigh 4,000 pounds.
 - A one-year-old *Maiasaura* was about 9 feet in length.
- Scientists have found VERY rare embryos of *Maiasaura* (and other dinosaurs) in unhatched egg fossils.

**TALKING POINT 15: *Achelousaurus***

- This is a holotype, which is first found specimen of a new species and serves as the basis for naming and describing the species.
- This was named after Jack Horner (*Achelousaurus horneri*)

**TALKING POINT 16: *Troodon***

- *Troodon* grew to be about 2 meters in length
- This dinosaur may have hunted in groups and was probably able to take down large plant-eaters.
- *Troodon* remains are often found on *Maiasaura* nesting a ground, which suggests that they might have preyed upon nestlings.



TALKING POINT 17: *Torosaurus* Full-scale Sculpture

- *Torosaurus* has the largest skull of any known dinosaur.
- The body of this animal is 26 feet long and would have weighed about 20,000 pounds. (A large bull elephant weighs about 14,000 pounds).
- The sleeping baby *Torosaurus* is about 2-3 months old.
- The skin is based on impressions found of other horned dino skin.
- The color of the *Torosaurus* was based on a monitor lizard and a bird because we don't know what colors dinosaurs were.

**TALKING POINT 18: *Torosaurus* Skull (MOR 1122)**

- This is the largest dinosaur skull ever found!
- It was found at the base of a 20-foot high sandstone cliff.
- It is nine feet long and six feet wide.
- The large ball on the skull connected the skull to the neck. It sat in the middle of the skull, allowing the head to be balanced.
- *Torosaurus* has holes in the neck shield, but *Triceratops* did not.

**TALKING POINT 19: *Triceratops* Growth Series**

- This is the world's most complete *Triceratops* growth series.
- The shield and horns changed shape as the *Triceratops* grew.
- The baby is less than one year old.
- A cast of the adult skull (named "MORT" – Museum of the Rockies *Triceratops*) can be seen in the lower lobby.

**TALKING POINT 20: *Edmontosaurus***

- This is one of the largest duck-billed skeletons found in North America.
- The tail is 26 feet long. The whole skeleton would have been nearly 50 feet in length if preserved.
- Skin impressions can be seen on the underside of the tail.
- Dinosaurs did not drag their tails.

**TALKING POINT 21: *T.rex* ate *Triceratops***

- This *Triceratops* pelvis has *T.rex* bite marks.
- The absence of any healing around the holes leads scientists to believe that this *Triceratops* was already dead when *T.rex* fed on it. (One piece of evidence *T.rex* was a scavenger.)



TALKING POINT 22: MOR 008 – Largest *T.rex* Skull

- This is the largest *T.rex* skull in the entire world.
- It was found east of Billings, MT.
- Few additional bones were found from this animal.
- *T.rex* teeth were replaced as they wore down and were shed.

**TALKING POINT 23: Wankel *T.rex***

- This is the real skeleton displayed just as it was found.
- This is the skeleton that was used to cast Big Mike, the bronze *T.rex* skeleton in front of the Museum.
- The Wankel *T.rex* had the first *T.rex* lower arm bones ever found.
- The Wankel *T.rex* is one of the most complete *T.rex* specimens ever found.

**TALKING POINT 24: B.rex**

- Excavators broke this *T.rex* femur in half to get it out of the field.
- After studying the broken pieces, Mary Schweitzer discovered soft tissue blood vessels and cells.
- It was the first discovery of soft tissue in a fossilized organism.
- It could possibly contain ancient DNA and proteins.
- Tissues in the bone showed that this dinosaur was about to lay eggs, making it a girl!

**TALKING POINT 25: Non-Dinosaurian Reptiles and Invertebrates**

- Crocodiles, alligators, many varieties of lizards, turtles, and even a few snakes lived with the dinosaurs.
- Newts and salamanders were the most common amphibians found.
- Mollusks and clams inhabited the freshwater streams, rivers, and lakes.

**TALKING POINT 26: Bird Video**

- Birds are living dinosaurs.



APPENDIX M

SCAVENGER HUNT: LEVEL 1

Appendix M
Scavenger Hunt: Level 1

MUSEUM OF THE ROCKIES
Montana State University



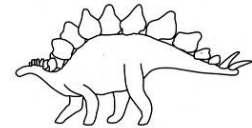
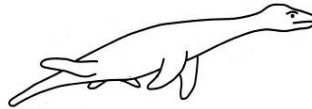
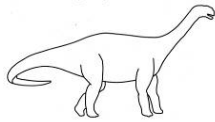
touch history

Name: _____

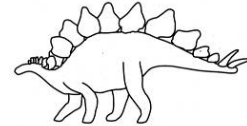
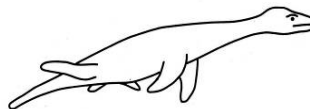
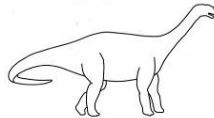
Dinosaurs under the Big Sky
Scavenger Hunt

These questions are designed for adult and child interaction. Visit the Dinosaur Halls to "scavenge" the answers.

1. Circle the sauropod.



2. Draw an X on the animal that is NOT a dinosaur.



3. Draw a picture of a dinosaur nest with eggs.

Error! Reference source not found.

4. Circle the biggest life-size dinosaur you can find in the Dinosaur Halls.



Triceratops



T.rex



Edmontosaurus



Torosaurus

5. How many *Triceratops* are in the *Triceratops* growth series? Write the number here: _____



Circle the youngest. Draw an X over the oldest.

6. One of these animals did not live with the dinosaurs and its fossils are not in the Dinosaur Halls. Draw an X on it.



Crocodile



Turtle



Caveman



Clam

7. Circle the animal below that is related to a dinosaur.



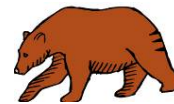
Cat



Bird



Crocodile



Bear

8. Draw a picture of your favorite dinosaur.





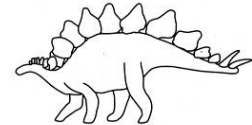
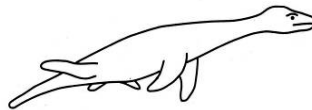
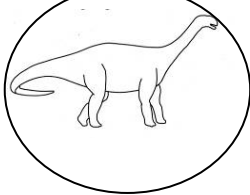
touch history

Name: KEY

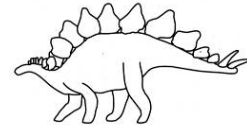
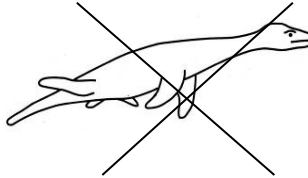
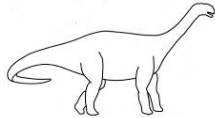
Dinosaurs under the Big Sky Scavenger Hunt

These questions are designed for adult and child interaction. Visit the Dinosaur Halls to "scavenge" the answers.

1. Circle the sauropod.



2. Draw an X on the animal that is NOT a dinosaur.



3. Draw a picture of a dinosaur nest with eggs.

Error! Reference source not found.

Drawings will vary.

4. Circle the biggest life-size dinosaur you can find in the Dinosaur Halls.



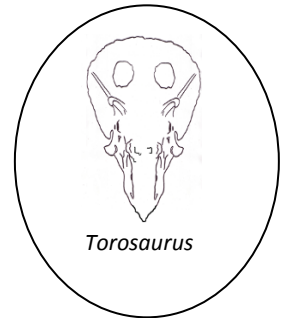
Triceratops



T.rex



Edmontosaurus



Torosaurus

5. How many *Triceratops* are in the *Triceratops* growth series? Write the number here: 6



Circle the youngest. Draw an X over the oldest.

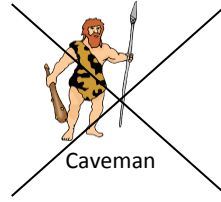
6. One of these animals did not live with the dinosaurs and its fossils are not in the Dinosaur Halls. Draw an X on it.



Crocodile



Turtle

~~Caveman~~

Clam

7. Circle the animal below that is related to a dinosaur.



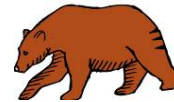
Cat



Bird



Crocodile



Bear

8. Draw a picture of your favorite dinosaur.

Drawings will vary.

APPENDIX N

SCAVENGER HUNT: LEVEL 2

Appendix N
Scavenger Hunt: Level 2

MUSEUM OF THE ROCKIES
Montana State University



touch history

Name: _____

Dinosaurs under the Big Sky
Scavenger Hunt

1. Fill in the blank.
 - a. _____ is process of observing, testing, and learning from mistakes.
 - b. Theory is a _____ that hasn't been proven wrong after many tests.
 - c. A hypothesis is an educated guess supported by _____ evidence like fossils.

2. What dinosaur ate the young sauropods (whose bones are on display at the Museum) while they were stuck in the mud? _____

3. Circle the animal that descended from dinosaurs.



Wolf



Bird



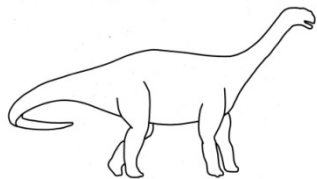
Crocodile



Lizard

4. Find the giant sea creature modeled in the exhibit. What is it called? _____
Why isn't this animal considered to be a dinosaur? _____

5. What raptor-like dinosaur is attacking this dinosaur in the exhibit? _____



Did this dinosaur drag its tail?

Did any dinosaur drag its tail?

6. What dinosaur laid the largest eggs on display at the Museum? _____

7. Small meat-eating dinosaurs, like *Troodon*, could take down very large plant-eating dinosaurs because these dinosaurs hunted... (Circle the correct answer.)

As a group

Alone

8. What dinosaur has the largest skull of any known dinosaur? _____

9. How many *Triceratops* are in the *Triceratops* growth series? Write the number here: _____



List one way the Triceratops changes as it grows.

10. What is the identification number for the largest T.rex skull in the entire world? _____

Is it the real fossil or a replica? _____

11. Is B.rex a male or female *Tyrannosaurus rex*? _____

12. The bronze dinosaur outside the Museum, "Big Mike," is a cast of one of the T.rex skeletons inside the Museum. Who first found this T.rex skeleton? _____

13. Draw a picture of one extinct animal that lived with the dinosaurs.

Error! Reference source not found.

14. What was your favorite thing you saw in the *Dinosaurs under the Big Sky* exhibit?



touch history

Name: KEY

Dinosaurs under the Big Sky Scavenger Hunt

1. Fill in the blank.
 - a. Science is process of observing, testing, and learning from mistakes.
 - b. Theory is a scientific hypothesis that hasn't been proven wrong after many tests.
 - c. A hypothesis is an educated guess supported by physical evidence like fossils.

2. What dinosaur ate the young sauropods (whose bones are on display at the Museum) while they were stuck in the mud? Allosaurus

3. Circle the animal that descended from dinosaurs.



Wolf



Bird



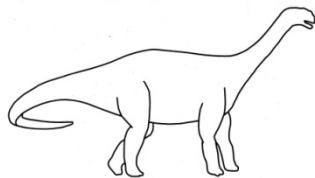
Crocodile



Lizard

4. Find the giant sea creature modeled in the exhibit. What is it called? plesiosaur or Edgarsaurus
Why isn't this animal considered to be a dinosaur? Dinosaurs lived on land, not in the sea. Dinosaurs are the only group of reptiles that walked with their legs directly underneath them.

5. What raptor-like dinosaur is attacking this dinosaur in the exhibit? Deinonychus



Did this dinosaur drag its tail?

NO

Did any dinosaur drag its tail?

NO

6. What dinosaur laid the largest eggs on display at the Museum? Lambeosaurine

7. Small meat-eating dinosaurs, like *Troodon*, could take down very large plant-eating dinosaurs because these dinosaurs hunted... (Circle the correct answer.)

As a group

Alone

8. What dinosaur has the largest skull of any known dinosaur? Torosaurus

9. How many *Triceratops* are in the *Triceratops* growth series? Write the number here: 6



List one way the Triceratops changes as it grows.

1. Young horns curved back. Older horns pointed forward. 2. Young skull has larger eyes. 3. Young skull has triangle shaped bones on top edge of frill. 4. Nasal bones are not fused. 5. The face grew longer as it got older. 6. Blood vessel grooves in the skull are more prominent in the older Triceratops.

10. What is the identification number for the largest T.rex skull in the entire world? MOR 008
Is it the real fossil or a replica? REAL

11. Is B.rex a male or female *Tyrannosaurus rex*? Female

12. The bronze dinosaur outside the Museum, "Big Mike," is a cast of one of the T.rex skeletons inside the Museum. Who first found this T.rex skeleton? Kathy Wankel

13. Draw a picture of one extinct animal that lived with the dinosaurs.

Error! Reference source not found.

Drawings will vary.

14. What was your favorite thing you saw in the *Dinosaurs under the Big Sky* exhibit?

 Answers will vary.

APPENDIX O

SCAVENGER HUNT: LEVEL 3

Appendix O
Scavenger Hunt: Level 3

MUSEUM OF THE ROCKIES
Montana State University



touch history

Name: _____

Dinosaurs under the Big Sky
Scavenger Hunt

1. List the three most important scientific theories of paleontology.
 1. _____
 2. _____
 3. _____

2. Dinosaurs lived _____ to _____ million years ago.

3. Dinosaurs are found in Montana from the Jurassic and Cretaceous Periods of the _____ Era.

4. If you find a fossil on federal land, who owns it? _____

5. Paleontologists can hypothesize how dinosaurs lived and died by how fossils are arranged in rocks. Explain how scientists think the juvenile sauropods on display died based on their arrangement.

6. What evidence to paleontologists have that suggests dinosaurs did not drag their tails?

7. The skeleton of a _____ is on display with _____ (number) *Deinonychus* teeth surrounding it. What does this tell paleontologists about how *Deinonychus* hunted?

8. How did the Museum's paleontologists determine what color to make the life-like dinosaurs?

9. Is the plesiosaur a dinosaur? Why or why not? _____

10. Some dinosaurs like _____ sat on their eggs to incubate them.
11. What small predatory dinosaur is often found right next to *Maiasaura* nests suggesting it fed on *Maiasaura* nestlings? _____
12. *Achelousaurus horneri* is a _____, meaning it is the first found specimen of a new species and serves as the basis for naming and describing the species.
13. List two ways the *Triceratops* changes as it grows.
1. _____
 2. _____
14. On the *Edmontosaurus* tail, the small bumps are impressions of the dinosaur's _____.
15. Was T.rex a scavenger or a predator? _____
List two reasons why or why not.
1. _____
 2. _____
16. Mary Schwietzer discovered the first _____ tissue blood vessels and cells in a T.rex known as "B.rex" or _____.
17. Based on the medullary bone found, scientists determined this dinosaur was a: (Circle one)
MALE or FEMALE
18. Name two extinct animals (that are not dinosaurs) that were found to live at the same time as dinosaurs.
1. _____
 2. _____
19. Write two facts you learned about dinosaurs today.
1. _____

 2. _____



touch history

Name: KEY

Dinosaurs under the Big Sky

Scavenger Hunt

1. List the three most important scientific theories of paleontology.
 1. *Theory of Extinction* _____
 2. *Theory of Darwinian Evolution* _____
 3. *Theory of Radiometric Dating* _____

2. Dinosaurs lived 230 to 65 million years ago.

3. Dinosaurs are found in Montana from the Jurassic and Cretaceous Periods of the Mesozoic Era.

4. If you find a fossil on federal land, who owns it? USA, Federal Government, or the people of the USA

5. Paleontologists can hypothesize how dinosaurs lived and died by how fossils are arranged in rocks. Explain how scientists think the juvenile sauropods on display died based on their arrangement.
The young Diplodocus got their feet stuck in the mud and could not escape. (Allosaurus most likely fed on the young animals while they were dying or after their death.) _____

6. What evidence to paleontologists have that suggests dinosaurs did not drag their tails?
Tail vertebrae of Deinonychus possess long extensions, ossified tendons that aided in creating a stiff tail.

7. The skeleton of a Tenontosaurus is on display with 11 (number) *Deinonychus* teeth surrounding it. What does this tell paleontologists about how *Deinonychus* hunted?
They hunted in packs. 11 teeth is to many for one Deinonychus to lose while feeding. _____

8. How did the Museum's paleontologists determine what color to make the life-like dinosaurs?
Paleontologists based colors on modern reptiles and birds, because they are related to dinosaurs.

9. Is the plesiosaur a dinosaur? *Why or why not?* No. Dinosaurs lived on land and their legs were directly under their bodies. This reptile lived in the ocean and had flippers. _____

10. Some dinosaurs like _____ *Troodon* _____ sat on their eggs to incubate them.
11. What small predatory dinosaur is often found right next to *Maiasaura* nests suggesting it fed on *Maiasaura* nestlings? _____ *Troodon* _____
12. *Achelousaurus horneri* is a _____ *holotype* _____, meaning it is the first found specimen of a new species and serves as the basis for naming and describing the species.
13. List two ways the *Triceratops* changes as it grows.
 1. *Young horns curved back. Older horns pointed forward.* 2. *Young skull has larger eyes.* 3. *Young skull has triangle shaped bones on top edge of frill.* 4. *Nasal bones are not fused.* 5. *The face grew longer as it got older.* 6. *Blood vessel grooves in the skull are more prominent in the older Triceratops.*
14. On the *Edmontosaurus* tail, the small bumps are impressions of the dinosaur's _____ *skin* _____.
15. Was T.rex a scavenger or a predator? _____ *scavenger* _____
 List two reasons why or why not.
 1. *T.rex ate Triceratops. Holes in the pelvis showed no signs of healing, so Triceratops was already dead when T.rex ate it.*
 2. *T.rex had long-distance smelling abilities and poor eyesight.*
 3. *The size of T.rex's leg bones suggests it could not run fast, which would have made it hard to catch prey.*
 4. *T.rex is commonly found. In ecosystems, scavengers are abundant, but predators are rare.*
16. Mary Schweitzer discovered the first _____ *soft* _____ tissue blood vessels and cells in a T.rex known as "B.rex" or _____ *Catherine* _____.
17. Based on the medullary bone found, scientists determined this dinosaur was a: (Circle one)
 MALE or FEMALE
18. Name two extinct animals (that are not dinosaurs) that were found to live at the same time as dinosaurs.
 Fossils on display at MOR include: turtles; lizards; crocodiles; Champsosaurus, Borealosuchus, Aspideretoides, Emarginochelys, Trionychoidea; fish including: gar, bowfin, ray, paratarpon, sturgeon; mollusks including: clam, snails, gigantoclam; mammals including Meniscoessus sp., Didelphodon sp.
19. Write two facts you learned about dinosaurs today.
 1. _____ *Answers will vary.* _____
 2. _____

APPENDIX P

SCAVENGER HUNT: LEVEL 4

Appendix P
Scavenger Hunt: Level 4

MUSEUM OF THE ROCKIES
Montana State University



touch history

Name: _____

Dinosaurs under the Big Sky
Scavenger Hunt

1. What is the single most important component of science? _____
Why? _____

2. Explain the difference(s) between avian and non-avian dinosaurs.

3. Define bone histology.

4. Describe a fifth possible hypothesis based on the physical evidence presented in the “Muddy Grave” display. _____

5. What are three pieces of physical evidence that suggest dinosaurs were endotherms?
 1. _____
 2. _____
 3. _____
6. How did the Museum’s paleontologists determine what color to make the life-like dinosaurs?

7. Define sexual dimorphism. Name one Yellowstone animal that displays this today.

8. What physical evidence recorded the presence of the Western Interior Seaway which covered the middle of North America during the Cretaceous Period?

9. What physical evidence suggests some dinosaurs cared for their young?

10. List two ways the *Triceratops* changes as it grows.

1. _____
2. _____

11. Was T.rex a predator or a scavenger? Defend your hypothesis with physical evidence.

12. What is so extraordinary about the "Catherine/B.rex" fossil?

13. Based on plant and animal fossils found in microsites, describe what eastern Montana was during the late Cretaceous Period. _____

14. What is the main difference between the extinction and non-extinction theories?



touch history

Name: KEY

Dinosaurs under the Big Sky Scavenger Hunt

1. What is the single most important component of science? *physical evidence*
Why? *Science without physical evidence is opinion, and opinion is not science – even if it’s the opinion of a scientist.*
2. Explain the difference(s) between avian and non-avian dinosaurs.
Non-avian dinosaurs are extinct. These dinosaurs lived 230-65 million years ago and walked with their legs directly underneath their bodies. Avian dinosaurs are living birds and alive today. They share many of the same characteristics of non-avian dinosaurs.
3. Define bone histology.
The study of the microscopic internal structure of bone.
4. Describe a fifth possible hypothesis based on the physical evidence presented in the “Muddy Grave” display. *Answers will vary.*
5. What are three pieces of physical evidence that suggest dinosaurs were endotherms?
 1. Dinosaurs grew quickly, so they had a high metabolism – both typical of endothermic animals.
 2. Only endothermic birds are known to sit on (brood) their eggs to incubate them.
 3. Feathers on birds (and dinosaurs) are designed to insulate the body to retain heat produced by endothermy.
6. How did the Museum’s paleontologists determine what color to make the life-like dinosaurs?
Paleontologists based colors on modern reptiles and birds, because they are related to dinosaurs
7. Define sexual dimorphism. Name one Yellowstone animal that displays this today.
The existence of physical difference between males and females of the same species (i.e. size, color, body parts used for courtship, etc.) Examples will vary.

8. What physical evidence recorded the presence of the Western Interior Seaway which covered the middle of North America during the Cretaceous Period?

__The rock layers. Within the seaway, blankets of silt and sand were laid down along the shorelines and in shallow water, eventually becoming the sandstone formations in Montana today. Deeper portions of the sea were carpeted in mud, found today in shale formations. _____

9. What physical evidence suggests some dinosaurs cared for their young?

__Maiasaura egg bones were too weak for walking or running. _____

10. List two ways the *Triceratops* changes as it grows.

1. Young horns curved back. Older horns pointed forward. 2. Young skull has larger eyes. 3. Young skull has triangle shaped bones on top edge of frill. 4. Nasal bones are not fused. 5. The face grew longer as it got older. 6. Blood vessel grooves in the skull are more prominent in the older Triceratops.

11. Was *T.rex* a predator or a scavenger? Defend your hypothesis with physical evidence.

Scavenger... MOR paleontologists hypothesize this dinosaur scavenged. This is not accepted by all.

- 1. T.rex ate Triceratops. Holes in the pelvis showed no signs of healing, so Triceratops was already dead when T.rex ate it.
2. T.rex had long-distance smelling abilities and poor eyesight.
3. The size of T.rex's leg bones suggests it could not run fast, which would have made it hard to catch prey.
4. T.rex is commonly found. In ecosystems, scavengers are abundant, but predators are rare.*

12. What is so extraordinary about the "Catherine/B.rex" fossil?

Mary Schwietzer discovered the first soft tissue blood vessels and cells in a T.rex known as "B.rex" or Catherine.

13. Based on plant and animal fossils found in microsites, describe what eastern Montana was during the late Cretaceous Period.

__Answers will vary. Eastern Montana was along the shoreline of the Western Interior Seaway, so terrestrial and marine fossils can be found from this environment. _____

14. What is the main difference between the extinction and non-extinction theories?

__The extinction hypothesis suggests all dinosaurs went extinct 65 million years ago. The non-extinction hypothesis suggests a group of theropod dinosaurs did not experience extinction and are now the avian dinosaurs or birds. _____