THE USE OF INSPIRATION AS A MULTIMEDIA PLENARY ACTIVITY FOR IMPROVING THE COGNITIVE ASSIMILATION OF BIOLOGY 12 STUDENTS

by

Christopher Barnett

B.Sc., University of British Columbia, 1986

THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF
MASTER OF EDUCATION IN MULTIDISCIPLINARY LEADERSHIP

UNIVERSITY OF NORTHERN BRITISH COLUMBIA

August 2011

© Christopher Barnett, 2011
NOTICE:
The author has granted a non-exclusive license allowing Library and Archives Canada to reproduce, publish, archive, preserve, conserve, communicate to the public by telecommunication or on the Internet, loan, distribute and sell theses worldwide, for commercial or non-commercial purposes, in microform, paper, electronic and/or any other formats.

The author retains copyright ownership and moral rights in this thesis. Neither the thesis nor substantial extracts from it may be printed or otherwise reproduced without the author's permission.

In compliance with the Canadian Privacy Act some supporting forms may have been removed from this thesis.

While these forms may be included in the document page count, their removal does not represent any loss of content from the thesis.

AVIS:
L'auteur a accordé une licence non exclusive permettant à la Bibliothèque et Archives Canada de reproduire, publier, archiver, sauvegarder, conserver, transmettre au public par télécommunication ou par l'Internet, prêter, distribuer et vendre des thèses partout dans le monde, à des fins commerciales ou autres, sur support microforme, papier, électronique et/ou autres formats.

L'auteur conserve la propriété du droit d'auteur et des droits moraux qui protège cette thèse. Ni la thèse ni des extraits substantiels de celle-ci ne doivent être imprimés ou autrement reproduits sans son autorisation.

Conformément à la loi canadienne sur la protection de la vie privée, quelques formulaires secondaires ont été enlevés de cette thèse.

Bien que ces formulaires aient inclus dans la pagination, il n'y aura aucun contenu manquant.
ABSTRACT

Unit plenary activities are review activities used at the end of an educational unit. This thesis examined the effects of using Inspiration, a concept mapping computer program, as a plenary activity on summative assessment scores, compared the effectiveness of Inspiration to Review Worksheets/Discussion, explored the effects of Inspiration on Understanding, Knowledge and Higher Order Process, examined time on-task behaviours and plenary completion rates, and examined student perception of the effectiveness of Inspiration as a plenary with two classes of Biology 12 students. An action research methodology was applied to collect data from two senior classes. Quantitative data was collected using pre-/post-test results, time on-task behaviour, and assignment completion. Qualitative data was collected to identify student perception of the plenary and student study habits. The findings indicate that Inspiration statistically significantly improved summative scores, Understanding, Knowledge, time on-task behaviours, and plenary completion rates. The Inspiration and Review Worksheet/Discussion plenary activities were not statistically different in improving summative scores.
# TABLE OF CONTENTS

Abstract ii  
Table of Contents iii  
List of Tables x  
List of Figures xii  
Acknowledgement xiv  
Chapter 1 Introduction 1  
Problem Statement 2  
Rationale and Theoretical Framework for the Study 2  
Statement of the Problem 4  
Hypotheses 6  
Limitations and Delimitations of the Study 7  
Definition of Terms 9  
Chapter Summary 10  
Chapter 2 Literature Review 13  
Constructivism 13  
Constructivism: Definition and a Brief History 14  
Piaget’s Theory of Development and Learning 16  
Vygotsky’s Theory of Development and Learning 18  
Arguing for the Use of Constructivism 20  
Counter Point to Constructivism 21  
Summary of Constructivism 22  
Plenary Activity Integration in Lesson Planning and Unit Planning 23  
Lesson Planning and Plenary Activities 24
Instrumentation 54

Plenary Tools 55

Pre-tests and Post-tests 55

Student Questionnaire 56

Notes and Observations 56

Summary of Instrumentation 57

Data Collection and Treatment 58

Time On-Task Behaviour 58

Task Completion 60

Pre-test and Post-test Analysis 61

Qualitative Analysis 62

Summary of Data Collection and Treatment 62

Chapter Summary 62

Chapter 4 Findings 64

Quantitative Findings 64

Does the Use of Inspiration Improve Test Scores? 65

Inspiration Compared to Review Worksheets/Discussion Activities 72

Inspiration effects on the Cognitive Domains 76

Understanding 76

Knowledge 77

Higher Order Process 81

Comparing Time On-task Behaviour for Inspiration and Review Worksheet/Discussion Activities 83
Comparing the effects of Inspiration to Review Worksheet/Discussion on Activity Completion 87

Summary of the Quantitative Findings 92

Qualitative Findings

Student Perspective of the Plenary Activities Related to Learning and Concept Understanding 94

Section One: Student Preparation 94

Section Two: Student Study and Test Preparation Habits 96

Question One: Identifying preference for individual or group study. 96

Question Two: Types of resources and study techniques used by students 96

Question Three: Student preference for teacher input. 97

Question Four: Student time commitment to study and review. 97

Question Five: Student extracurricular time commitment. 98

Section Three: Review Activity Assessment 98

Question One: Identifying Student Plenary Preference. 98

Question Two: Student perspective on plenary type and test preparation. 100

Question Three: Identifying student effort on plenary activities. 102

Question Four: Student perception of choice for self-expression. 102

Question Five: Student indication of future use of Inspiration. 103
<table>
<thead>
<tr>
<th>Chapter</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Observational Notes</td>
<td>103</td>
</tr>
<tr>
<td></td>
<td>Summary of the Qualitative Findings</td>
<td>105</td>
</tr>
<tr>
<td></td>
<td>Other Findings</td>
<td>107</td>
</tr>
<tr>
<td></td>
<td>Effects of the Review Worksheets/Discussion Plenary Activity on Test Scores</td>
<td>107</td>
</tr>
<tr>
<td></td>
<td>Effects of the Review Worksheet/Discussion Plenary on the Cognitive Domains</td>
<td>113</td>
</tr>
<tr>
<td></td>
<td>Understanding</td>
<td>113</td>
</tr>
<tr>
<td></td>
<td>Knowledge</td>
<td>115</td>
</tr>
<tr>
<td></td>
<td>Higher Order Process</td>
<td>115</td>
</tr>
<tr>
<td></td>
<td>Comparisons of the Effects of the Plenary Activities on Cognitive Domains</td>
<td>117</td>
</tr>
<tr>
<td></td>
<td>Summary of Other Findings</td>
<td>123</td>
</tr>
<tr>
<td></td>
<td>Chapter Summary</td>
<td>124</td>
</tr>
<tr>
<td></td>
<td>Chapter 5 Analysis of the Findings</td>
<td>127</td>
</tr>
<tr>
<td></td>
<td>Analysis of the Quantitative Findings</td>
<td>128</td>
</tr>
<tr>
<td></td>
<td>Does the Use of Inspiration Improve Test Scores?</td>
<td>128</td>
</tr>
<tr>
<td></td>
<td>Inspiration Compared to Review Worksheet/Discussion Activities</td>
<td>131</td>
</tr>
<tr>
<td></td>
<td>Inspiration Effects on the Cognitive Domains</td>
<td>134</td>
</tr>
<tr>
<td></td>
<td>Understanding</td>
<td>134</td>
</tr>
<tr>
<td></td>
<td>Knowledge</td>
<td>136</td>
</tr>
<tr>
<td></td>
<td>Higher Order Process</td>
<td>137</td>
</tr>
<tr>
<td></td>
<td>Comparing Time On-task Behaviour and Activity Completion for Inspiration and Review Worksheet/Discussion Activities</td>
<td>138</td>
</tr>
</tbody>
</table>
Question 2: Does the use of Inspiration, as a plenary activity, significantly improve time on task when compared to the use of review worksheets and lecture/discussion activities?

Question 3: Does the use of Inspiration, as a plenary activity, significantly improve activity completion when compared to the use of review worksheets combined with lecture/discussion activities?

Question 4: Do students believe that using Inspiration provided them more choice, allowed them to direct their own learning, and provide them with a better understanding of the concepts studied?

Summary of the Conclusions to the Problems and Questions

Other Conclusions, Study Impact and Further Research

Effect of Review Worksheet/Discussion on Cognitive Domains

Cognitive Domain comparison between Inspiration and Review Worksheet/Discussion Plenary Activities

Student Perceptions and Review

Impact of the Study and Further Research

Summary of Other Conclusions, Study Impact, and Further Research

Chapter Summary

References

Appendix A

Appendix B

Appendix C
LIST OF TABLES

Table 1  
*The pre- and post-test analyses of the Inspiration plenary for six units of Biology 12.*  
71

Table 2  
*Pre-/post test overall results for the Inspiration plenary compared to the Review Worksheet/Discussion plenary.*  
74

Table 3  
*Pre-/post-test analyses of the Understanding domain for the Inspiration plenary.*  
78

Table 4  
*Pre-/post-test analyses of the Knowledge domain for the Inspiration plenary.*  
80

Table 5  
*Pre-/post-test analyses of the Higher Order Process domain for the Inspiration plenary.*  
82

Table 6  
*Students’ On-task behaviour while participating in the plenary activities.*  
84

Table 7  
*On-task behaviour of students during Inspiration and review worksheet/discussion.*  
85

Table 8  
*Inspiration and Review Worksheet/Discussion plenary ANOVA statistics for on-task behavior.*  
86

Table 9  
*A comparison of completion percentages for Inspiration and Review Worksheet/Discussion plenary activities.*  
91

Table 10  
*The ANOVA statistics comparing the plenary completion of groups completing Inspiration activities to groups completing Review Worksheets/Discussion activities.*  
91

Table 11  
*The ANOVA statistics comparing the plenary completion of Group One Inspiration, Group Two Inspiration, Group One Review Worksheet/Discussion, and Group Two Review Worksheet/Discussion activities.*  
92

Table 12  
*Pre- and post- test analyses of the Review Worksheet/Discussion plenary for six units of Biology 12.*  
112

Table 13  
*Pre-/post-test analyses of Understanding for the Review Worksheet/Discussion plenary.*  
114

Table 14  
*Pre-/post-test analyses of Knowledge for the Review Worksheet/Discussion plenary.*  
116
Table 15  Analyses of Higher Order Process scores for the Review Worksheet/Discussion plenary.  

Table 16  Pre- and post-test comparative results for the Inspiration plenary and Review Worksheet/Discussion plenary for the Understanding cognitive domain.  

Table 17  Pre- and post-test comparative results for the Inspiration plenary and Review Worksheet/Discussion plenary for the Knowledge cognitive domain.  

Table 18  Pre- and post-test comparative results for the Inspiration plenary and Review Worksheet/Discussion plenary for the Higher Order Process cognitive domain.
**LIST OF FIGURES**

| Figure 1 | Group One post-test versus pre-test scores for the DNA unit after using Inspiration. | 66 |
| Figure 2 | Group Two post-test versus pre-test scores for the DNA unit after using Inspiration. | 66 |
| Figure 3 | Group One post-test versus pre-test scores for the Circulatory unit after using Inspiration. | 67 |
| Figure 4 | Group Two post-test versus pre-test scores for the Respiratory unit after using Inspiration. | 67 |
| Figure 5 | Group Two post-test versus pre-test scores for the Excretory unit after using Inspiration. | 68 |
| Figure 6 | Group One post-test versus pre-test scores for the Nervous unit after using Inspiration. | 68 |
| Figure 7 | A comparison of overall improvement for the Inspiration and the Review Worksheet/Discussion plenary activities. | 75 |
| Figure 8 | The group on-task behaviour rates for the Inspiration and Review Worksheet/Discussion (RW/D) plenary activities. | 85 |
| Figure 9 | Task completion rates for Group One. | 89 |
| Figure 10 | Task completion rates for Group Two. | 89 |
| Figure 11 | A comparison of task completion rates using Inspiration or Review Worksheet/Discussion as a plenary activity. | 90 |
| Figure 12 | Group One post-test versus pre-test scores for the Digestion unit after using Review Worksheets/Discussion. | 109 |
| Figure 13 | Group Two post-test versus pre-test scores for the Digestion unit after using Review Worksheets/Discussion. | 109 |
| Figure 14 | Group Two post-test versus pre-test scores for the Circulation unit after using Review Worksheets/Discussion. | 110 |
| Figure 15 | Group One post-test versus pre-test scores for the Respiration unit after using Review Worksheets/Discussion. | 110 |
| Figure 16 | Group One post-test versus pre-test scores for the Excretion unit after using Review Worksheets/Discussion. | 111 |
Figure 17  Group Two post-test versus pre-test scores for the Nervous unit after using Review Worksheets/Discussion.

Figure 18  A comparison of cognitive improvement in Understanding for the Inspiration and the Review Worksheet/Discussion plenary activities.

Figure 19  A comparison of cognitive improvement in Knowledge for the Inspiration and the Review Worksheet/Discussion plenary activities.

Figure 20  A comparison of cognitive improvement in Higher Order Process for the Inspiration and the Review Worksheet/Discussion plenary activities.
ACKNOWLEDGEMENT

I would like to thank Dr. Andrew Kitchenham for his guidance and support. His patience and professionalism were beyond reproach, and his thoughtful input has allowed me to significantly improve my writing abilities.

I would also like to thank my committee members, Dr. Colin Chasteauneuf, Ms. Timma Blain, and Dr. Saphida Migabo, for their thoughtful comments and commitment of time to this thesis.

To my family; thank you for being there when I needed a break and for keeping me focused on the important things in life.

Finally, I would like to thank the students who participated in my study. Their input was invaluable and eye opening.
CHAPTER 1

Endings, like beginnings, are extremely important. A movie or story that ends abruptly or leaves questions unanswered is often thought of as incomplete and can leave the audience with a sense of something missing. In this fashion, education is very similar. A lesson or unit that is not ended well may leave the learner with unanswered questions or with the inability to formulate an appropriate understanding of the material that was covered. To illustrate this point further, consider the following:

A comedian and a teacher are walking down the street. The comedian turns to the teacher and says, “Do you know what the similarity between a good joke and a good lesson is?”

The teacher replies, “No, what is the similarity between a good joke and a good lesson?”

…. At this point the comedian stops and forgetting the punch line sheepishly replies, “Sorry. I forgot the punch line.”

The teacher then states, “I don’t get it!”

“I don’t get it.” The four little words consistently uttered when understanding is not attained and a lesson is ended poorly.

A good lesson or unit ending should allow the learner to draw upon what he or she has learned and display what he or she knows in one fashion or another. A good ending may also allow the learner to make connections between different topics or disciplines that brings about further understanding and may act as a spark to lead into further topics for exploration.

In designing plenary activities, the educator must decide upon the activities that will grab the intended audience’s attention, convey a formative or summative message, and identify gaps or weaknesses in knowledge and understanding to be repaired.

Educators have a number of review activities that may be used as plenary activities. Plenary activities include but are not limited to: games such as Jeopardy or Knowledge Bingo, study note production, question and answer discussions, review worksheets,
crosswords, word searches, poster projects, presentations, and graphical organizers. These activities may be used at the end of a single lesson, to review material the day after, a week later or several weeks or months later.

To add to the repertoire of plenary activities, recent advances in technology have produced a number of innovative methods for presenting, summarizing, and connecting ideas. Many multimedia programs claim to engage learners and allow them the opportunity to formulate their own understanding. Multimedia allows learners to explore topics and make connections using words, pictures and sounds resulting in better explanations and understanding than simply using words alone (Mayer, 2001).

Problem Statement

Rationale and Theoretical Framework for the Study

The importance of using reviews and concluding activities has been highlighted as teaching functions consistently performed by effective teachers. Good and Grouws (1979) emphasized the use of weekly and monthly reviews as one of their five teaching functions. They also suggested that effective teachers spent 15 to 20 percent of their instructional time on weekly and monthly reviews. Plenary activities used during the weekly and monthly reviews reinforce past learning and help in content mastery.

Concluding activities are important parts of any lesson. The concluding activities provide assessment of what was learned, allow a teacher to know where to begin the next day and can act to motivate students (Clement, 2005). Good and Grouws (1979) mentioned the use of daily, weekly and monthly reviews, suggesting effective teachers should devote a large portion of instructional time to review but failed to mention the effectiveness of review type. The effective teaching compilations of Rosenshine and Stevens (1986) also emphasized the daily use of lesson review and similarly failed to discuss the
types of activities to use as plenary activities at the end of a day nor at the end of a unit; nor
did they list plenary activities as part of their major components in systematic teaching. This
trend continued in the discussions of Hunter and Russell (1981).

Hunter and Russell (1981), and Rosenshine and Stevens (1986) focused on individual
lessons and failed to expand their theories to unit presentation. Unit plans allow instructors a
method of formulating lesson progressions that may increase understanding and internal
constructions. The proper use of plenary activities and reviews during a unit could help link
lessons and forge new mental operations. The production of a proper unit plan could diminish
the possibility of lesson plans becoming individual, un-related events strung together.
Stringing together unrelated lessons could make it more difficult to construct internalizations
from external events.

Plenary activities involving the use of graphic organizers, question and answer
discussions, peer/group learning, computer programs, and games and simulations have been
listed by some authors (e.g., Clement, 2005; McKeachie, 2002), but the authors did not list
evidence of the actual effectiveness of each of the plenary activities. Further review of
studies presented by Clement, McKeachie, Good and Grouws, and Rosenshine and Stevens
also failed to present evidence to verify the effectiveness of the review activities listed.

Personal observations have allowed me to question the use of certain mainstay
activities, as it appears that our student population’s access to multimedia has increased, as
has their penchant for collaboration. The review worksheets that held the attention of
students 20 years ago do not do so today even in an updated format. Also, it is my
experienced opinion that many students, although capable of directing their own learning,
would rather rely on the teacher to summarize and put together a review that the student may
use. By relying on the teacher, students may be hindering their acquisition of content
understanding and contextual development. To this extent, I believe that multimedia activities may be used to encompass a wide range of learning types and abilities and prove beneficial in acquiring knowledge and understanding.

One such multimedia tool available to instructors is Inspiration™ (Helfgott & Westhaver; Inspiration Software Inc., 2005). Inspiration, a webbing software program, is a form of interactive multimedia that can be used as a plenary activity to engage student learning and to build a more complete understanding of topics covered in chapters and units. Inspiration is customizable and can allow students to individualize their own learning and understanding, which in turn would improve their retention of knowledge and reiteration of concepts. Inspiration allows students to organize information and allows them to incorporate sound, pictures, notes and web-links (see Appendix A) that may direct the user to video or interactive/simulation sites. With all of its capabilities this type of software may have the ability to engage learners and supply the information they desire in the format that is best suited to them.

Statement of the Problem

I realize the effects on student achievement of a good concluding activity, summarizing concepts, and making cognitive connections. At present a variety of plenary activities exist that try to increase recall of concepts and attempt to engage students in meaningful formative or summative exercises. A teachers' repertoire of plenary activities may include the use of games, quizzes, discussions, worksheets, simulations, graphic organizers, study notes, computer programs, multimedia, or other forms of technology. However, the question arises as to whether one plenary activity type is more effective at engaging students, building knowledge, and increasing understanding than another plenary type.
I believe that engaging the students in active meaningful review is necessary in order to allow students to build the contextual understanding necessary to be successful. In order to focus the study I compared two review methods that I had previously used. The first method relied on the use of concept mapping software, Inspiration, and the second plenary activity involved the use of active discussion and worksheets designed to cover the learning outcomes of a course. Bruillard and Baron (2000) suggested concept mapping and computer programs that allow the creation of graphic organizers are effective at providing students a means of summarizing knowledge and at increasing the students' abilities to direct the students' own learning. However, I wondered if concept mapping was more effective than review and discussion.

The purpose of this study was to answer the following questions:

1. To what extent, does the use of Inspiration, as a plenary activity, improve test scores in Biology 12?
2. To what extent, does the use of Inspiration, as a plenary activity, more significantly improve test scores when compared to the use of review worksheets and lecture/discussion activities?

Subsequently, I also looked for possible reasons for the increase in knowledge retention and collected data to determine cause. I used the following questions to direct data collection:

1. Does the use of Inspiration, as a plenary activity, significantly improve Knowledge, Understanding, or Higher Order Process achievement for test scores?
2. Does the use of Inspiration, as a plenary activity, significantly improve time on task when compared to the use of review worksheets and lecture/discussion activities?
3. Does the use of Inspiration, as a plenary activity, significantly improve activity completion when compared to the use of review worksheets combined with lecture/discussion activities?

4. Does a student believe that using Inspiration provided them more choice, allowed them to direct their own learning, and provide them with a better understanding of the concepts studied?

*Hypotheses*

Preliminary observations and readings suggested that the use of multimedia technologies could inspire and direct understanding in various ways (Goldfarb, 2002; Mayer, 2001). I hypothesized that the use of Inspiration would improve test scores, time on task and participatory behaviours, and completion rates. The use of multimedia technology allowed the students to direct their learning to the extent that was desirable to them which helped raise their levels of understanding in terms of knowledge acquisition and ability to better answer Understanding and Higher Order Process questions.

A secondary benefit to using the Inspiration multimedia program was the time the teacher had to spend with an individual student. As the program could be used to organize information, those students who preferred a student-centered approach were able to work independently, while those students who preferred a teacher-centred approach were able to utilize more of the teacher’s time. The outcome of this was that all students could improve their Understanding and Knowledge. It also provided time for the teacher to instill confidence and calculated risk-taking behaviours in a student who did not usually like to direct his or her own learning. The result was improved student understanding and critical analysis abilities. This finding suggests that the student-centred Inspiration plenary could improve summative assessment results better than the more teacher-centred Review
Worksheet/Discussion plenary activity. The more student-centred approach could also be the more student-preferred plenary compared to the Review Worksheet/Discussion plenary.

**Limitations and Delimitations of the Study**

The proposed study contained several limiting and delimiting factors. Limitations, factors over which the research has no control, included:

1. Participation of students – Student participation was not complete as several students did not return the permission forms, some chose not to participate in the study, some students withdrew from the study or the course, and several parents and guardians chose to not allow their child to participate in the study.

2. Class make-up – The students in the class were assigned according to timetabling events that took place in April of the previous school year. The high school studied was a relatively small secondary school and timetabling resulted in some streaming of abilities. The action research design of the study allowed me to monitor events in the classroom and guide practice, to ensure the students received similar treatments. The use of dependent and independent analyses ensured that streaming would have limited effects on the overall conclusion.

3. Prior learning and knowledge – Biology 12 is an elective course with limited prerequisites. Students who took Biology 12 needed only to be successful in Science 10. Thus it was possible for students who had been exposed to other senior science classes such as Biology 11, senior Chemistry, or senior Physics to have a more extensive knowledge of subject matter or a better understanding of the effort needed to be successful in a senior Biology course. Two steps were taken to limit the effects of previous learning. First, the number of senior courses taken by students was determined and compared between the sample populations. Second, the study used a
pre-test/post-test design to collect, compare, and analyze data. After data collection dependent t-tests were used to determine the effects of the plenary activities on the summative assessments.

4. Previous understanding and knowledge of the software used – Students were taught how to use Inspiration as part of the actions taken during the project and modifications to increase the users power in performing operations with the software was attempted throughout the study. The students were presented with an introduction to the software and allowed to use the program to develop a web diagram for a single unit before data was collected. Feedback was regularly provided to help guide the students in producing future inspiration documents.

5. Room assignment, computer room booking, unforeseen disruptions, and unforeseen computer problems – The secondary school used in the research is a fairly small school and it was necessary to share resources including the computer rooms. Fortunately, the classes were run in true science classrooms, in some years, science classes were run in classrooms that were not designated as such. This limited the physical positioning of materials and students, and created dissimilar learning environments. During the study, an impromptu grad assembly and field trip, booked by others, caused the delay of a plenary in one unit and necessitated a slight modification of the intended time frame for data collection Several technical issues also occurred and were dealt with: lost files, system crashes, and image problems lead to some students losing valuable time in the computer labs.

6. The researcher’s preference for instruction type. The bias was known and controlled by monitoring my actions during presentation of the plenary activities. However, the bias might have come out through hidden or subconscious actions that the researcher
was unaware of. The excitement or apprehension of the instructor might have resulted in unrecognized similar displays by the students.

Several delimitations, factors controlled by the researcher, may have affected the data and nature of the study. The delimiting factors monitored and controlled included the: amount of time spent on each plenary activity, delivery of expectations before plenary activities, monitoring of student actions, amount of direction given during each activity, time between plenary activity and assessment, and the collection and return of completed materials before assessment. Each factor was assessed beforehand and guidelines were put into place to ensure that a systematic trial of the activities occurred.

**Definition of Terms**

*Chapter Review:* an activity that occurs at the end of a unit composed of a single chapter. The activity serves as a summation of understanding and knowledge.

*Cognitive:* pertaining to the mental processes of perception, memory, judgment, and reasoning.

*Formative (Assessment, Knowledge, or Understanding):* the development of ideas, thoughts, and understanding that are produced from the obtaining of knowledge through various activities. Formative processes are ongoing and diagnostic (Clement, 2005).

*Higher Order Process:* the Higher Order Process level is equivalent to the Higher Mental Processes level. This cognitive level includes analysis, synthesis, and evaluation. The Higher Order Process level subsumes both the Knowledge and the Understanding and Application levels (BC Ministry of Education, 2006).

*Interactive:* acting upon or with another. For the purpose of our study we will confine the interactions to a person’s activities in conjunction with an electronic device to obtain knowledge and understanding.
Knowledge: includes those behaviours that emphasize the recognition or recall of ideas, material, or phenomena (BC Ministry of Education, 2006).

Multimedia: any “screen based system where information in the form of text, figures, pictures, sounds or moving images is available to the user” (Latchem, Williamson, & Henderson-Lancett, 1993, p.116).

Plenary activities: activities that occur at the end of a lesson, chapter, or unit that complete or conclude the lesson. For the purpose of this study, the term plenary activities will be used interchangeably with review activities.

Summative (Assessment, Knowledge, or Understanding): the reiteration, or collection, of knowledge or understanding obtained through various activities. Summative processes occur at the end of a lesson, unit, or course and are evaluative in nature (Clement, 2005).

Understanding and Application: a cognitive level that represents a comprehension of the literal message contained in a communication, and the ability to apply an appropriate theory, principle, idea, or method to a new situation (BC Ministry of Education, 2006).

Unit Review: an activity that occurs at the end of a unit composed of several chapters. The activity serves as a summation of understanding and knowledge.

Chapter Summary

Good and Grouws (1979), Hunter and Russell (1981), and Rosenshine and Stevens (1986) suggested that effective teachers commonly include plenary (review) activities as a teaching function. Plenary activities may be used to assess what the student has learned, can be used to focus and motivate the student, allow the student to assimilate knowledge not yet mastered, and provide an opportunity to build further conceptual understanding. Various forms of plenary activities have been identified but the effectiveness of each review type as a means to review whole units needs to be studied in order to best utilize the limited class time.
available. The implementation of the computer into the school system has provided opportunities to use multimedia technology to develop knowledge and build understanding.

This study attempted to determine if Inspiration, a form of multimedia software, could be used as a plenary activity to significantly improve summative assessment scores. The study also compared the summative assessment effects of the Inspiration plenary to a Review Worksheet/Discussion plenary activity. The two major hypotheses were that the learner would benefit from the use of Inspiration as demonstrated by higher assessment scores and that the Inspiration plenary could provide better summative assessment improvement than the Review Worksheet/Discussion plenary.

Four secondary questions were also examined to determine the effect of Inspiration on Understanding, Knowledge, and Higher Order Process cognitive levels, the effect of Inspiration on on-task behaviours and plenary completion rates as compared to Review Worksheet/Discussion activities, and the perception of students regarding the effectiveness of Inspiration at developing conceptual understanding and allowing students to direct their own learning. Quantitative and qualitative data were collected to identify student behaviour and achievement. Summative achievements, focus during the activity, completion rates of the plenary activity, student acknowledgement of the effort that he or she used to complete the plenary, and an indication of future desire to use Inspiration as a plenary were used to support or refute the hypotheses.

Chapter 2 will discuss the professional literature. The literature review will add credence to my study and will be used to reinforce the findings of my study. Chapter 3 will provide a detailed review of the Research Methods and Methodology. Chapter 3 will be used to outline the specific procedures used to attain the data. Chapter 4 will present the findings, both qualitative and quantitative. Chapter 5 will be used to provide a detailed analysis of the
findings presented in Chapter 4. The analysis will cross-reference the findings with the literature presented in Chapter 2 of this study. The final chapter, Chapter 6, will be used to present the conclusions to the two main problems and the four questions presented in Chapter 1.
CHAPTER 2 – LITERATURE REVIEW

In Chapter 1 the problem to be studied was introduced. The introduction identified the question studied, listed the hypotheses tested, identified the limitations, delimitations, and terms presented, and provided reasoning for the study. This chapter will review the literature relevant to the construction of knowledge through the use of graphic organizers and plenary activities. The chapter will begin by reviewing constructivism. Constructivism is a major educational theory employed in the acquisition of knowledge and knowledge development. The second section will review the development of effective lesson and unit plans and will attempt to outline the need to develop effective plenary activities as well as highlight the lack of information available on the use of plenary activities. The third section will discuss the need to present learners with a variety of visual and verbal learning activities and highlight how multimedia and computer technologies have made this an interactive/participatory event. The combining of graphic organizers and computer technology is outlined and two methods in which Inspiration has been used to improve learning are presented.

Constructivism

Plenary activities are designed to bring understanding to the learner and act as a final check for cognitive assimilation. In designing specific plenary activities we may think of the learner as a receptacle to be filled with facts and information or an active participant in the attainment of understanding. I currently believe in the latter; however, the method in which the learner becomes an active participant in the learning process needs to be considered. A learner following a pure progressive or constructivist’s view of learning would be provided the opportunity to openly discover and explore concepts with little or no guidance. A second approach would see the instructor guiding the learner through a series of preplanned activities or discussions in order to construct the necessary knowledge and understanding. In both
cases, the learner must be an active participant, interacting with his/her environment to construct his/her view of the concepts and subjects (Jonassen, 1994).

This section will present a brief description and history of constructivism followed by a discussion of the major ideologies of current constructivist theory. The development of constructivism will be reviewed leading to the current roots of constructivist principles outlined by Piaget and Vygotsky. Piaget’s and Vygotsky’s understandings of development and learning will be reviewed in order to identify the basic principles of individual versus socio-cultural constructivist views. Finally, a brief argument against pure constructivist practice will be presented.

*Constructivism: Definition and a Brief History*

Constructivism is the educational theory that asserts that learners should be provided the opportunity to become involved in the educational process so they could construct their own understanding. Duffy and Cunningham (1996) contended that most constructivists hold the view that learning is an active process of knowledge construction and the instruction process is used to support that construction. In contrast, traditional instructors may contend learning is knowledge acquisition derived from the communication of knowledge through instruction. Duffy and Cunningham further contended that traditional instruction focused on the information presented and that learner activity was for information transfer or processing. In contrast, constructivists viewed the situation as a whole and suggested that learning occurs in context.

Constructivism is not a new theory as Von Glaserfeld (cited in Duffy and Cunningham, 1996) contended that the Italian philosopher, Giambattista Vico, presented ideologies consistent with constructivist theory in the early 18th century. Duffy and Cunningham outlined the efforts of Rousseau during the middle part of the eighteenth
century. Rousseau emphasized learning by doing and suggested that the main role of the teacher was to provide problems to capture the attention of the student and to promote learning. Rousseau’s early theories were the basis for later educational reform.

Richardson (2007) and Duffy and Cunningham (1996) extolled the contributions to constructivist theory made by John Dewey. Dewey studied and developed many progressive principles centred on the principles of student experience and discovery. Dewey saw learning as an active process identical to scientific inquiry. The expert teacher would supply learners with problem-solving and reasoning skills and then use different issues to pique the interest of the learner. Once perturbed the learner would use a scientific “hands-on”/“minds-on” approach that required active involvement to solve the issue and develop understanding (Richardson, 2007).

Current constructivist theories identified two paths to understanding: learner centred approaches that follow an individualistic cognitive approach based on Piaget’s theories and the more socio-cultural approach identified by Vygotsky (Duffy & Cunningham, 1996; Richardson, 2007). Piaget (1964) identified learning as an individual activity that occurred when a person attempted to construct an understanding of the world and resolve discrepancies between expected and experienced events. Piaget suggested that knowledge development was tied to embryogenesis and occurred spontaneously; while, learning was aroused by the teacher or situation. Vygotsky (1978) suggested that knowledge construction and learning occurred through the interaction of individuals with expert adult guides or with more capable peers. Constructivists following Vygotsky’s theories believe that higher mental functions begin as social interactions (interpersonal processes) among human individuals before transforming and turning inward to become part of the individual’s set of cognitive constructs (i.e. intrapersonal processes).
Piaget's Theory of Development and Learning

Piaget (1964) viewed the development of knowledge as the building of operations. Operations are interiorized actions capable of transforming or modifying knowledge. Piaget suggested that to know an object or event was to be able to transform and modify the object as well as understand the transformation process. He also contended that operations were not isolated constructs but consisted of linked operational structures composing a total structure. Operational structures formed the basis of knowledge and could be understood by looking at knowledge development.

Piaget thought that development explained learning and learning was subordinate to development. He proposed four stages of development: the sensory-motor/pre-verbal stage, the pre-operational stage, the concrete operations stage, and the hypothetic-deductive operations stage. The sensory-motor/pre-verbal stage allows for the development of practical knowledge. Pre-operational representation results in the reconstruction of the sensory motor acknowledgments, and begins language and thought development without operation construction in the second stage. The third stage operates on objects and allows for the development of the first operations at a concrete level. In the third stage the student could begin to classify and order objects numerically, spatially, or temporally. The final stage of development allows the student to reason on hypotheses and not objects alone. New operations are created, combined and modified to attain new structures.

Piaget contended that the development of knowledge relied upon four fundamental factors: maturation, experience, social transmission (i.e. linguistic or educational transmission), and equilibration (i.e. the process of self-regulation). Equilibration was described as an active, compensatory, process that lead to operational reversibility. The first three factors were insufficient to create development on their own and equilibration was the
fundamental factor that equilibrated (collected, integrated and balanced) the three factors.

Piaget viewed the processes of development and learning as independent and claimed that learning was subordinate to development. Piaget described learning as a cyclical stimulus-response schema. He believed that a stimulus assimilates into a structure, if the structure is present, and the structure triggers the response. In this sense the response is preset before the stimulus is experienced. Piaget contended that learning occurred during active assimilation, and he emphasized that the subject must be active during the transformation/integration of reality into structures.

The concept of structure development and active assimilation extended into Piaget's belief that external reinforcement was able to produce a physical experience but incapable of producing logical structure. Logical structures are developed when the subject undergoes internal equilibration. Simple operations are developed, integrated and transformed into structures. As development occurs, internal conflicts or incompatibilities arise and self-regulation (equilibration) allows the subject to resolve the conflicts and reach higher levels of equilibrium.

The preceding brief explanation of Piaget's theories suggest that he believed knowledge had an adaptive ability as the cognitive individual transforms his/her conceptual operations and structures with his/her experiential world. The individual's environment is specific to him/her and the perceived and conceived events that the individual encounters are transformed according to his/her previous encounters, actions, and reflections. This suggested that knowledge is personalized and exists within the individuals mind.

Instructors attempting to develop student learning could develop activities that tap into an individual's previously developed operations and responses. Self-regulation may then allow the individual to transform the operations and develop internalized connections. Once
the learning activities and knowledge assimilation has occurred the instructor must accept that peoples perceptions and conceptions are individualized and the instructor will not be able to determine if two individuals have the same knowledge. However, the final outcome of successful knowledge acquisition will be determined if the instructor is able to observe operations/structures that seem to function the same in both individuals.

**Vygotsky’s Theory of Development and Learning**

Richardson (2007) reported that Vygotsky focused on the social nature of humans and not on academics alone. Vygotsky (1978) claimed academics were attained within a social environment and as such the teacher must also be cognizant of moral and ethical behaviors that must be imparted on the learners to allow them to function socially. If the classroom is to be a learning community, the participants need to partake in shared activities that could influence their cognitive constructs.

Vygotsky (1978) rejected Piaget’s theoretical position regarding development and learning. Piaget viewed learning as independent and subordinate to development and suggested that learning utilized development but would not initiate the modification of development. In contrast, Vygotsky believed that learning and development began from the first day of a child’s life and were mutually related. He also claimed that preschool learning and school learning were markedly different entities.

Systematic activities (including movement and perception) in the preschool child are determined by the child’s organic development and his/her mastery of sign and tool use (Vygotsky, 1978). This initial cognitive development of practical intelligence or technical thinking begins at an age prior to the development of intelligent speech. However, Vygotsky claimed that speech was essential to the organization of higher psychological instructions. He believed that speech and practical thinking were actively integrated during development and
that the most significant point in the course of intellectual development occurred when practical activity and speech converged. (Vygotsky, 1978, p.24) The development of speech provides the child with a new way to solve practical tasks. Speech creates a freedom from the concrete that allows the child to analyze situations before acting and enables the child by allowing him/her to direct his/her own behaviour.

The continued use of speech in problem solving transforms from the egocentric to the social. Interpersonal speech allows the child to communicate with others. In later development the interpersonal/social nature of speech may be internalized through intrapersonal function. At this point the child develops a behavioral method to guide himself or herself, organizing his/her own activities, behaviours, and attitudes according to his/her own social form.

Vygotsky considered the internalization of socially and historically developed activities a key characteristic of human psychology. Internalization occurred through a series of transformations. Over a long series of developmental events external activities were reconstructed internally to form various operations or higher mental processes. A key to this series of events was the way in which development appeared first on the social (interpersonal) level and later on the individual level (intrapersonal). Relations between human individuals may eventually develop into higher functions such as logical memory and concepts, as the interpersonal processes transform into intrapersonal processes.

Vygotsky (1978) contended that the differences in school learning and preschool learning were not attributed to the systemic nature of school learning alone but also involved the concept he termed the zone of proximal development. The zone of proximal development is a concept that describes the actual mental development level (i.e., independent problem solving level) of a person to his/her potential mental development (i.e., the problem-solving
level achievable under adult guidance or in collaboration with capable peers). The zone of proximal development defines the mental development levels that are in a maturation state and which the student will be capable of performing independently in the future.

Educators applying the zone of proximal development must acknowledge that students with the same mental development may not have the same zone of proximal development. The individual independent abilities of different students may be at an equal level but his/her future abilities, determined with guidance, may be different. The educator must also acknowledge that a student cannot imitate or internalize concepts beyond his/her immediate zone of proximal developmental levels. Acknowledgment of the zone of proximal development could allow the educator to customize activities for individual students or to develop activities that will allow students to progress through the appropriate stages needed to accomplish the necessary learning objectives.

Vygotsky (1978) concluded that learning and development were not synonymous and were not accomplished in unison. Essential to learning is the creation of the zone of proximal development. He viewed learning as a set of processes that preceded the developmental processes, sharing a highly complex and dynamic relationship. If learning is to occur the student must be engaged in social activities that focus on his/her future capabilities and not the developmental levels/operations that he/she has assimilated or mastered. During the learning process students interact with adults or peers, processes are internalized and could eventually become part of the student’s independent achievements.

Arguing for the Use of Constructivism

In a study to be discussed in detail later in this chapter, De Simone, Schmid and McEwan (2001) present a study that supports the constructivist approach to knowledge development. De Simone, Schmid, and McEwan (2001) contended that the role of the teacher
in a constructivist approach was to provide the learner with flexible learning tools and the necessary scaffolds for the learner to make progress. The availability of flexible tools encouraged the learners to be strategic in their learning, guiding them to use prior knowledge, motivation, and the available resources needed to approach the task. During their study, they decided to use collaborative learning as they felt structured group work would support discussion and dialogue thereby enhancing achievement and productivity. In their conclusion, De Simone et al. (2001) found evidence that social interaction was of value in the development of individual cognition.

Johnson (2002) concurred and suggested a student-centred learning approach, progressing at the student’s pace, allowed the student to investigate his/her own talents and to develop his/her own learning styles. In regards to a social context she suggested, student collaboration aided students in the identification of issues and the formulation of solutions. By listening to one another students developed a collective context and this lead to successful acquisition of knowledge and understanding.

**Counter Point to Constructivism**

Some constructivists believe in pure discovery learning and experiential learning. The concept of pure discovery-based learning has not been accepted by everyone. Mayer (2004) suggested that instruction that is structured, guided, and cognitively focused is more effective at aiding student learning than is pure discovery-based instruction/learning. Mayer contended that the use of activities could promote meaningful learning “but instead of behavioral activity per se (e.g., hands-on activity, discussion, and free exploration), the kind of activity that really promotes meaningful learning is cognitive activity (e.g., selecting, organizing, and integrating knowledge)” (p. 17). Mayer did not argue against learning as being a form of knowledge construction nor did he insist that hands-on activities or
discussions should not be used in the development of knowledge construction; he did, however, insist that learning by thinking was the best constructivist approach.

Kirschner, Sweller and Clark (2006) reviewed the literature regarding a constructivist’s view of minimal guidance and concluded that the research did not support the constructivist approach. For novice and intermediate learners, they suggested that during instruction the controlled studies support effectively directed instructional guidance over minimal guidance, and also concluded that for students with prior knowledge and understanding of a topic, strong guidance and unguided approaches are equally effective during the learning process. They also suggested that unguided instruction could have negative effects, especially if students develop knowledge misconceptions, do not develop complete knowledge, or develop disorganized knowledge.

**Summary of Constructivism**

Constructivism considers learning to be an active process where learners are presented with perturbances that arouse the learner. The learner then attempts to resolve these discrepancies by constructing meaning. The constructivist approach to learning is not new and has led to educational change. (Duffy and Cunningham, 1996) The recent ideologies of constructivism are rooted in the theories presented by Piaget and Vygotsky.

Piaget viewed knowledge development as an individuals attempt to equilibrate knowledge attained through maturation, experience, and social transmission. Piaget determined that learning was sub-ordinate to development and believed that responses are preset but their deployment depends on the assimilation of a stimulus into a knowledge structure. He also contended that learning occurred during active assimilation and insisted that the learner must be active during the transformation/integration of reality into structures.
Vygotsky presented a socio-cultural view of learning. Vygotsky suggested that all learning begins and is achieved through social interaction where the interpersonal becomes the intrapersonal. Vygotsky introduced the zone of proximal development and suggested that an educator may use the zone of proximal development to identify the student's ability to attain knowledge at higher levels. The educator could then design social activities that focus on what a learner will be capable of doing and not what a learner can do.

Mayer (2004) and Kirschner, Sweller, and Clark (2006) do not agree with a minimal guidance approach presented by some constructivists. Mayer argued that structured, guided, and cognitively focused instruction is more effective at aiding student learning than is pure discovery-based instruction/learning. Kirschner, Sweller, and Clark (2006) concurred as their literature review failed to support the constructivists' claims and suggested that negative effects could be seen in individuals that develop knowledge misconceptions, do not develop complete knowledge, or develop disorganized knowledge.

The theories outlining constructivism and the arguments against constructivism identified the active participation of the learner and the internalization of external events/concepts as the main idiom to attaining knowledge and understanding. The differences were in the method that guided the student to that personal understanding and the driving force that is to be credited for creating the knowledge development.

**Plenary Activity Integration in Lesson Planning and Unit Planning**

This section will identify the need for effective lesson and unit planning and the integration of plenary activities. The elements of effective lesson planning will be discussed first. The discussion will identify the need for plenary activities and highlight the omission and lack of information regarding the use of plenary activities. As well, a brief discussion of unit planning will describe the current practice of unit development.
Lesson Planning and Plenary Activities

Educational units are compilations of lessons that are designed to develop understanding of several related topics. The literature regarding lesson planning is quite similar in the structuring of lesson format. Hunter and Russell (1981) identified several elements of lesson design for effective teaching including: setting standards, developing an anticipatory set, stating objective and purpose, teaching, guided practice, independent practice, and closure. Their findings were consistent with other researchers and became part of Rosenshine and Stevens (1986) compilation of effective teaching components. Rosenshine and Stevens suggested that effective teachers consistently began lessons with a short review of the previous day's learning and used small incremental steps to establish understanding and skill development.

The effective teaching compilations of Rosenshine and Stevens (1986) failed to discuss the use of reviews as plenary activities at the end of a day nor at the end of a unit; nor did they list plenary activities as part of their major components in systematic teaching. This trend continued in the discussions of Hunter and Russell (1981) and Rosenshine and Stevens (1986) as they focused on individual lessons and failed to expand their theories to unit presentation. Unit plans allow instructors a method of formulating lesson progressions that may increase understanding and internal constructions. The proper use of plenary activities and reviews during a unit may help link lessons and forge new mental operations. The production of a proper unit plan could diminish the possibility of lesson plans becoming individual, un-related events strung together. Stringing together unrelated lessons could make it more difficult to construct internalizations from external events.

More recently, McKeachie (2002) and Clement (2005) discussed lesson development. McKeachie and Clement agreed that a lesson should contain an introduction/focus, a lesson
body, and a conclusion. Each author described at length, the skills and activities to be used for introductions and lesson bodies, suggesting that the time spent on each activity varies and understanding could be monitored through questioning and by watching for non-verbal and verbal clues. Where the texts fall short is in their failure to expand on lesson conclusion skills. McKeachie admitted that, as a lecturer, one of his greatest problems was the preparation of his conclusions.

Concluding activities were discussed by Wintersgill (2007) and identified as plenaries. He described plenaries as activities that provide an opportunity to compile and direct learning. These activities allow a pupil to focus on what is important, what he/she has learned, the progress he/she has made and his/her next steps. Wintersgill also suggested that a plenary can be used within the lesson but a final plenary is essential as it collects and reviews the various concepts and ideas presented during the entire lesson.

A review-based study performed by Rogers (2007), made reference to the use of reviews in the re-encoding of concepts. Rogers’ study supported the belief that review should be used as a means of increasing retention and understanding. However, Rogers’ study was more concerned with the frequency of review occurrence and not the types of review being used.

The topic of review and plenary activities is essential to formative assessment and cognitive development. Harris (2007) contended that lesson endings must be more structured. Harris further recorded that

Pupils need to be encouraged to express what they have learned at the end of a lesson to determine, first and foremost, that something has been learned. This can then be compared with the learning objectives set out at the beginning of the lesson. Pupils can then be asked to reflect on how successful their learning was and at what they still need to apply themselves. Again, there is a variety of methods of doing this such as pairs discussion, note-making, written work, drawing, mind-mapping, role-play, reporting to the class and so on. (p. 258)
Harris also suggests that student motivation must be analyzed and reported to the students as it may demonstrate the significant impact that motivation plays on student achievement.

Unit Planning

Literature regarding unit development in the classroom is sparse. Texts such as McKeachie's (2002), *Teaching Tips* and Stone's (2002) *Best Practices for High School Classrooms* offer advice on lesson planning but completely omit unit planning. Clements (2005) expanded on unit development but her discussion was minimal and limited to the definition of the term "unit", a description of the questions an instructor would ask to begin unit planning, and finished with a brief discussion of unit assessment. She did introduce the ideas of formative and summative assessment and tied this to the lessons conveyed within the unit but again there was only a brief reference.

Sánchez and Valcárcel (1999) studied a group of 27 science teachers in an attempt to identify the teacher's view and practices when planning teaching units or individual lessons. The qualitative study involved the gathering of individual verbal information through a structured interview and a written commentary of how teachers prepare a unit. The interview attempted to determine the process teacher's undertook during short term planning and the interest, intentions, and assessment of the teacher's planning.

Analysis of the qualitative data involved coding the information into categories and descriptors. The content of the interviews was first divided into what teachers do while planning and what the teachers thought of the planning process followed by a further division of the categories into more detailed sub-categories. The results indicated that teachers used unit content and time as the principal criteria for unit preparation; however, in practice the
teachers suggested that they concentrated on the lessons they would partake in during the following day or week, even though the lessons were only a part of the unit as a whole.

The procedures for short term planning included the selection of activities. 88% of the teachers interviewed mentioned activity selection as a necessary part of planning. The teachers who elaborated on their activity choice indicated the use of various teacher delivered notes, written exercises, laboratory work, and the use of problem sets. No reference to review or plenary activities were made.

In their study, Sánchez and Valcárcel (1999) suggested that most teachers begin unit development by thinking of the objectives to be taught and then choose activities to convey the materials. Sánchez and Valcárcel (1999) concluded that activity choice was determined to play a complementary role in unit development but was not identified to be of primary importance. Sánchez and Valcárcel attempted to correlate activity choice to unit development but the study was not designed to look at the effectiveness of specific activities. Their findings demonstrated that when planning units the content is considered more important than the activities, and their conclusion stated that teaching strategies, the roles of the teacher and student, and the sequencing of activities needed to be further investigated. The teachers interviewed appeared to offer ideas that were far from the constructivist approach that is currently directing education in science.

Increasing student learning, understanding, critical abilities, and the desire to learn, are important considerations when producing educational programs, lessons, and units. Harris (2007) stated that planning a wide variety of strategies for inclusion was beneficial to students and adapting teaching styles and learning situations to suit individual learners was crucial. Harris believed the needs of the learner are met more often when an educator uses a variety of techniques and also contended that pupils benefit from the formative assessments
occurring within plenary activities. The formative assessments that occurred quite often led to improved working and learning and this lead to further enhancing pupil self-esteem.

Summary of Lesson and Unit planning

Effective unit planning requires the educator to identify the objectives that need to be covered, the time needed, and then the activities needed to convey the information effectively. Units are composed of individual lessons that should be organized effectively and used to convey the individual concepts. McKeachie (2002) and Clement (2005) agreed that a lesson should contain an introduction/focus, a lesson body, and a conclusion. Harris (2007) suggested the lesson introductions, bodies, and plenary activities should use a variety of techniques in order to meet the needs of the learners. Discussions regarding the conclusion activities indicated that plenary activities are necessary but have been poorly studied and are often poorly delivered.

Visual Communication and Multimedia

The current understanding of the processing of information by humans suggests that they process material both visually and verbally (Mayer, 2001). To offer instruction in only one mode means that understanding may be less than complete. Deeper understanding is developed as the learner builds connections between concepts and is able to mentally integrate verbal and visual material.

This section will introduce the need to use visual and verbal communication and discuss the use of graphic organizers. The use of multimedia and computer technologies will be presented and focused on discussions highlighting the benefits of multimedia use. Finally, the use of Inspiration™ will be discussed to identify how it has been used to improve the learning process.
An Argument for the Inclusion of Visual Communication

The major form of presenting instructional material throughout written history is through the use of words (Mayer, 2001). To this end, Mayer contended that verbal and written communication and learning had been the major focus of study. Recently a transition has occurred whereby verbal and written forms of instruction are being replaced or supported by visual technologies (Cuban, 2001; Goldfarb, 2002; Mayer, 2001). Cuban contended that the introduction of multimedia was designed to support three goals: to make schools more efficient and productive, to prepare students for the future workplace, and to transform the education process into an interactive activity connected to the real world.

Clement (2005) endorsed the use of visuals to aid the learning process, citing that many lecturers talk too quickly, talk too much, and fail to be heard. She also explicated that hearing and understanding are not the same thing. Students may often listen attentively but fail to internalize the presented material. Visual aids may be used to focus students, and allow them to create the internal connections necessary to create the necessary operations and structures to aid information processing.

Concept Mapping/Graphic Organizers

In combining visual and verbal instruction educators may choose to use some form of spatial or graphical organizer. Mind maps, knowledge maps, concept maps, and other graphic organizers use various methods of representing concept points, often referred to as nodes, and various links (lines, arrows, or arcs) to display the relationships that may exist between concepts. A student’s spatial organizers may represent the student’s organization of his or her cognitive structure. Novak and Gowin (1984) suggested that concept maps are designed to access a learner’s cognitive structure and to physically display what the learner already knows. The externalization of the internal constructs benefits both the learner and the teacher.
as the display can then be studied to identify the operations and structures the student has assimilated.

Robinson and Kiewra (1995) attempted to prove that graphical organizers were superior to outlines in improving learning from text. After two experiments they determined that when

...students are given enough time to study and review a set of graphic organizers is more effective than a set of informationally equivalent outlines or the text alone for learning (a) hierarchical relations, (b) coordinate relations, (c) the application of that knowledge given new examples, and (d) the composition of essays expressing coordinate relations in an integrated manner. (p.466)

However, for representational facts, graphic organizers and outlines were shown to be equally effective.

The Robinson and Kiewra (1995) study involved two experiments to determine the effects of studying text, text plus outlines, or text plus graphic organizers on information retention and immediate versus delayed testing. The types of information tested included: non-represented facts, represented facts, hierarchical relations, co-ordinate relations, contrasting premises and application. After each experiment the participants were asked to complete a questionnaire inquiring about the students perception of the study materials ease of reading, usefulness, the participants perception of time allotment for reading, and time allotment for review.

The first experiment involved 111 students in an undergraduate psychology class divided into two groups. The students read for 45 minutes and then studied their adjunct materials for 15 minutes. One group of students immediately wrote a test to assess their knowledge retention while the other group returned two days later to write the test. Analysis using a 3X2 factorial ANOVA at the α=.05 level determined that students tested
immediately performed statistically better than students tested after a two-day delay. Text only and text plus outline groups performance decreased more than the graphic organizer plus text group over the two-day delay.

Analysis of the dependent measures showed variation in the achievement depending on the measure and the adjunct material used for study purpose. The Text Only group performed better on non-represented facts, no difference was found for represented facts or application knowledge, the Graphic Organizer group performed better than the Outline and Text only groups on co-ordinate relations, and the Graphic Organizer group performed better than the Outline plus Text group for contrasting relations. No statistical information was listed for the Text only group on contrasting relations.

Students were asked about the need for extra reading and study time in the questionnaire. Students’ who used the graphic organizers and outlines felt he/she did not have enough reading time while students who read the text alone felt they did have a sufficient amount of time to read. Twenty-nine percent of the participants believed that they needed more reading time and 40% of the students using outlines felt rushed. This may have been due to the need to move back and forth between the text and the outline.

The 42 participants (students from an undergraduate educational psychology course) in the second experiment were placed in one of three groups depending on the text and adjunct study material. The students studied for one hour using text only, text plus graphic organizers, or text plus outlines. The students then left and returned a day later, looked over their study materials for 15 minutes then wrote a test. Data were collected and one-way ANOVA’s were performed.

Analysis of the data indicated no statistically significant difference in performance for the Graphic Organizer group, Outline group, or Text Only groups existed on non-represented
facts and contrasting premises. The Graphic Organizers did not perform statistically better than the outline group for represented facts but both groups did statistically outperform the Text Only group. The Graphic Organizer group did perform statistically better than the Outline group and Text Only group on relations and applications.

The completed questionnaires indicated that the participants felt that the reading and adjuncts were reader friendly. Fourteen percent of the students felt that they needed more reading time but only 8% of the outline group felt rushed. The change in perception may have been due to the extra time given during the second session.

Robinson and Kiewra (1995) concluded that graphic organizers effectively aid relational learning. The study demonstrated that graphic organizers produced statistically significant improvements in hierarchical relations, co-ordinate relations, and application of knowledge, when compared to the use of outlines or text alone. Graphic organizers were as effective as using outlines or the text alone for learning facts.

The Robinson and Kiewra (1995) study contained a number of limitations that may have affected the results or which did not mimic real world situations. Attentional data was not collected to determine the students focus, performance was not linked to grades and this may have resulted in an insincere level of effort put into the study, and time allotted for study was limited and may not have been sufficient for mastery. The most notable limitation was that students were not allowed to highlight or write anything during the study. They were simply asked to read from the presented study tools. By not constructing the adjunct displays a crucial step in constructing knowledge may have been missed. This would be atypical of many classrooms and would be a major error if one were following a constructivist paradigm.

Robinson and Kiewra’s (1995) final suggestions: indicated they believed it necessary to support chapter-length text with graphic organizers when the student is given enough time
to read, study, and review before testing. They concluded that graphic organizers could aid factual and relational learning, application, and integrated writing. They also indicated that there was a need to explore how various graphic displays could be used to aid student learning.

Bruillard and Baron (2000) reviewed the literature regarding concept mapping and contended that concept maps are important when using a constructivist approach. Accordingly, an individual would create his or her own mental framework of 'mind maps' and this would determine future thought and action. They also concluded that effective learning depends upon the formation of new conceptual frameworks or on the expansion or remodeling of existing conceptual schema.

De Simone, Schmid, and McEwen (2001) described concept maps as tools used to explore thinking, develop awareness of understanding, and support planning and organization of understanding. As such concept mapping could be considered a complex tool to be used by a constructivist. As a learning tool/strategy, concept mapping would be considered capable of supporting learning through knowledge construction, inference development, and increased understanding and relation building through elaboration with new or prior knowledge.

Katayama and Robinson (2000) reviewed several types of spatial organizers including: knowledge maps, concept maps and graphic organizers. They contended that the manner in which spatial organizers could be best used had not been investigated. They cited that a few authors: Robinson and Kiewra (1995) and Robinson et al. (1998) suggested that graphic organizers were best suited to the learning of conceptual relations and application processes.
Further to this Katayama and Robinson (2000) designed and completed a study to determine the effects of using and constructing graphic organizers compared to text based outlines for performance on factual or application tests. The researchers also attempted to determine if it was better to supply the learner with complete, partially complete, or skeletal adjunct displays. Katayama and Robinson predicted that the use of partial notes or graphic organizers would allow students to perform better than if they were to use complete or skeletal notes. They also predicted that using a graphic organizer would allow students to outperform the participants who used text-based outlines.

The study involved 117 students in an undergraduate education course. Participants were volunteers who received course credit for their participation. Students were assigned to one of six groups: complete graphic organizer, partial graphic organizer, skeletal graphic organizer, complete outline, partial outline, and outline. Students were then given a set of instructions and 40 minutes to read a chapter length text, study their complete notes, or study and finish their incomplete notes. At the end of the first session each student packed away his/her material into an envelope and returned two days later to complete the process in another 40-minute period. On the third day each student reviewed his/her material for ten minutes and then wrote a test to assess his/her retention of factual and application knowledge.

A 2 X 3 factorial ANOVA was conducted at the $p = .05$ level to compare the results of the adjunct display use on the factual and application tests. Analysis of the results indicated no significant difference in factual retention between the use of study notes and graphic organizers and there was no significant effect due to the amount of information supplied. Statistically significant results were found on the application tests. Students performed better when they used graphic organizers than if they used study notes alone, and
students using partially complete graphic organizers performed better than students who used complete or skeletal graphic organizers and outlines.

Katayama and Robinson's results suggested that encoding benefits on application tests could be seen as partial notes outperformed both complete and skeletal notes. The use of graphic organizers was also demonstrated to be statistically significant. The study did not account for student familiarity with the subject matter nor with the familiarity of use with graphic organizers, or incomplete outlines. As well, students were instructed to not discuss the reading or text, which would contravene a constructivist's viewpoint whereby social interaction would facilitate the development of the interpersonal level before the intrapersonal assimilation.

The physical construction of concept maps rather than the use of pre-made concept maps may increase their effectiveness; however, concept map production using pen and paper may prove to be difficult and revision can be cumbersome and messy. A number of computer-based programs exist that alleviate many problems associated with hand-built concept maps. Ease of construction, revision, modification, and customization are desirable features to enhance the learning process. Bruillard and Baron (2000) suggested that computer-based concept mapping is capable of reordering mental constructs in ways that would not be possible without the computer. The electronic medium could allow the learner to focus on the learning and not the map constructing process.

**Multimedia Technologies**

The transition to combined verbal and visual education processes could lead to the implementation of multimedia technologies. Leutner (2001) contended that multimedia technologies are capable of providing visualizers and verbalizers access to the form of instructional material that is individually preferred for learning and understanding. The
argument favouring the use of multimedia activities and technology is further supported by research involving the engagement of learners in various activities.

Semb and Ellis (1994) suggested instructional strategies that actively involve students could result in qualitatively different memories that promote learning and retention in all learners. Promoters of multimedia learning suggested that this was a characteristic of good multimedia activities. McKeachie (2002) supported this, as he proposed that the use of technology-enhanced learning environments has a positive influence on student motivation.

Research in various methods of knowledge acquisition suggested that various forms of mastery learning might prove beneficial. Péladeau, Forget, and Gagné (2003) and Kulik, Kulik, and Bangert-Drowns (1990) both reported that mastery learning techniques produced higher examination scores, reduced variation, and produced more positive academic attitudes. Ornstein (1994) showed that high-achieving students find drill and practice boring and counter-productive, whereas problem solving and advanced cognitive questions caused low-achieving students to give up. To this end another means of lesson delivery needed to be used. Ornstein suggested that multimedia technologies could be incorporated into lessons to provide the appropriate amounts of direction for both low and high achieving learners. Mastery learning techniques could be incorporated through multimedia activities and assessment for mastery to be obtained prior to evaluation.

Ornstein (1994) contended that the abilities and interests, and the different learning styles of individuals must be considered in producing lessons and activities. “The ability to select, acquire, construct, and integrate new information with old information … results in generalizing and applying the incoming information in another situation-including a classroom or test” (p. 66). The power of creating individualized instruction is further supported by Giles et al. (2006). Evidence gathered suggested stronger students’ display a
need to freely explore a subject under expert guidance. The stronger students internal focus and drive motivate him/her to search for solutions to tasks/problems presented. In contrast, the lower achieving students were more extrinsically motivated, preferring a more teacher-centered approach to lesson delivery. Again it seems plausible that multimedia technologies could be used to customize instruction to accommodate both high and low achievers and benefit both.

Sandholtz, Ringstaff, and Dwyer (1997) reported that students preferred instructional methods that involved active involvement rather than passive forms (e.g., traditional lecture). Using a student-centred approach, based around the computer, resulted in several positives including: increased initiative as students would often go beyond the presented assignment requirements, increased enthusiasm and greater on-task behaviour requiring little assistance, increased peer collaboration, and an increase in the students taking responsibility for their own learning.

Jonassen (2001) stated that most studies of multimedia instruction have shown that learners prefer multimedia instructional material. He also contended that learners would learn more by constructing multimedia materials than by studying multimedia created by others. Jonassen added that multimedia could be used as a cognitive tool in a constructivist approach such that learners may represent what they know in different ways. He claimed that the learners function as interpreters, organizers, and designers of their own personal knowledge becoming the knowledge engineers rather than knowledge receivers. Also, Mayer argued that effectively designed multimedia engages learners in the cognitive processes required for meaningful learning. (as cited in Jonassen, 2001)

The computer may be used as a useful form of multimedia technology. Dijkstra, Jonassen, and Sembill (2001) stated that contemporary theories of learning suggested
students needed to be active and that the computer could be used as a multimedia platform to deliver interactive, multi-sensory messages in a digital format. Adding to this, Dijkstra (2001) suggested that the computer was a useful medium for education as it allows adequate coaching possibilities, was capable of providing immediate feedback and provided students the chance to work independently and at their own pace.

The use of multimedia technologies in plenary activities led to better understanding of concepts and led to the transfer of knowledge to new situations. Shepard (2000) suggested providing the learner with a variety of practice applications increases the likelihood of learning transference. Russell (1999) concurs and suggested that:

... carefully designed, multimedia instruction can be very effective as a method to increase motivation and alertness (Nelson, Watson, Ching, & Barrow, 1996) and can improve the quality of student responses (Mayer, 1997). Its wide variety of formats such as text, graphics, film, video, hypermedia, and other interactive formats are thought to engage more senses than conventional teaching methods (Mayer, 1997; Najjar, 1997; Nelson, et al., 1996; Pea, 1991) and thus facilitate better learning. (retrieved March 10, 2008 from http://education.gsu.edu/spehar/FOCUS/EdPsy/misc/Consider1.htm, Practical Considerations, para 2)

Multimedia activities could be customizable and allow the user to integrate a variety of applications and materials to better suit the individual student.

The use of multimedia technologies was not considered completely positive. Jonassen (2001) contended that learning gains from multimedia are inconsistent and Sandholtz et al. (1997) reported several negative effects in using computers. These included: lack of time, negative use of time, frustration with software, difficulty for some students to adjust to increased noise, sharing, and simultaneous activities. De Simone et al. (2001) suggested that the amount of training and feedback was a concern in developing computer based concept maps and thought that time should be spent to describe good Gestalt principles ensuring that
key ideas are centrally or hierarchically organized. De Simone et al. (2001) added the use of appropriate link representations needed to be considered.

**Inspiration**

In their 2001 study, De Simone, Schmid, and McEwen found that the majority of their students felt that Inspiration was a useful, flexible, and motivating tool that allowed them to quickly visualize ideas and led to building relationships and understanding. However, the instructors suggested that the maps, developed by the students, were ineffective in representing the arguments in an integrative manner.

The researchers, De Simone, Schmid, and McEwan (2001), performed an exploratory qualitative study to determine student perception regarding the use of concept maps, in a collaborative setting, and electronic technologies. They believed the three tools: collaboration, concept mapping, and electronic technologies, had the potential to foster and support skill development for application, investigation, relational thinking, and communication. Two classes of graduate students, 26 students in total, participated in the study. In groups of three to five students, students were asked to collaboratively develop three concept maps and accompanying prose over the term.

De Simone et al. believed that the use of concept mapping would allow students to externalize internal concepts and collaboration could be used to explore and discuss the students' externalizations. During the study students were given instruction on the uses of concept mapping and one class of training on how to use the mapping software, platform difficulties were encountered leading to the use of Inspiration rather than PIVit. Students were also instructed in the use of FirstClass, a form of communication software, intended to be used for asynchronous collaboration.
Development of the concept maps centred around three integrative statements. The instructor generated the first two statements, while the groups generated the third statement. Completed collaborative concept maps and prose were submitted, evaluated, and feedback was provided using a holistic approach summarizing general impressions. Students did not receive grades from the researchers. At the end of the course students were asked to complete an objective questionnaire.

Instructors found that the submitted concept maps differed in the structure of the representations and the ability to represent the text based knowledge. Content was successfully analyzed but the groups were less successful in using their maps to support the integrative statements. The instructors believed the groups failed to create supported arguments.

Completed questionnaires indicated the majority of respondents enjoyed concept mapping and felt that it helped him or her learn. The respondents indicated that one must be familiar with the content and that it must match the individual learning preference. The participants believed that concept mapping simplified content and led to higher-level understanding. Most participants believed that the concept mapping strategy was easy to use and facilitated the exchange of ideas. In regards to electronic concept mapping, most respondents liked Inspiration and felt it was an effective tool that facilitated the exchange of ideas when in a face-to-face environment but did not like the asynchronous aspect of electronic communication using FirstClass. Students felt concept mapping made it easier to organize and understand the content and appreciated that the information could be arranged in the way he/she thought. The respondents also believed that the computer concept mapping was fun, encouraged collaboration and encouraged creativity, as the tool was flexible, transportable, exchangeable, and easy to edit. Several respondents suggested that a paper pen
method of producing concept maps would be awkward and felt the electronic concept
mapping using Inspiration shifted the learning from the mechanics of concept mapping to
increased learning within the domain.

The participants in the De Simone et al. study elaborated on several activity
requirements that they disliked. The participants suggested they needed more training and
feedback, especially just in time support containing feedback on the mapping process and
apparent understanding. The students indicated they did not like the time it took to
collaborate, complete the prose and produce the concept map nor did they like the
asynchronous communication and felt face-to-face communication and collaboration was
better. The majority of students indicated they would use concept mapping again especially
as an organizational tool (to guide outline creation, organize notes, plan and structure tasks).

The De Simone et al. study used Inspiration as a cognitive tool to organize and
convey information in a collaborative setting. Inspiration has also been used as a teaching
tool to direct and identify learning. Boon, Fores III, Ayres, and Spencer (2005) outlined a
pilot study involving ten tenth grade students with mild to moderate disabilities. The purpose
of the study was to determine if an electronic cognitive organizer (i.e., Inspiration 6) could
improve content area learning in social studies.

The study was conducted over a two-week period. The students were given a pre-test
on the first day followed by instruction on the use of cognitive organizers and the Inspiration
6 software. Students were also asked to use the software to create a cognitive organizer on a
familiar but non-social studies related topic. The second day of the study was used to instruct
the students on three Civilizations of the Americas that they would be creating the cognitive
organizer for. The students were given a blank organizer they were required to complete by
hand while following the guidance of the teacher. The students were repeatedly asked to
compare, contrast, and identify various attributes of the three civilizations during the teacher led presentation. On the third day of the study students were asked to transfer their pen-and-paper cognitive organizers to a template designed using the Inspiration 6 software. The students complied and were then asked to add to the organizer by inserting pictures, varying backgrounds, editing text and utilizing other features of the software. The completed electronic organizers were then printed in both graphic and outline mode. The students were then supplied with a teacher created review and summary of the chapter. On the fourth day of the study the students presented their cognitive organizers to the class and discussed the main ideas. The presentation/review was followed by an immediate post-test. A week after the immediate post-test the students were given a delayed post-test containing identical information to the original post-test, and a questionnaire surveying the students attitudes and perceptions in regard to the Inspiration software.

Analysis of the collected pre-test/post-test results was conducted using paired sample t-tests. The pre-test/ immediate post-test and pre-test/ delayed post-test results both indicated statistically significant improvement occurred for recall and comprehension of the material after completing the training. The results obtained from the questionnaire indicate the students liked using the Inspiration 6 software and believed they were more motivated and increased their ability to remember the topic details.

The main limitations of the study included: a small sample size and the lack of a comparison group. The researcher identified the main limitations but failed to acknowledge the effects of the teacher guided interactions and the mastery learning technique used to present the material. Boon et al. (2005) concluded that the technology based cognitive organizer has the potential to increase content-area learning recall and suggested that future study was needed to explore the use of technology based cognitive organizers.
Summary of Visual Communication and Multimedia

The use of visual information combined with verbal information could allow learners to utilize more than one sense in acquiring information. Graphic organizers could be used to visualize relations and various concepts regarding many different subject topics. Novak and Gowin (1984) suggested that visual organizers could be used to externalize the constructs that a learner has internalized.

Robinson and Kiewra (1995) studied the effectiveness of graphic organizers in constructing knowledge. They concluded that graphic organizers were more effective than text alone in learning relations and the application of knowledge. However, the study failed to mimic the real world as students were given organizers and text to study but were only allowed to read the pre-made outlines and organizers and were not allowed to use any writing utensils to construct anything.

Katayama and Robinson (2000) compared the use of graphic organizers to outlines and cross-referenced the adjunct materials with complete, partially complete and skeletal presentations. They determined that the students who were presented with and used partially complete graphic organizers as study aids performed better on application tests than students who used complete or skeletal outlines, or complete graphic organizers. Katayama and Robinson suggested that the improvement could be due to encoding benefits.

Recent developments in computer and multimedia technology have provided educators with new tools to use in conveying visual and verbal information. Multimedia strategies have the ability to involve students in interactive environments and can be used to support the development of individualized learning plans. Computer based graphic organizers have allowed learners to focus on the learning and not the process of concept map construction.
Inspiration is a multimedia tool that combines computer technology with graphic organizer creation. De Simone, Schmid, and McEwen (2001) used Inspiration in a self-guided collaborative setting to collectively organize and outline information, while Boon et al. used Inspiration in a teacher guided setting to direct learning. In both studies the participants found Inspiration to be a "fun" and useful tool to construct and organize knowledge. Boon et al. also concluded that inspiration was capable of improving comprehension and recall of events.

Chapter Summary

Burge (1999) recognized many positive and negatives aspects of using technology and concept mapping, and realized the need to make informed decisions when determining whether or not to use learning technologies. Before beginning an activity and or choosing a learning technology an instructor must understand the inherent biases of each technology, the technologies advantages and disadvantages, and the time/productivity constraints needed for completion, thinking and processing. Also, the desired outcome must be matched to the strengths of the chosen strategy.

The need for further study to determine the best uses of concept mapping has been recognized by several authors (Katayama & Robinson, 2000; Ruiz-Primo & Shavelson, 1996; Sanchez & Valcárcel, 1999). In their conclusion, Robinson and Kiewra (1995) wrote,

In terms of implications, we advise teachers and instructional designers to support chapter-length text with graphic organizers when students are given enough time to read and study and are given an opportunity to review their materials before testing (which is similar to what students actually do). They aid factual and relational learning, application, and integrated writing. Future research should continue to explore how adjunct displays may be used to aid student learning. (p.466)
The research obtained from my study could support the use of computer concept mapping in a collaborative form as a successful plenary activity and support current constructivist theories.

As my results demonstrate, in choosing a plenary activity to complete a unit, I believe a constructivist could suggest the use of Inspiration and allow the students to develop their own graphic organizer with study notes that they develop on their own. The supporters of a guided approach could suggest that the use of Inspiration or guided review and discussion would be equally beneficial to the construction of knowledge and understanding as the teaching of the individual lessons should impart the prior knowledge and understanding needed before the plenary is begun. In either case both groups could acknowledge that the key component of knowledge construction is the active engagement of the learner. Johnson (2002) supported this viewpoint and promoted the idea of contextual teaching and learning. She suggested that for students to discover meaning they must become involved in the learning process. By searching and exploring, organizing and making decisions the student is able to develop the context that is needed to give the content meaning.

Chapter 1 introduced the problem to be studied and set the hypotheses to be tested. Chapter 2 identified the literature that will be used to identify the theories of knowledge construction, lesson and unit planning, graphic organizers, multimedia integration, and methods for the use of Inspiration. In the next chapter, I will discuss the research procedures and methodologies used to study the question and test the hypotheses presented in Chapter 1.
CHAPTER 3 - RESEARCH PROCEDURES

Chapter 1 introduced the relevance and use of plenary activities, identified key terminology, stated limitations, provided a rationale for the proposed study, described the problem to be investigated and set out the primary and secondary hypotheses that would guide the study. Chapter 2 provided a historical overview of the processes of learning, the development of lesson and unit plans, the need for plenary activities, the use of concept mapping and graphic organizers, the advent of multimedia technology to aid in the creation of concept maps, and the need for further research to identify the uses for concept mapping.

This chapter outlines the research methodology used during the study. A description of the research methodology is followed by a description of the research population. The research population is described using general characteristics of the school population and using data collected from a questionnaire completed by the participants. Specific procedures are discussed to describe the steps used to test the hypotheses. An instrumentation section describes the various tools used to gather evidence and test the hypotheses. The last section outlines the procedures used for data collection and data treatment.

Research Methodology and Research Population

The following section describes the research method used to study the problem identified in Chapter 1. The section will also look at the population used to study the problem, the selection of the research population, and the methods used to gather characteristics of the research population.

Research Methodology

The following section describes the research methodology used to study the problem of plenary effectiveness. The identification of the effects of plenary activities on knowledge retention and understanding is a classroom-based problem and could lead to improvement of
teaching practice along with student learning. Greenwood (2007) suggested that action research works well in the classroom and in small and marginal projects as it promotes successful, sustainable, and liberating change. I chose to employ a practical action research approach (Creswell, 2005; Mills, 2000) to study the problem. Creswell and Avison, Lau, Myers, and Nielsen (1999) indicated that action research should involve: a systematic and cyclic approach of problem diagnosis, focus area identification, action intervention, data collection, data analysis, reflective learning, and action plan development. Avison et al. suggested research performed in this manner is more productive as research and practice work together to facilitate and improve each other.

During the study, I analyzed both quantitative and qualitative data collected by using Mills' (2000) three E's of data collection: Experiencing, Enquiring and Examining. Data collection through Experiencing involved the production of observational notes and field notes either written by a participant or me. Enquiring involved the collection of data through the use of interviews, focus groups, questionnaires, surveys, and standardized tests. The Examining techniques required the production of records of occurrences and the collection of artefacts. Each of these methods of data collection was invaluable in gaining the information that could be used as evidence in the inquiry. The qualitative and quantitative data were used to identify the effects of participating in the Inspiration plenary and Review Worksheet/Discussion plenary on the student's summative assessment scores and student plenary perception. The data were also used to compare the use of Inspiration to the Review Worksheet/Discussion method.

*Research Population*

The following subsections identify the selection and characteristics of the sample population used in my study. The selection of the students, the division of the students into
two groups according to timetable placement, and the method for collecting general characteristics of each group will be described. The individuals in the groups were willing and active participants and agreement to participate was not a guarantee of academic success in the course.

*Student Selection*

The study was conducted during the 2008/2009 school year, at a secondary school in a large urban centre in British Columbia. In British Columbia, Biology 12 is an academic elective course that may be taken without any senior course (Grade 11 or 12) pre-requisites. Before the study began, approval was sought from the UNBC Research Ethics Board, the school district, and the secondary school involved in the study. Once approval was obtained, information and participation permission forms were sent to the parents or guardians, and students that were involved with the study. Care was taken to exclude any students from data collection who had not received permission to participate from their parents or guardians, who had not agreed to participate, or who had chosen to remove themselves from the study.

The study participants included two groups of students taking Biology 12 in this school. The population sample was chosen according to my teaching assignment for the 2008-2009 school year. The reason for using Grade 12 Biology students was threefold. First, I had easy access to the study groups. Second, the school involved in the study had a varied demographic as the students came from a wide range of ethnic and economic backgrounds. Third, the Biology 12 course being implemented during the 2008-2009 school year had an established curriculum that allowed the development of new and reliable assessment instruments.
Group Assignment

Two separate groups of students were created based upon enrolment in a given section of the course. The first group, Group One, was composed of first semester students while the second group, Group Two, was composed of students enrolled in a second semester section. At the beginning of each course the students were informed of the study and its intent. The agreement for student participation was obtained prior to the study and students were informed that they could withdraw from the study at any time.

Group Characteristics

The first group began as a class of 29 students. Of those 29 students, 22 completed and returned the consent form and eventually three of the consenting students chose to remove themselves from the course and the study. Thus Group One contained 19 student subjects. Group Two began as a class of 29 students. Of those 29 students, 26 completed and returned the consent form and eventually one of the consenting students chose to be removed from the course and the study. Thus Group Two contained 25 student subjects.

A questionnaire was distributed at the end of the course and was voluntarily completed by students from each group. The questionnaire was completed and returned by 16 Group One students and 24 Group Two students. The questionnaire was used to identify several traits of each group that could be used to compare the groups. The questionnaire was also used to collect data that could be used to analyze qualitatively. The questionnaire was designed to assess the level of comfort that students had working with the computer, if they had been exposed to concept mapping and/or Inspiration, and their comfort with guiding their own learning. The questionnaire also assessed student study habits, student preference for plenary activities, and student perspectives on the plenary activities.
Summary of Research Methodology and Research Population

This section identified the research methodology used and the selection and characterization of the research population. I chose to use a practical action research methodology in order to systematically diagnose the problem being studied by focusing on intervention, data collection, data analysis, reflective learning, and future action plan development. The three E's of experiencing, enquiring and examining were used to collect qualitative and quantitative data in attempt to compare the use of the Inspiration plenary to the Review Worksheet/Discussion plenary.

The section also described the selection of the students who participated in the study. The study population was from a school in a large urban center of British Columbia. The study population was divided into two groups according to the semester allocation. The characteristics of each group were collected using a questionnaire. The questionnaire was designed to collect data that could be used to compare the groups in order to suggest similarity. The student characteristics collected included a description of the academic achievements, study preference, study habits, computer abilities, and opinions regarding the plenary.

Specific Procedures

This section is used to identify the specific processes used to test the hypotheses. The section begins with a general identification of the set-up process and considerations used prior to the study. The section then outlines the plenary Inspiration and Review Worksheet/Discussion describing each plenary and how it was conducted. The section ends with a look at the modifications that were required due to unanticipated occurrences.
Pre-study Considerations

The students participating in the study covered the same material and were taught the subjects as they would normally be taught. The one changed variable was the plenary activities employed at the end of each unit. To optimize concept delivery, the Biology 12 curriculum was delivered as 10 separate units. Before beginning the collection of data, the timetabling and block scheduling suggested that six of the ten units could be used to collect data. After the delivery of the unit material, two days of plenary activities were completed before the unit post-test. To this extent, the first day of the plenary activity included a 20-minute pre-test immediately followed by a brief introduction and the implementation of the plenary activity. The second day was used to complete the plenary activity followed by the post-test on the third day.

Plenary Activities

Two types of plenary activities were used during the study. Before the plenary activity began, each student was supplied with a list of the learning outcomes for the unit. The timeline for completion and the necessity to complete and submit his or her final product was reviewed. During the plenary activity, students were encouraged to seek concept clarification, to ask questions, and to share responses by discussing ideas with their peers and the teacher. Students were informed that they were to stay on task and that off-task behaviour would be addressed.

The first plenary activity involved using Inspiration to complete a concept map or outline of the main ideas of the unit. Inspiration is a computer program that allows the user to easily create, organize, and edit a graphic organizer or concept outline. The program may be used to individually or collaboratively structure thoughts and communicate concepts and concept relationships.
The Inspiration plenary was introduced along with the location of a variety of supplemental resources. Before beginning, students were supplied with several files that included graphics from the chapter as well as a template of concepts (see Appendix B), without links, that they could use as a starting point, if they so chose. The students were also informed that their completed Inspiration assignment was theirs to complete; however they were encouraged to use graphics, links to websites, video, and sound. The first day of the plenary was used to begin the outline and the second day allowed students to complete, share, discuss, ask questions, seek clarification on the concepts, and to polish their Inspiration products into a useful study tool.

The second plenary activity included beginning a set of unit worksheets during the first session followed by a class to complete the assigned worksheets, clarify answers, and discuss further concepts and misunderstandings. Students were encouraged to ask questions and share ideas on both days of the review activity and were instructed to focus on the task. During the second day, the answers to the worksheets were reviewed. The review included concept clarification and was followed by a discussion highlighting the learning outcomes for the unit. The discussion focused on student initiated questions and answers, supplemented by teacher derived questions to fill in missed concepts. During the discussion and review, care was taken to involve all of the students and to maintain student attention.

On the day of the post-test, students were asked to submit printed copies of their completed review worksheets and their printed or electronic copies of their Inspiration creations. Students were then given directions for completing the test and allowed one hour to complete the post-test. After the test, students were instructed to hand in their completed post-test and were reminded to submit their completed plenary. Several Review
Worksheet/Discussion plenary activities were submitted late and were counted towards their final grades.

Before data collection began, all of the Group One and Group Two students were given a two-day introduction on the use of Inspiration. The training included: identifying the location of available files, diagrams, PowerPoints that corresponded to and accompanied the student text, instruction on how to create a graphic organizer with elements and relational links, and how to incorporate pictures, notes, sound, and web links for video or to websites. Students were also shown how to print off their Inspiration creations, to transfer between graphic and outline format, to transfer their creations to Word processor form, and to export to HTML. During the training process students were shown various examples of Inspiration creations and a discussion was held as to what was useful, as well the students were continually reminded that their finished products had to be functional and that they had limited time for completion. The training Inspiration activities were collected, marked, and returned with suggestions for improvement.

After the training/introductory unit, six units were used to collect data for comparison between the two groups. In the first unit, both groups were required to use Inspiration and in the second unit, both groups were presented with the Review Worksheet/Discussion plenary. For the third and sixth unit, Group One used Inspiration and Group Two used the Review Worksheet/Discussion. For the fourth and fifth units Group Two used Inspiration and Group One used the Review Worksheet/Discussion plenary. For each unit, the students were required to submit their completed plenaries. Plenary activities submitted were reviewed and suggestions for improvement or consideration were made and returned to the student.
Unanticipated Changes

Each unit was mapped out in order to determine the number of days that were needed to present each unit and to maintain continuity between the first and second semester classes. All of the units maintained the planned schedule except for the Respiration unit. During the delivery of this unit, extra days were used for Group One. The time used for the plenary was the same. This alteration was necessary as an unprecedented number of absences on the day of the pre-test administration resulted in a postponement of the pre-test and plenary implementation by one day. A second interruption occurred on the second day of the Review Worksheet/Discussion plenary as an unanticipated Grade 12 assembly resulted in a loss of one half of the review period. The plenary was continued for one-half of the next day and the post-test resulted the day after. The time of plenary activity was the same but the days used resulted in an extra night of study time. These same conditions could not be recreated in the second semester.

Summary of Specific Procedures

This section described the need to maintain a controlled experiment by developing specific procedures before starting the study and maintaining those procedures throughout the study. A description of the Inspiration and Review Worksheet/Discussion plenary activities was provided and the method of implementation was covered to identify how consistency was maintained. Finally, a description of unforeseen interruptions in the study was presented and the process used to adjust for the change in procedure was described.

Instrumentation

This section identifies the specific instruments that were used to test the hypotheses. A description of the plenary tools outlining the Inspiration and review worksheets is made,
followed by a description of the pre- and post-tests. The student questionnaire is described in
detail and the methods used to record notes and observations are described.

Plenary Tools

Inspiration is a computer software program that may be used for concept mapping.
Inspiration allows the production of concept nodes and supports a variety of linking methods
as well as allows the users to transfer their concept maps into outlines and more textual
formats. The users may insert a variety of audio and visual media as well as external web-
links in order to enhance their productions. The Inspiration website contends that the
Inspiration software may be used to create a variety of webs, maps, graphic organizers, and
diagrams for thinking organizing and writing and suggests that “Inspiration encourages
deeper, more critical thinking and that improves creativity, comprehension and retention”
(Visualize & Develop Ideas. Understand & Retain Concepts, para. 1).

The review/discussion plenary used a variety of teacher-created unit worksheets and
unit worksheets that came from the Inquiry into Life student study guides (Mader, 1988,
The worksheets were selected or designed to completely cover all of the intended learning
outcomes. The Inspiration plenary required the use of a class set of computers that contained
and were capable of running Inspiration version 7.6, a web browser, Microsoft PowerPoint,
Adobe Reader, Adobe Photoshop, QuickTime, and Microsoft Word.

Pre-tests and Post-tests

The two groups were tested using a set of pre-tests and post-tests in order to determine the
assimilated knowledge, understanding, higher order abilities, and overall information that
each group possessed. The pre- and post-tests were composed of multiple-choice (objective)
questions designed to assess the cognitive domains and learning outcomes in the proportions
set by the BC Ministry of Education for Biology 12. The Ministry standards indicated that the ratio of Knowledge: Understanding: Higher Order questions should be approximately 22:58:20 (BC Ministry of Education, 2006). Each pre-test was 20 marks in length to facilitate a writing time of 20 minutes or less, and each post-test was composed of 40 questions. In order to maintain a close approximation to the ministry standards, the pre- and post-test ratio of Knowledge: Understanding: Higher Order questions were 4:12:4 and 9:23:8, respectively.

Various item characteristics were considered in the creation of each question to lower the chance of guessing correctly on any given question. Each question contained five distracters with similar sentence lengths. The correct answers were randomly distributed for each unit test.

*Student Questionnaire*

The student questionnaire contained five sections designed to identify the students: academic accomplishments, exposure to concept mapping, comfort with the computer, study habits, preference for a particular plenary method, and learning style. The questionnaire was designed to obtain both quantitative evidence to compare the groups and qualitative evidence to analyze the plenary activities.

The questionnaires were presented a week before the last class of the course. The students were given 20 minutes to complete the surveys in class. Students that failed to complete the questionnaires were asked to complete them outside of class time and return them later that day or at the beginning of the next class. A copy of the questionnaire is contained in Appendix C.

*Notes and Observations*

Prior to observation and data collection, criteria were developed to identify what types of field notes, artefacts, and observations would be collected. Definitions were
developed for on-task/off-task behaviour and the three identified cognitive domains. On-task/off-task behaviour was recorded as an indicator of student focus during the plenary, plenary completion was recorded as a group, pre- and post-tests scores were collected, categorized and analyzed, completed plenary activities were archived, and student plenary preference was obtained through written feedback on the questionnaires.

On-task data was collected to assess the Inspiration and Review Worksheet/Discussions plenary activities to maintain student focus and to motivate the student. Sandholtz, Ringstaff, and Dwyer (1997) suggested students preferred instructional methods that involved active involvement and that a student-centred approach, based around the computer, could increase student initiative, enthusiasm, on-task behaviour, peer collaboration, and the students' taking responsibility for their own learning. Collecting student on-task data and identifying student preference could also be used to verify Robinson and Kiewra’s (1995) study findings and address the lack of attentional data that were a suggested limitation. These findings could then be used to support the hypotheses that suggest Inspiration will increase on-task behaviour and plenary completion.

Summary of Instrumentation

This section identified the various tools used to collect data regarding the ability of the plenary activities to improve academic achievement. The section described the plenary tools used, including the Inspiration software and the types of review worksheets presented to the students. The plenary description was followed by a description of the pre- and post-tests that were developed. Each test was developed in accordance to Ministry standards and the Intended Learning Outcomes (ILOs) for each unit. A description of the student questionnaire used to identify interests, study habits and personal opinions was presented followed by a review of the types of notes and observations that were to be completed and recorded.
Data Collection and Treatment

This section outlines the types of data collected and the data treatments performed in order to analyze and provide evidence for accepting or rejecting the hypotheses. A description of the data collected and the statistical tests used to analyze the data for time on-task behaviour, plenary completion percentages, pre- and post-test scores, and the identification of qualitative data is presented.

*Time On-Task Behaviour*

During the first day of each plenary, the plenary was introduced and each student was given the opportunity to work on his/her assigned tasks. After the plenary introduction student behaviour was observed over a 30-minute period. At five-minute intervals from the start (i.e., time = zero) to the end (i.e., time = 30 minutes) the number of students who were off-task was recorded. Intervention and verbal refocusing occurred when students displayed excessive off-task student behaviour. The number of students on-task was later determined by subtracting the number of off-task students from the total number. This value was then converted into a percentage and recorded.

Before gathering on-task data, two practice sessions per Group were performed. The practice sessions occurred during the DNA Inspiration plenary and during the Digestive system Review Worksheet/Discussion plenary. The practice sessions were used to map the room and student placement, determine what constituted off-task or on-task behaviour, determine my ability to record data consistently, and identify a method to ensure that the recording intervals were maintained. The data collected during the practice session units were not used in the analysis of on-task behaviour.

When monitoring students, I determined if the students were either on-task and engaged or off-task. On-task behaviour included: actively answering the questions presented
through writing, active discussion about the topic matter, researching the topic matter, asking questions, movement around the room to retrieve print outs or to gather necessary resources such as worksheets, and general engagement in the instructional activity. Off-task behaviour included: misbehaving, active off-topic discussion, movement around the room or out of the room for no apparent reason, and the use of electronic devices such as cell phones, personal movie players, or personal game machines. Students displaying off-task behaviours were passively and actively encouraged to refocus and complete the plenary.

Data collection for on-task behaviour was collected during the plenary activities involving the Circulatory, Respiratory, Excretory, and Nervous System units. The Inspiration plenary was used by Group One for the Circulatory and Nervous units and by Group Two for the Respiratory and Excretory units. The Review Worksheet/Discussion plenary was used by Group One for the Respiratory and Excretory units and by Group Two for the Circulatory and Nervous System units. Seven data entries, according to five-minute interval timeframe, were recorded for each plenary type. The data was averaged by plenary type and group to produce four independent samples: Group One Inspiration, Group One Review, Group Two Inspiration, and Group Two Review.

A one-way analysis of variance ANOVA was performed to compare the four independent groups and Tukey’s Honestly Significant Difference (HSD) test was used to analyze statistical significance. The one-way ANOVA can be used as a statistical test to determine if the means of two or more independent groups are equal. Tukey’s HSD is used in conjunction to the ANOVA. Tukey’s HSD can be used to perform pair-wise comparisons of means in an attempt to detect which means are statistically different from one another.
Task Completion

Plenary activity task completion was determined by the number of students submitting completed or partially completed plenaries, either in hardcopy or electronic format. Being present during the plenary activity was not sufficient evidence to count for plenary completion as artifacts had to be tangible. Inspiration plenary submissions were considered complete if the Intended Learning Outcomes (ILOs) were covered as notes, pictures, charts, or other references embedded in the Inspiration student file. Review worksheet/Discussion plenary submissions were considered complete if the worksheets contained answers for 50% or more of the activity. A reference to partially complete submissions was created as a field note if a submission was less than 70% completed.

Each group completed six plenary activities, three involving Inspiration and three involving Review Worksheet/Discussion activities. Group One completed Inspiration plenary activities for the DNA, Circulation and Nervous System units plenary, and Group Two completed an Inspiration plenary for the DNA, Respiratory, and Excretory units. Group One completed Review Worksheet/Discussion plenary activities for the Digestion, Respiratory, and Excretory units and Group Two completed a Review Worksheet/Discussion plenary for the Digestion, Circulation and Nervous System units.

After determining the completion percentages, an independent one-tailed t-test was used to compare the Inspiration plenary activity completion rates to the Review Worksheet/Discussion plenary completion rates. Further analysis was performed using a one-way ANOVA and a two-by-two factorial ANOVA for the four separate groups: Group One Inspiration, Group One Review Worksheet/Discussion, Group Two Inspiration, and Group Two Review Worksheet/Discussion. Tukey's HSD was calculated for all statistically-significant results.
Pre-test and Post-test Analysis

The majority of quantitative data was collected in the form of pre- and post-test marks. The test marks were collected and analyzed in their entirety and in part (i.e., categorized by cognitive domain: Knowledge, Understanding, or Higher Order Process). Inspiration data were collected for Group One using the DNA, Circulation, and Nervous system units and Group Two using the DNA, Respiratory, and Excretory units. Review Worksheet/Discussion data were collected for Group One using the Digestion, Respiratory, and Excretory and for Group Two using the Digestion, Circulation and Nervous System units.

For the Inspiration plenary, dependent t-tests were run to assess the effects of the plenary activities on overall test scores. Dependent t-tests were performed as repeated measures (pre-test/post-test) and were used to collect and analyze sample data. Effect size and power were also determined. Further analysis was performed to determine the effects of the Inspiration plenary on the three cognitive domains. Dependent t-tests were conducted for each unit analyzing the separate cognitive domains. Effect size and power were also calculated and recorded for each unit.

In order to compare the Inspiration and Review Worksheet/Discussion, differences were determined between the pre-test and post-test scores. The differences were then analyzed using independent t-tests for the individual units. Effect sizes and power were determined and recorded.

An analysis of the Review Worksheet/Discussion plenary results was completed in the same manner as the Inspiration plenary. Overall and cognitive domain results were determined. Dependent t-test scores, effect sizes and power were calculated and listed for each unit. The information provided from these findings were not needed to support the
hypotheses but were of interest as they provided evidence to the effectiveness of review worksheets and discussion techniques as a plenary activity.

Qualitative Analysis

Qualitative data were collected by using comments made on the student questionnaire, through field notes dealing with on-task behaviour, and by collecting artifacts of completed plenary activities. Qualitative information from the students was gathered, coded, and analyzed to identify themes and draw conclusions to identify the participants' views on the two types of plenary activities studied. Plenary activities that display high appeal to the individual students were given equal consideration to those that display the best results quantitatively. Students were encouraged to complete the entire questionnaire and were asked to be honest and truthful.

Summary of Data Collection and Treatment

The data collection and treatment section identifies the methods used to record and analyze the data used as evidence in accepting or rejecting the hypotheses. Quantitative data was collected to identify time on-task behaviour, plenary completion percentages, and pre- and post-test scores. A student questionnaire was used to assess the academic preparation, study habits and plenary opinion of the research population.

Chapter Summary

The purpose of this study was to demonstrate the necessity of plenary activities and to show that plenary activities that engage the student and bring about formative knowledge and understanding are superior to others used in Biology 12. I contend that the choice of plenary activity for Unit review is a classroom-based problem that requires the collection of both quantitative and qualitative data. Practical action research was used and a system of action initiations, data collections, reflections, and analyses occurred throughout the study. Avison
et al. (1999) suggested that this was a necessary part of the process of problem diagnosis, action intervention, and reflective learning preventing simple action without research or vice versa.

Quantitatively, performance based data were collected and analyzed with respect to review methods used. Other quantities collected included: participation rates/time on task, and task completion. These were analyzed to identify correlations with review methods. The quantitative data was assessed in order to identify whether the Inspiration software improves results better than review worksheets combined with lecture/discussion. The pre-test/ post-test data was analyzed to determine the effects of the plenary activity on overall score, as well as on improvement in knowledge, understanding, and higher order understanding results.

Qualitatively, the students’ thoughts and feelings toward the various plenary activities were collected, coded, and analyzed for themes. These themes were also compared to the themes developed from the researcher’s notes and observations during the students’ participation in the various plenary activities. The qualitative and quantitative results were reported to produce a complete assessment of the various plenary activities.

Chapter 4 presents the findings of the various collection instruments. An analysis of the data will occur in Chapter 5. Both the quantitative and qualitative findings will be presented and analyzed. In this way, I will provide evidence for the acceptance or rejection of the hypotheses outlined in Chapter 1. Namely, that the use of Inspiration would improve test scores, time on-task behaviours, and completion rates.
CHAPTER 4 – FINDINGS

Chapter 1 introduced the need for educators to use plenary activities, identified several types of plenary activities, identified the problem to be investigated, outlined several hypotheses to test, identified limitations, and presented various terms. Chapter 2 reviewed the professional literature and supplied evidence for the validity of this research identifying gaps in the understanding of plenary use, exploring the benefits and drawbacks of concept map use, identifying the need for students to actively engage in learning, and suggesting a benefit from multimedia integration. Chapter 3 presented the research procedures, identified the research population and described the data collection and analysis procedures. This chapter will identify the findings, presenting the quantitative and qualitative data that will be used to support or refute the hypotheses.

The presentation of the findings is organized according to the presentation of the two primary and four secondary research questions. Quantitative data were collected, analyzed through a series of dependent $t$-tests, independent $t$-tests, and/or ANOVA calculations, and used to investigate the first five questions. The sixth question was investigated using a questionnaire that led to the collection of qualitative data in an attempt to identify the students' perceptions of the plenary activities compared. Finally, a number of extra findings are presented to further analyze and compare the Inspiration™ and Review Worksheet/Discussion plenary activities. The quantitative, qualitative, and extra findings are used to support or refute the hypotheses, and are presented as evidence to support conclusions in the next chapter.

Quantitative Findings

This section identifies the quantifiable evidence gathered from the pre- and post-tests, task completion rates, and on-task behaviour observations. Pre-test and post-test scores were
collected and used to analyze the effects of Inspiration, as a plenary, on overall academic improvement, in comparison with the Review Worksheet/Discussion plenary, and on cognitive domain improvement. The pre-test and post-test scores were graphed to display the raw data and were analyzed using one-tailed dependent or one-tailed independent t-tests.

In the pre-test/post-test comparisons the differences are presented as negative values. A negative value represents a higher post-test score and a lower pre-test score. The larger the difference the better the student did on the post-test in comparison to his/her pre-test score.

The fourth and fifth research questions were analyzed by collecting and recording data and observations, based on set criteria. On-task behaviour was recorded by collecting data while the students were completing the required plenary activity. Task completion data were collected through submission of assignments, recorded as a completion percentage, and then cross-referenced with Group and plenary type. The collected data were displayed using graphs and analyzed using one-tailed independent t-tests, one-way ANOVA’s, and/or 2 X 2 factorial ANOVA’s to determine significance.

*Does the Use of Inspiration Improve Test Scores?*

The Inspiration plenary was used for both Group One and Group Two in the first unit (DNA), for Group One in the third unit (Circulation), for Group Two in the fourth unit (Respiration) and fifth unit (Expiration), and for Group One in the sixth unit (Nervous System). Pre-tests were administered two days before the post-tests. The plenary activity began immediately after the pre-test and was completed the next day. The post-test was administered the day after the plenary. Students were allowed to use their completed plenary for study purposes and were encouraged to do so.
Figure 1. Group One post-test versus pre-test scores for the DNA unit after using Inspiration. The scores are percentages displayed in decimal form. The graph displays a correlation with $r = .600$ and RMSE (root mean square error) = .143.

Figure 2. Group Two post-test versus pre-test scores for the DNA unit after using Inspiration. The scores are percentages displayed in decimal form. The graph displays a correlation with $r = .746$ and RMSE = .095.
Figure 3. Group One post-test versus pre-test scores for the Circulatory unit after using Inspiration. The scores are percentages displayed in decimal form. The graph displays a correlation with $r = .678$ and RMSE = .151.

Figure 4. Group Two post-test versus pre-test scores for the Respiratory unit after using Inspiration. The scores are percentages displayed in decimal form. The graph displays a correlation with $r = .514$ and RMSE = .132.
Figure 5. Group Two post-test versus pre-test scores for the Excretory unit after using Inspiration. The scores are percentages displayed in decimal form. The graph displays a correlation with $r = .590$ and RMSE = .149.

Figure 6. Group One post-test versus pre-test scores for the Nervous unit after using Inspiration. The scores are percentages displayed in decimal form. The graph displays a correlation with $r = .657$ and RMSE = .157.
Figures 1 through Figure 6 display the raw data for each of the trials. Each graph displays the Pearson product moment correlation coefficient for a sample (r) and the root mean square error (RMSE). RMSE measures the difference between values predicted by a model and the actual values, collecting the differences to form a single measure of precision that may have predictive power. Each post-test/pre-test graph indicated a medium to high correlation. The calculated r-values ranged from .514 to .746. The range in RMSE was from .095 to .157.

The clustering of the data to the left and higher on the graph, the positive intercepts, except the Nervous system unit graph, and the positive slopes of each graph indicated improvement occurred from pre-test to post-test assessment. The graphed scores were clustered to the left indicating low pre-test scores and were vertically higher indicating higher post-test scores. Students who scored higher on the pre-test generally scored higher on the post-test. The negative y-intercept and steep (>1) slope of the linear fit line for the Nervous system suggested improvement occurred from pre-test to post-test assessment.

Analysis of the data occurred using directional dependent t-tests with an alpha level (α) of .05 to determine significance. The t-tests were completed to assess the effects of the plenary on student achievement and were used to test the hypothesis: If a student uses Inspiration as a plenary activity then his/her test scores will improve. For each of the units the following null hypothesis (H₀) and alternative hypothesis (H₁) were used in the pre-test/ post-test comparisons,

\[
H₀: \quad \mu_{\text{Pre}} \geq \mu_{\text{Post}} \quad \text{or} \quad \mu_{\text{Pre}} - \mu_{\text{Post}} \geq 0 \quad \text{or} \quad \mu_D \geq 0
\]

\[
H₁: \quad \mu_{\text{Pre}} < \mu_{\text{Post}} \quad \text{or} \quad \mu_{\text{Pre}} - \mu_{\text{Post}} < 0 \quad \text{or} \quad \mu_D < 0
\]
For the DNA unit, Group One had a sample size of \( n = 16 \) and the students had an average difference of -20.3\% (-0.203) with a standard deviation (\( s_D \)) of 0.143. The difference was negative as the post-test scores were higher than the pre-test scores. The observed \( t \)-score for Group One was statistically significant as \( t_{\text{obs}} = -5.699 \) and \( p < .001 \). The critical value for this test was \( t_{c}(15) = -1.753 \). The test had an effect size index of \( d = -1.425 \).

The Group Two DNA sample had a sample size of \( n = 25 \) and the students had an average difference of -19.2\% (-0.192) with a standard deviation (\( s_D \)) of 0.110. The observed \( t \)-score for Group Two was statistically significant as \( t_{\text{obs}} = -8.701 \) and \( p < .001 \). The critical value for this test was \( t_{c}(24) = -1.711 \). The effect size index was \( d = -1.740 \).

The Group One Circulation sample had a sample size of \( n = 19 \) and the students had an average difference of -6.7\% (-0.067) with a standard deviation (\( s_D \)) of 0.147. The observed \( t \)-score for Group One was statistically significant as \( t_{\text{obs}} = -1.990 \) and \( p = .0310 \). The critical value for this test was \( t_{c}(18) = -1.734 \). The effect size index was \( d = -0.457 \).

The Group Two Respiration sample had a sample size of \( n = 23 \) and the students had an average difference of -23.6\% (-0.236) with a standard deviation (\( s_D \)) of 0.165. The observed \( t \)-score for Group Two was statistically significant as \( t_{\text{obs}} = -6.858 \) and \( p < .001 \). The critical value for this test was \( t_{c}(22) = -1.717 \). The effect size index was \( d = -1.430 \).

The Group Two Excretion sample had a sample size of \( n = 24 \) and the students had an average difference of -11.8\% (-0.118) with a standard deviation (\( s_D \)) of 0.166. The observed \( t \)-score for Group Two was statistically significant as \( t_{\text{obs}} = -3.476 \) and \( p < .001 \). The critical value for this test was \( t_{c}(23) = -1.714 \). The effect size index was \( d = -0.710 \).

The Group One Nervous sample had a sample size of \( n = 19 \) and the students had an average difference of -10.7\% (-0.107) with a standard deviation (\( s_D \)) of 0.157. The observed \( t \)-score for Group One was statistically significant as \( t_{\text{obs}} = -2.964 \) and \( p < .004 \). The critical
Table 1

The pre- and post-test analyses of the Inspiration plenary for six units of Biology 12.

<table>
<thead>
<tr>
<th>Group</th>
<th>DNA M&lt;sub&gt;pre&lt;/sub&gt;</th>
<th>DNA s&lt;sub&gt;X&lt;/sub&gt;</th>
<th>Circ. M&lt;sub&gt;post&lt;/sub&gt;</th>
<th>Circ. s&lt;sub&gt;X&lt;/sub&gt;</th>
<th>Resp. M&lt;sub&gt;post&lt;/sub&gt;</th>
<th>Resp. s&lt;sub&gt;X&lt;/sub&gt;</th>
<th>Excr. M&lt;sub&gt;post&lt;/sub&gt;</th>
<th>Excr. s&lt;sub&gt;X&lt;/sub&gt;</th>
<th>Nerv. M&lt;sub&gt;post&lt;/sub&gt;</th>
<th>Nerv. s&lt;sub&gt;X&lt;/sub&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 1</td>
<td>0.484</td>
<td>0.139</td>
<td>0.688</td>
<td>0.173</td>
<td>0.481</td>
<td>0.185</td>
<td>0.424</td>
<td>0.098</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group 2</td>
<td>0.468</td>
<td>0.164</td>
<td>0.660</td>
<td>0.199</td>
<td>0.481</td>
<td>0.185</td>
<td>0.599</td>
<td>0.530</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: t<sub>cv</sub> calculated at † p = 0.05 for a one-tailed t-test. Circ = Circulatory. Resp = Respiratory. Excr. = Excretory. Nerv. = Nervous.
The pre-test/post-test comparisons for the six units indicated that statistically significant improvements occurred after administration of the pre-test and implementation of the Inspiration plenary. Table 1 indicates that the mean improvement ranged from 6.7% to 23.6% with improvement effect sizes ranging from 0.457 (medium) to 1.740 (large). Data was gathered and analyzed using three separate units for both Group One and Group Two.

**Inspiration Compared to Review Worksheets/Discussion Activities**

The Review Worksheet/Discussion (RW/D) type plenary was used for both Group One and Group Two for the second unit (DNA), for Group Two in the third unit (Circulation), for Group One in the fourth unit (Respiration) and fifth unit (Expiration), and for Group Two in the sixth unit (Nervous System). Pre-tests were administered two days before the post-tests. The plenary activity began immediately after the pre-test and was completed the next day. The worksheets were reviewed before the end of the second day. Discussion during the activity was directed through student questioning, teacher directing and teacher redirecting. Each post-test was administered the day after the plenary. Students were allowed to use their completed plenary for study purposes and were encouraged to do so. The differences in pre- and post-test scores for the RW/D group were compared to the differences in pre- and post-test scores of the Inspiration group using directional independent t-tests.

The units used to compare the effects of the plenary activities included the Circulatory, Respiratory, Excretory, and Nervous System. For each of the units the following null hypothesis ($H_0$) and alternative hypothesis ($H_1$) were used in the plenary comparisons,

$$H_0: \mu_{D_{\text{inspiration}}} \leq \mu_{D_{\text{Review}}} \quad \text{or} \quad \mu_{D_{\text{inspiration}}} - \mu_{D_{\text{Review}}} \leq 0$$
Each of the \( t \)-tests used an alpha level (\( \alpha \)) = .05 for determining significance.

In the Circulatory unit, the Inspiration group demonstrated an average pre-test/post-test difference of -6.7% (-0.067) and the RW/D group demonstrated an average pre-test/post-test difference of -6.6% (-0.066). The one-tailed independent \( t \)-test demonstrated no statistical significance as \( t_{obs} = -0.028 \) and \( t_{cv}(39) = -1.685 \). The effect size index for the compared plenaries was \( d = -0.007 \), with \( p = .489 \) and a power of .052.

In the Respiratory unit, the Inspiration group demonstrated an average pre-test/post-test difference of -23.6% (-0.236) and the RW/D group demonstrated an average pre-test/post-test difference of -21.4% (-0.214). The one-tailed independent \( t \)-test indicated no statistical significance as \( t_{obs} = -0.393 \) and \( t_{cv}(37) = -1.688 \). The effect size index for the compared plenaries was \( d = -0.127 \), with \( p = .348 \) and a power of .105.

In the Excretory unit, the Inspiration group demonstrated an average pre-test/post-test difference of -11.8% (-0.118) and the RW/D group demonstrated an average pre-test/post-test difference of -7.8% (-0.078). The one-tailed independent \( t \)-test indicated no statistical significance as \( t_{obs} = -0.769 \) and \( t_{cv}(38) = -1.686 \). The effect size index for the compared plenaries was \( d = -0.251 \), with \( p = .224 \) and a power of .193.

In the Nervous system unit, the inspiration group demonstrated an average pre-test/post-test difference of -10.7% (-0.107) and the RW/D group demonstrated an average pre-test/post-test difference of -9.3% (-0.093). The one-tailed independent \( t \)-test indicated no statistical significance as \( t_{obs} = -0.277 \) and \( t_{cv}(39) = -1.685 \). The effect size index for the compared plenaries was \( d = -0.087 \), with \( p = .392 \) and a power of .085.
Table 2 displays a complete summary of the data comparing the results of pre-test/post-test differences for the Inspiration and Review Worksheet/Discussion plenary activities.

Table 2

*Pre-/post test overall results for the Inspiration plenary compared to the Review Worksheet/Discussion plenary.*

<table>
<thead>
<tr>
<th>Students</th>
<th>Circ</th>
<th>Resp</th>
<th>Excr</th>
<th>Nerv</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inspiration Group (( \bar{D}_{\text{Insp}} ))</td>
<td>-0.067</td>
<td>-0.236</td>
<td>-0.118</td>
<td>-0.107</td>
</tr>
<tr>
<td>SD (s( D ))</td>
<td>0.147</td>
<td>0.165</td>
<td>0.166</td>
<td>0.157</td>
</tr>
<tr>
<td>( n_1 = )</td>
<td>19</td>
<td>23</td>
<td>24</td>
<td>19</td>
</tr>
<tr>
<td>Review Group (( \bar{D}_{\text{Rev}} ))</td>
<td>-0.066</td>
<td>-0.214</td>
<td>-0.078</td>
<td>-0.093</td>
</tr>
<tr>
<td>SD (s( D ))</td>
<td>0.123</td>
<td>0.178</td>
<td>0.149</td>
<td>0.152</td>
</tr>
<tr>
<td>( n_2 = )</td>
<td>22</td>
<td>16</td>
<td>16</td>
<td>22</td>
</tr>
<tr>
<td>( s^2_{\text{pooled}} )</td>
<td>0.018</td>
<td>0.029</td>
<td>0.025</td>
<td>0.024</td>
</tr>
<tr>
<td>( s^2_{\bar{n}_1 - \bar{n}_2} )</td>
<td>0.042</td>
<td>0.056</td>
<td>0.052</td>
<td>0.048</td>
</tr>
<tr>
<td>( t_\text{obs} )</td>
<td>-0.028</td>
<td>-0.393</td>
<td>-0.769</td>
<td>-0.277</td>
</tr>
<tr>
<td>( t_\text{cv} )</td>
<td>-1.685</td>
<td>-1.687</td>
<td>-1.686</td>
<td>-1.685</td>
</tr>
<tr>
<td>( df )</td>
<td>39</td>
<td>37</td>
<td>38</td>
<td>39</td>
</tr>
<tr>
<td>( p )</td>
<td>.489</td>
<td>.348</td>
<td>.224</td>
<td>.392</td>
</tr>
<tr>
<td>( d )</td>
<td>-0.007</td>
<td>-0.127</td>
<td>-0.251</td>
<td>-0.087</td>
</tr>
<tr>
<td>Power</td>
<td>.052</td>
<td>.105</td>
<td>.193</td>
<td>.085</td>
</tr>
</tbody>
</table>

Note: \( \bar{D} \) = mean difference, Circ = Circulatory, Resp = Respiratory, Excr. = Excretory, Nerv. = Nervous, \( \alpha = .05 \).
Table 2 indicates that students utilizing the Inspiration plenary activity scored higher than the students using the RW/D plenary. The overall differences between improvement obtained after using the Inspiration and RW/D plenary varied from 0.1% for the Circulation unit to 4.0% for the Excretion unit. The differences were not determined to be statistically significant. The power levels for the calculations ranged from 0.052 to 0.193, indicating that the trials were underpowered.

Figure 7 represents the mean percentage improvement of post-test scores compared to pre-test scores. The graphed differences are positive, as post-test scores for the Circulation, Respiration, Excretion and Nervous System were higher than the pre-test scores. The differences were not statistically significant; however, the plotted Inspiration plenary differences produced consistently larger improvements in all four of the trials when compared to the Review Worksheet/Discussion plenary.

![Figure 7](image)

*Figure 7.* A comparison of overall improvement for the Inspiration and the Review Worksheet/Discussion plenary activities. The mean difference between post-test and pre-test scores was calculated for each unit and graphed as the percentage improvement.
**Inspiration Effects on the Cognitive Domains**

The Inspiration plenary was used for both Group One and Group Two in the first unit (DNA), for Group One in the third unit (Circulation), for Group Two in the fourth unit (Respiration) and fifth unit (Expiration), and for Group One in the sixth unit (Nervous System). The cognitive domains were analyzed using six different tests. Prior to test administration, the pre- and post-tests were constructed using set proportions of Knowledge, Understanding and Higher Order Process questions. Student test scores were categorized according to their pre- and post-test results in the cognitive domains and one-tailed dependent t-tests were performed to determine significance.

For each of the cognitive areas the following null- and alterative hypotheses were set

\[ H_0: \mu_{\text{Pre}} \geq \mu_{\text{Post}} \quad \text{or} \quad \mu_{\text{Pre}} - \mu_{\text{Post}} \geq 0 \quad \text{or} \quad \mu_D \geq 0 \]

\[ H_1: \mu_{\text{Pre}} < \mu_{\text{Post}} \quad \text{or} \quad \mu_{\text{Pre}} - \mu_{\text{Post}} < 0 \quad \text{or} \quad \mu_D < 0 \]

**Understanding**

Data collection for the Inspiration plenary began in the DNA unit for both Group One and Group Two. For the Understanding cognitive domain, Group One demonstrated an average DNA pre-test/post-test difference of -10.9% for Understanding (see Table 3). The one-tailed dependent t-test was statistically significant as \( t_{obs} = -2.603 \) and \( t_{cv}(15) = -1.753 \) for \( \alpha = 0.05 \). The effect size index for the Group One DNA Understanding domain was \( d = -0.651 \), with \( p = .010 \) and a power of .343. For the same test, Group Two demonstrated an average DNA pre-test/post-test difference of -13.5% for understanding. The one-tailed dependent t-test was statistically significant as \( t_{obs} = -3.716 \) and \( t_{cv}(24) = -1.711 \) for \( \alpha = .05 \). The effect size index for the Group Two Understanding domain was \( d = -0.743 \), with \( p < .001 \) and a power of .562.
The four units covered after introducing the plenary activities included the Circulatory, Respiratory, Excretory, and Nervous System. For the Circulatory unit, Group One demonstrated an average Circulatory pre-test/post-test difference of -16.3% for Understanding. The one-tailed dependent $t$-test was statistically significant as $t_{obs} = -4.083$ and $t_{cv}(18) = -1.734$ for $\alpha = .05$. The effect size index for the circulatory Understanding domain was $d = -0.937$, with $p < .001$ and a power of .624. For the Respiratory unit, Group Two demonstrated an average Respiratory pre-test/post-test difference of -22.6% for Understanding. The one-tailed dependent $t$-test was statistically significant as $t_{obs} = -5.748$ and $t_{cv}(22) = -1.717$ for $\alpha = .05$. The effect size index for the Respiratory Understanding domain was $d = -1.198$, with $p < .001$ and a power of .872. For the Excretory unit, Group Two demonstrated an average Excretory pre-test/post-test difference of -7.3% for Understanding. The one-tailed dependent $t$-test was statistically significant as $t_{obs} = -1.854$ and $t_{cv}(23) = -1.714$ for $\alpha = .05$. The effect size index for the Excretory Understanding domain was $d = -0.379$, with $p = .038$ and a power of .228. For the Nervous unit, Group One demonstrated an average Nervous System pre-test/post-test difference of -5.2% for Understanding. The one-tailed dependent $t$-test was not statistically significant as $t_{obs} = -1.279$ and $t_{cv}(18) = -1.734$ for $\alpha = .05$. The effect size index for the Nervous Understanding domain was $d = -0.294$, with $p = .109$ and a power of .152.

Knowledge

For the Knowledge cognitive domain, Group One demonstrated an average DNA pre-test/post-test difference of -53.8% for Knowledge (see Table 4). The one-tailed dependent $t$-test was statistically significant as $t_{obs} = -9.908$ and $t_{cv}(15) = -1.753$ for $\alpha = .05$. The effect size index for the Group One DNA Knowledge domain was $d = -2.477$, with $p < .001$ and a
## Table 3

**Pre-/post-test analyses of the Understanding domain for the Inspiration plenary.**

<table>
<thead>
<tr>
<th></th>
<th>DNA U Group 1</th>
<th>DNA U Group 2</th>
<th>Circ. U Group 1</th>
<th>Resp. U Group 2</th>
<th>Excr. U Group 2</th>
<th>Nerv. U Group 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>$M_{Pre}$</td>
<td>0.578</td>
<td>0.500</td>
<td>0.430</td>
<td>0.406</td>
<td>0.517</td>
<td>0.461</td>
</tr>
<tr>
<td>$s_{X_{pre}}$</td>
<td>0.189</td>
<td>0.201</td>
<td>0.172</td>
<td>0.218</td>
<td>0.175</td>
<td>0.128</td>
</tr>
<tr>
<td>$M_{Post}$</td>
<td>0.688</td>
<td>0.635</td>
<td>0.593</td>
<td>0.631</td>
<td>0.591</td>
<td>0.513</td>
</tr>
<tr>
<td>$s_{X_{post}}$</td>
<td>0.200</td>
<td>0.166</td>
<td>0.202</td>
<td>0.163</td>
<td>0.217</td>
<td>0.231</td>
</tr>
<tr>
<td>$\sum D_i$</td>
<td>-1.750</td>
<td>-3.370</td>
<td>-3.094</td>
<td>-5.188</td>
<td>-1.757</td>
<td>-0.989</td>
</tr>
<tr>
<td>$\sum D_i^2$</td>
<td>0.615</td>
<td>1.244</td>
<td>1.048</td>
<td>1.950</td>
<td>0.990</td>
<td>0.618</td>
</tr>
<tr>
<td>$n$</td>
<td>16</td>
<td>25</td>
<td>19</td>
<td>23</td>
<td>24</td>
<td>19</td>
</tr>
<tr>
<td>$\bar{D}$</td>
<td>-0.109</td>
<td>-0.135</td>
<td>-0.163</td>
<td>-0.226</td>
<td>-0.073</td>
<td>-0.052</td>
</tr>
<tr>
<td>$\sum (D_i - \bar{D})^2$</td>
<td>0.424</td>
<td>0.790</td>
<td>0.544</td>
<td>0.780</td>
<td>0.861</td>
<td>0.566</td>
</tr>
<tr>
<td>$SD (s_D)$</td>
<td>0.168</td>
<td>0.181</td>
<td>0.174</td>
<td>0.188</td>
<td>0.193</td>
<td>0.177</td>
</tr>
<tr>
<td>Var. ($s^2$)</td>
<td>0.028</td>
<td>0.033</td>
<td>0.030</td>
<td>0.035</td>
<td>0.037</td>
<td>0.032</td>
</tr>
<tr>
<td>$SE (s_{\bar{D}})$</td>
<td>0.042</td>
<td>0.036</td>
<td>0.040</td>
<td>0.039</td>
<td>0.040</td>
<td>0.041</td>
</tr>
<tr>
<td>$t_{obs}$ value</td>
<td>-2.603</td>
<td>-3.716</td>
<td>-4.083</td>
<td>-5.748</td>
<td>-1.854</td>
<td>-1.279</td>
</tr>
<tr>
<td>$t_{cv}^+$</td>
<td>-1.753</td>
<td>-1.711</td>
<td>-1.734</td>
<td>-1.717</td>
<td>-1.714</td>
<td>-1.734</td>
</tr>
<tr>
<td>$p$ (one-tailed)</td>
<td>&lt;.010</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>.038</td>
<td>.109</td>
</tr>
<tr>
<td>$d$ (effect)</td>
<td>-0.651</td>
<td>-0.743</td>
<td>-0.937</td>
<td>-1.198</td>
<td>-0.379</td>
<td>-0.294</td>
</tr>
<tr>
<td>Power</td>
<td>.343</td>
<td>.562</td>
<td>.624</td>
<td>.872</td>
<td>.228</td>
<td>.152</td>
</tr>
</tbody>
</table>

Note: Circ. = Circulatory System, Resp. = Respiratory System, Excr. = Excretory System, Nerv. = Nervous System, U = understanding. $t_{cv}$ calculated at $+ p = 0.05$ for a one-tailed t-test.
power of .998. For the same test, Group Two demonstrated an average DNA pre-test/post-test difference of -25.8% for Knowledge. The one-tailed dependent t-test was statistically significant as $t_{obs} = -6.386$ and $t_{cv}(24) = -1.711$ for $\alpha = .05$. The effect size index for the Group Two Knowledge domain was $d = -1.277$, with $p < .001$ and a power of .927.

For the Circulatory unit, Group One demonstrated an average Circulatory pre-test/post-test difference of 6.7% for Knowledge. The one-tailed dependent t-test was not statistically significant as $t_{obs} = 1.485$ and $t_{cv}(18) = -1.734$ for $\alpha = .05$. The effect size index for the Circulatory Knowledge domain was $d = 0.341$, with $p = .923$ and a power of .176. For the Respiratory unit, Group Two demonstrated an average Respiratory pre-test/post-test difference of -19.8% for Knowledge. The one-tailed dependent t-test was statistically significant as $t_{obs} = -3.159$ and $t_{cv}(22) = -1.717$ for $\alpha = .05$. The effect size index for the Respiratory Knowledge domain was $d = -0.659$, with $p = .002$ and a power of .454. For the Excretory unit, Group Two demonstrated an average Excretory pre-test/post-test difference of -30.3% for knowledge. The one-tailed dependent t-test was statistically significant as $t_{obs} = -4.321$ and $t_{cv}(23) = -1.714$ for $\alpha = .05$. The effect size index for the Excretory Knowledge domain was $d = -0.882$, with $p < .001$ and a power of .673. For the Nervous unit, Group One demonstrated an average Nervous System pre-test/post-test difference of -22.7% for knowledge. The directional dependent t-test score was statistically significant as $t_{obs} = -2.634$ and $t_{cv}(18) = -1.734$ for $\alpha = .05$. The effect size index for the Nervous System Knowledge domain was $d = -0.604$, with $p = .008$ and a power of .352.
Table 4

*Pre-/post- test analyses of the Knowledge domain for the Inspiration plenary.*

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Group 1</td>
<td>Group 2</td>
<td>Group 1</td>
<td>Group 2</td>
<td>Group 2</td>
<td>Group 1</td>
</tr>
<tr>
<td>$M_{Pre}$</td>
<td>0.281</td>
<td>0.560</td>
<td>0.763</td>
<td>0.609</td>
<td>0.479</td>
<td>0.434</td>
</tr>
<tr>
<td>$s_{X_{Pre}}$</td>
<td>0.180</td>
<td>0.195</td>
<td>0.195</td>
<td>0.236</td>
<td>0.329</td>
<td>0.287</td>
</tr>
<tr>
<td>$M_{Post}$</td>
<td>0.819</td>
<td>0.818</td>
<td>0.696</td>
<td>0.807</td>
<td>0.782</td>
<td>0.661</td>
</tr>
<tr>
<td>$s_{X_{Post}}$</td>
<td>0.140</td>
<td>0.128</td>
<td>0.242</td>
<td>0.175</td>
<td>0.172</td>
<td>0.252</td>
</tr>
<tr>
<td>$\sum D_i$</td>
<td>-8.611</td>
<td>-6.444</td>
<td>1.278</td>
<td>-4.556</td>
<td>-7.278</td>
<td>-4.306</td>
</tr>
<tr>
<td>$\sum D_i^2$</td>
<td>5.343</td>
<td>2.639</td>
<td>0.787</td>
<td>2.892</td>
<td>4.926</td>
<td>3.507</td>
</tr>
<tr>
<td>n</td>
<td>16</td>
<td>25</td>
<td>19</td>
<td>23</td>
<td>24</td>
<td>19</td>
</tr>
<tr>
<td>$\overline{D}$</td>
<td>-0.538</td>
<td>-0.258</td>
<td>0.067</td>
<td>-0.198</td>
<td>-0.303</td>
<td>-0.227</td>
</tr>
<tr>
<td>$\sum (D_i - \overline{D})^2$</td>
<td>0.708</td>
<td>0.978</td>
<td>0.701</td>
<td>1.990</td>
<td>2.719</td>
<td>2.531</td>
</tr>
<tr>
<td>$SD (s_D)$</td>
<td>0.217</td>
<td>0.202</td>
<td>0.197</td>
<td>0.301</td>
<td>0.344</td>
<td>0.375</td>
</tr>
<tr>
<td>Var. ($s^2$)</td>
<td>0.047</td>
<td>0.041</td>
<td>0.039</td>
<td>0.090</td>
<td>0.118</td>
<td>0.141</td>
</tr>
<tr>
<td>$SE (s_{\overline{D}})$</td>
<td>0.054</td>
<td>0.040</td>
<td>0.045</td>
<td>0.063</td>
<td>0.070</td>
<td>0.086</td>
</tr>
<tr>
<td>$t_{obs}$ value</td>
<td>-9.908</td>
<td>-6.386</td>
<td>1.485</td>
<td>-3.159</td>
<td>-4.321</td>
<td>-2.634</td>
</tr>
<tr>
<td>$t_{cr}$</td>
<td>-1.753</td>
<td>-1.711</td>
<td>-1.734</td>
<td>-1.717</td>
<td>-1.714</td>
<td>-1.734</td>
</tr>
<tr>
<td>p (one-tailed)</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>.077</td>
<td>.002</td>
<td>&lt;.001</td>
<td>.008</td>
</tr>
<tr>
<td>d (effect)</td>
<td>-2.477</td>
<td>-1.277</td>
<td>0.341</td>
<td>-0.659</td>
<td>-0.882</td>
<td>-0.604</td>
</tr>
<tr>
<td>Power</td>
<td>.998</td>
<td>.927</td>
<td>.176</td>
<td>.454</td>
<td>.673</td>
<td>.352</td>
</tr>
</tbody>
</table>

For the Higher Order Process cognitive domain, Group One demonstrated an average DNA pre-test/post-test difference of -13.3% for Higher Order Process (see Table 5). The one-tailed dependent t-test was not statistically significant as $t_{obs} = -1.563$ and $t_{cv}(15) = -1.753$ for $\alpha = .05$. The effect size index for the Group One DNA Higher Order Process domain was $d = -0.391$, with $p = .070$ and a power of .184. For the same test, Group Two demonstrated an average DNA pre-test/post-test difference of -26.5% for Higher Order Process. The one-tailed dependent t-test was statistically significant as $t_{obs} = -5.712$ and $t_{cv}(24) = -1.711$ for $\alpha = .05$. The effect size index for the Group Two Higher Order Process domain was $d = -1.143$, with $p < .001$ and a power of .870. For the Circulatory unit, Group One demonstrated an average Circulatory pre-test/post-test difference of 9.9% for Higher Order Process. The one-tailed dependent t-test was not statistically significant as $t_{obs} = 1.756$ with and $t_{cv}(18) = -1.734$ for $\alpha = .05$. The effect size index for the Circulatory Higher Order Process domain was $d = 0.403$, with $p = .952$ and a power of .211. For the Respiratory unit, Group Two demonstrated an average Respiratory pre-test/post-test difference of -28.3% for Higher Order Process. The one-tailed dependent t-test was statistically significant as $t_{obs} = -4.713$ and $t_{cv}(22) = -1.717$ for $\alpha = .05$. The effect size index for the Respiratory Higher Order Process domain was $d = -0.983$, with $p < .001$ and a power of .737. For the Excretory unit, Group Two demonstrated an average Excretory pre-test/post-test difference of -4.2% for Higher Order Process. The one-tailed dependent t-test was not statistically significant as $t_{obs} = -0.902$ and $t_{cv}(23) = -1.714$ for $\alpha = .05$. The effect size index for the Excretory Higher Order Process domain was $d = -0.184$, with $p = .188$ and a power of .113. For the Nervous unit, Group One demonstrated an average Nervous System pre-test/post-test difference of -16.4% for Higher Order
Table 5

*Pre-/post- test analyses of the Higher Order Process domain for the Inspiration plenary.*

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Group 1</td>
<td>Group 2</td>
<td>Group 1</td>
<td>Group 2</td>
<td>Group 2</td>
<td>Group 1</td>
</tr>
<tr>
<td>$M_{Pre}$</td>
<td>0.406</td>
<td>0.280</td>
<td>0.566</td>
<td>0.261</td>
<td>0.375</td>
<td>0.303</td>
</tr>
<tr>
<td>$s_{x_{Pre}}$</td>
<td>0.272</td>
<td>0.232</td>
<td>0.233</td>
<td>0.232</td>
<td>0.221</td>
<td>0.197</td>
</tr>
<tr>
<td>$M_{Post}$</td>
<td>0.539</td>
<td>0.545</td>
<td>0.467</td>
<td>0.543</td>
<td>0.417</td>
<td>0.467</td>
</tr>
<tr>
<td>$s_{x_{Post}}$</td>
<td>0.222</td>
<td>0.210</td>
<td>0.186</td>
<td>0.243</td>
<td>0.214</td>
<td>0.224</td>
</tr>
<tr>
<td>$\sum D_i$</td>
<td>-2.125</td>
<td>-6.625</td>
<td>1.875</td>
<td>-6.500</td>
<td>-1.000</td>
<td>-3.125</td>
</tr>
<tr>
<td>$\sum D_i^2$</td>
<td>2.016</td>
<td>3.047</td>
<td>1.266</td>
<td>3.656</td>
<td>1.219</td>
<td>2.234</td>
</tr>
<tr>
<td>$n$</td>
<td>16</td>
<td>25</td>
<td>19</td>
<td>23</td>
<td>24</td>
<td>19</td>
</tr>
<tr>
<td>$\bar{D}$</td>
<td>-0.133</td>
<td>-0.265</td>
<td>0.099</td>
<td>-0.283</td>
<td>-0.042</td>
<td>-0.164</td>
</tr>
<tr>
<td>$\sum (D_i - \bar{D})^2$</td>
<td>1.733</td>
<td>1.291</td>
<td>1.081</td>
<td>1.819</td>
<td>1.177</td>
<td>1.720</td>
</tr>
<tr>
<td>$SD (s_D)$</td>
<td>0.340</td>
<td>0.232</td>
<td>0.245</td>
<td>0.288</td>
<td>0.226</td>
<td>0.309</td>
</tr>
<tr>
<td>Var. ($s^2$)</td>
<td>0.116</td>
<td>0.054</td>
<td>0.060</td>
<td>0.083</td>
<td>0.051</td>
<td>0.096</td>
</tr>
<tr>
<td>$SE (s_{SD})$</td>
<td>0.085</td>
<td>0.046</td>
<td>0.056</td>
<td>0.060</td>
<td>0.046</td>
<td>0.071</td>
</tr>
<tr>
<td>$t_{obs}$ value</td>
<td>-1.563</td>
<td>-5.712</td>
<td>1.756</td>
<td>-4.713</td>
<td>-0.902</td>
<td>-2.319</td>
</tr>
<tr>
<td>$t_{cv}^*$</td>
<td>-1.753</td>
<td>-1.711</td>
<td>-1.734</td>
<td>-1.717</td>
<td>-1.714</td>
<td>-1.734</td>
</tr>
<tr>
<td>$p$ (one-tailed)</td>
<td>.070</td>
<td>&lt;.001</td>
<td>.048</td>
<td>&lt;.001</td>
<td>.188</td>
<td>.016</td>
</tr>
<tr>
<td>$d$ (effect)</td>
<td>-0.391</td>
<td>-1.143</td>
<td>0.403</td>
<td>-0.983</td>
<td>-0.184</td>
<td>-0.532</td>
</tr>
<tr>
<td>Power</td>
<td>.184</td>
<td>.870</td>
<td>.211?</td>
<td>.737</td>
<td>.113</td>
<td>.297</td>
</tr>
</tbody>
</table>

Process. The directional dependent $t$-test was statistically significant as $t_{obs} = -2.319$ and $t_{cv} = -1.734$ for $\alpha = .05$. The effect size index for the Nervous System Higher Order Process domain was $d = -0.532$, with $p = .016$ and a power of .297.

Participating in the Inspiration plenary resulted in the mean post-test scores being significantly higher than many of the mean pre-test scores. Analysis of the test scores indicated improvement in several of the cognitive areas. The $t$-test scores suggested statistical significance for improvement in five of the six trials for Understanding, five of the six trials for Knowledge, and in three of the six trials for Higher Order Process.

*Comparing Time On-task Behaviour for Inspiration and Review Worksheet/Discussion Activities*

Time on-task behaviour was determined by repeatedly observing the number of students on-task at a given time interval. Student behaviour was observed and recorded every 5 minutes over a 30-minute time frame (see Table 6). The number of students on-task was converted into a percentage of students on-task compared to the total number who had consented to be part of the study and who were participating in the plenary. On-task behaviour was recorded while the students participated in either the Inspiration or Review Worksheet/Discussion (RW/D) plenary.

The units used to compare the effects of the plenary activities included the Circulation, Respiration, Excretion, and Nervous System units. For each of the units the following null hypothesis ($H_0$) and alternative hypothesis ($H_1$) were used in the plenary comparisons of time on-task.

\[
H_0: \quad \mu_D^{\text{Inspiration}} \leq \mu_D^{\text{Review}} \quad \text{or} \quad \mu_D^{\text{Inspiration}} - \mu_D^{\text{Review}} \leq 0
\]

\[
H_1: \quad \mu_D^{\text{Inspiration}} > \mu_D^{\text{Review}} \quad \text{or} \quad \mu_D^{\text{Inspiration}} - \mu_D^{\text{Review}} > 0
\]
Table 6

Students' on-task behaviour while participating in the plenary activities.

<table>
<thead>
<tr>
<th>Time (minutes)</th>
<th>Group 1</th>
<th>Group Two</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Inspiration</td>
<td>Review</td>
</tr>
<tr>
<td>0</td>
<td>.895</td>
<td>.875</td>
</tr>
<tr>
<td>5</td>
<td>.895</td>
<td>.813</td>
</tr>
<tr>
<td>10</td>
<td>1.000</td>
<td>.719</td>
</tr>
<tr>
<td>15</td>
<td>1.000</td>
<td>.750</td>
</tr>
<tr>
<td>20</td>
<td>1.000</td>
<td>.594</td>
</tr>
<tr>
<td>25</td>
<td>1.000</td>
<td>.719</td>
</tr>
<tr>
<td>30</td>
<td>1.000</td>
<td>.594</td>
</tr>
</tbody>
</table>

Note: The table displays percentages, in decimal form, of the students demonstrating on-task behaviour.

For the Inspiration plenary, on average 97.0% of the Group One students were on-task during the sampling time and Group Two demonstrated an average of 96.3% on-task during each sampling time (see Table 7). For the RW/D plenary, an average 72.3% of the Group One students were on-task during the sampling time and Group Two students demonstrated an on-task average of 67.2% during each sampling time. During the data collection Inspiration students showed their lowest on-task behaviour during the settling in period at the beginning of the plenary, while the RW/D plenary demonstrated a steady decline in on-task behaviour over the 30-minute time frame.

Figure 8 displays the on-task behaviour of the student groups participating in the Inspiration or RW/D plenary. The mean on-task behaviour exhibited during the Inspiration plenary was 96.7% (SD = 4.8%). The graph suggests students, participating in the Inspiration
Table 7

On-task behaviour of students during Inspiration and review worksheet/discussion.

<table>
<thead>
<tr>
<th></th>
<th>Group 1</th>
<th>Group 2</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Inspiration</td>
<td>Review</td>
<td>Inspiration</td>
</tr>
<tr>
<td>N</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\Sigma X$</td>
<td>6.789</td>
<td>5.063</td>
<td>6.744</td>
</tr>
<tr>
<td>M</td>
<td>0.970</td>
<td>0.723</td>
<td>0.963</td>
</tr>
<tr>
<td>$\Sigma X^2$</td>
<td>6.601</td>
<td>3.727</td>
<td>6.510</td>
</tr>
<tr>
<td>Variance ($s^2$)</td>
<td>0.003</td>
<td>0.011</td>
<td>0.002</td>
</tr>
<tr>
<td>SD</td>
<td>0.051</td>
<td>0.104</td>
<td>0.047</td>
</tr>
<tr>
<td>SE ($s_x$)</td>
<td>0.019</td>
<td>0.039</td>
<td>0.018</td>
</tr>
</tbody>
</table>

Note: The values of $X$ were measured as a percentage of students on-task during a specific time collection interval over a 30-minute period.

Figure 8. The group on-task behaviour rates for the Inspiration and Review Worksheet/Discussion (RW/D) plenary activities. On-task behaviour rates are displayed as percentages presented in decimal form. Mean on-task behaviour displayed by the Inspiration group was 96.7% ($SD = 4.8\%$). Mean on-task behaviour displayed by the RW/D group was 69.8% ($SD = 10.5\%$).
plenary, maintained focus over the 30-minute interval. The mean on-task behaviour exhibited during the RW/D plenary was 69.8% ($SD = 10.5\%$). During the RW/D plenary, students exhibited a decrease in on-task behaviour as demonstrated by the downward trend as time proceeded.

A one-way ANOVA for the four independent samples was performed to compare the Group One Inspiration on-task behaviours to the Group One RW/D plenary to the Group Two Inspiration on-task behaviours, and to the Group Two RW/D plenary (see Table 8). The one-way ANOVA comparing the on-task behaviour of students participating in the Inspiration plenary to RW/D was statistically significant, $F(3,24) = 22.14, p < .0001$. The magnitude of the effect was determined and indicated eta-squared ($\eta^2$) = 0.735 and omega-squared ($\omega^2$) = 0.661.

Table 8

*Inspiration and Review Worksheet/Discussion plenary ANOVA statistics for on-task behaviour.*

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment (Between groups)</td>
<td>0.5158</td>
<td>3</td>
<td>0.1719</td>
<td>22.14</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Error</td>
<td>0.1864</td>
<td>24</td>
<td>0.0078</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>0.7022</td>
<td>27</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: $F_{cv,p} = 3.01, p = .05$.

Tukey's HSD test set $HSD[0.05] = 0.13$, and $HSD[0.1] = 0.16$. The resulting HSD calculations showed statistical significance occurred between Inspiration Group One and RW/D Group One, $HSD = 0.247, p < .01$. Inspiration Group One and RW/D Group Two, $HSD = 0.298, p < .01$, Inspiration Group Two and RW/D Group One, $HSD = 0.240, p < .01$,.
and Inspiration Group Two and Review Group Two, $HSD = 0.291, p < .01$. No statistically significant differences were determined to exist between Inspiration Group One and Inspiration Group Two, $HSD = 0.007$, nor RW/D Group One and RW/D Group Two, $HSD = 0.051$.

Comparing the effects of Inspiration to Review Worksheet/Discussion on Activity Completion

Percentage completion of the plenary activity was determined by the number of students who submitted their completed plenary for marking. Submission of the completed plenary activity was required before the post-test was written; however, late submissions and partially complete plenary activities were accepted if the student could produce the plenary before the end of the day. Students who did not submit a completed plenary were individually informed that they needed to do so. Several late and partially completed assignments were submitted for the Review Worksheet/Discussion plenary, whereas, no late or partially completed plenary assignments were submitted for the Inspiration plenary. The quality of the submitted Inspiration plenary activities appeared consistent. Recall, that Group One received extra class time for the Respiratory unit. An unprecedented number of absences on the day of the pre-test administration resulted in a postponement of the pre-test and plenary implementation by one day and an unanticipated grade 12 assembly, resulted in an extra half day of review accompanied by an extra night of study time.

Each group completed six plenary activities, three Inspiration and three Review Worksheet/Discussion (RW/D) plenaries. For the Inspiration plenary Group One had completion rates of 100.00% (DNA), 88.24% (Circulation), and 84.21% (Nervous), and Group Two had completion rates of 88.00% (DNA), 95.45% (Respiration) and 86.36% (Excretion). For the Review Worksheet/Discussion plenary Group One had completion rates of 84.21% (Digestion), 89.47% (Respiration) and (Excretion) 63.16%, and Group Two had
completion rates of 72% (Digestion), 72% (Circulation) and 68% (Nervous). During the Digestion RW/D activity, 56% of Group Two students submitted their plenary on time and 16% submitted his/her plenary late. During the Nervous RW/D activity 36% of Group Two students submitted his/her plenary on time and fully completed, 32% submitted plenaries partially completed. Observations, during the second and third Inspiration plenary activities, indicated many of the students began working together to complete sections of the Intended Learning Outcomes, share their finished sections, and then discussing what they had learned.

Figure 9, Figure 10, and Figure 11 identify the plenary completion rates of Group One, Group Two, and Group One and Two combined, respectively. The figures indicate completion rates for the Inspiration plenary activities were consistently higher, except for the Group One Respiration plenary. The grouped data display a mean score of 90.4% with SD = 6.0% and the RW/D mean completion score was 74.8% with SD = 10.0%.

For each of the plenary activities the following null hypothesis (H₀) and alternative hypothesis (H₁) were used to compare completion percentages.

\[
\begin{align*}
H₀: & \quad \mu_{G1 \text{ Inspiration}} + \mu_{G2 \text{ Inspiration}} \leq \mu_{G1 \text{ Review}} + \mu_{G2 \text{ Review}} \\
H₁: & \quad \mu_{G1 \text{ Inspiration}} + \mu_{G2 \text{ Inspiration}} > \mu_{G1 \text{ Review}} + \mu_{G2 \text{ Review}}
\end{align*}
\]

The combined mean completion of the students for the Inspiration plenary was 90.377% with a standard deviation of 6.045% (see Table 9). The combined mean completion of the Review Worksheet/ Discussion plenary was 74.807% with a standard deviation of 10.012%. The completion percentage differences were statistically significant as the directional independent t-test score was \( t_{obs} = 3.26 \) with \( df = 10, p = 0.004 \), an effect size of \( d = 1.88 \), and a power of 0.919. A one-way ANOVA confirmed the statistical significance as \( F = 10.63 \) (see Table 10). The calculated value of \( \eta^2 \) would be 0.515 and omega squared would be 0.445.
Figure 9. Task completion rates for Group One. The Inspiration mean score was 90.8% with \( r = -0.925 \) and RMSE = 4.42%. The Review Worksheet/Discussion mean score was 79.0% with \( r = -0.619 \) and RMSE = 15.5%.

Figure 10. Task completion rates for Group Two. The Inspiration mean score was 89.9% with \( r = -0.111 \) and RMSE = 6.81%. The Review Worksheet/Discussion mean score was 70.7% with \( r = 0.971 \) and RMSE = 0.79%.
Figure 11. A comparison of task completion rates using Inspiration or Review Worksheet/Discussion as a plenary activity. The Inspiration mean score was 90.4% with \( r = -0.678 \) and RMSE = 4.97%. The Review Worksheet/Discussion mean score was 74.8% with \( r = 0.481 \) and RMSE = 9.81%.

Individual t-tests comparisons of plenary completion for Group One indicated no statistical significance for plenary completion between Inspiration and RW/D activities. The observed t-score was \( t_{obs} = 1.27 \) with \( df = 4 \). The probability value was \( p = 0.136 \) with an effect size of \( d = 1.039 \) and power = 0.287. Individual t-tests comparisons of plenary completion for Group Two indicated statistical significance for plenary completion between Inspiration and RW/D activities. The observed t-score was \( t_{obs} = 6.22 \) with \( df = 4 \). The probability value was \( p = 0.136 \) with an effect size of \( d = 5.081 \) and power = 1.000.

A 2X2 Factorial ANOVA indicated no statistical significance between the Group One inspiration plenary completion, the Group One RW/D completion, Group Two Inspiration plenary completion, nor the Group Two RW/D completion but did find statistical
Table 9

*A comparison of completion percentages for Inspiration and Review Worksheet/Discussion plenary activities.*

<table>
<thead>
<tr>
<th></th>
<th>Inspiration</th>
<th>Review</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>6</td>
<td>6</td>
<td>12</td>
</tr>
<tr>
<td>$\sum x$</td>
<td>542.260</td>
<td>448.840</td>
<td>991.100</td>
</tr>
<tr>
<td>Mean</td>
<td>90.377</td>
<td>74.807</td>
<td>82.592</td>
</tr>
<tr>
<td>$\sum x^2$</td>
<td>49190.373</td>
<td>34077.391</td>
<td>83267.764</td>
</tr>
<tr>
<td>SS</td>
<td>182.723</td>
<td>501.166</td>
<td>1411.164</td>
</tr>
<tr>
<td>Variance</td>
<td>36.545</td>
<td>100.233</td>
<td>128.288</td>
</tr>
<tr>
<td>SD</td>
<td>6.045</td>
<td>10.012</td>
<td>11.326</td>
</tr>
<tr>
<td>SE</td>
<td>2.468</td>
<td>4.083</td>
<td>3.270</td>
</tr>
</tbody>
</table>

Note: Review refers to review worksheet/discussion. The inspiration plenary averages and review completion averages were determined by using three samples from group 1 and three samples from group 2.

Table 10

*The ANOVA statistics comparing the plenary completion of groups completing Inspiration activities to groups completing Review Worksheets/Discussion activities.*

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>p (two-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment</td>
<td>727.275</td>
<td>1</td>
<td>727.275</td>
<td>10.63</td>
<td>0.009</td>
</tr>
<tr>
<td>Error</td>
<td>683.889</td>
<td>10</td>
<td>68.389</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>1411.164</td>
<td>11</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: $F_{cv} = 4.965$. $\alpha = .05$
difference between the Inspiration completion percentages and the RW/D completion percentages. (i.e., $F_{\text{Insp vs Rev}} = 10.03, p = .013$ (two-tailed), $F_{\text{Group1 vs Group2}} = 0.87, p = .378$ (two-tailed) (see Table 11)). The effect displayed between the Inspiration and RW/D rows would produce a magnitude of effect value of 0.515 for eta-squared and 0.441 for omega squared.

Table 11

*The ANOVA statistics comparing the plenary completion of Group One Inspiration, Group Two Inspiration, Group One Review Worksheet/Discussion, and Group Two Review Worksheet/Discussion activities.*

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>$p$ (two-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rows $_{\text{Insp vs Rev.}}$</td>
<td>727.27</td>
<td>1</td>
<td>727.28</td>
<td>10.03</td>
<td>0.013</td>
</tr>
<tr>
<td>Columns $_{G1 vs G2}$</td>
<td>62.93</td>
<td>1</td>
<td>62.93</td>
<td>0.87</td>
<td>0.378</td>
</tr>
<tr>
<td>rows x columns</td>
<td>41.07</td>
<td>1</td>
<td>41.07</td>
<td>0.57</td>
<td>0.472</td>
</tr>
<tr>
<td>Error</td>
<td>579.89</td>
<td>8</td>
<td>72.49</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>1411.164</td>
<td>11</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note: Insp. = Inspiration, Rev. = Review worksheet/discussion, G1 = Group one, G2 = Group two, $F_{ec} = 4.965, \alpha = 0.05$*

**Summary of the Quantitative Findings**

In this section, the quantitative findings were presented to support or refute the hypotheses identified by the first five questions listed in Chapter 1. The first three questions utilized the collection of data from pre- and post-tests developed for this study. The fourth and fifth questions used classroom data gathered during the plenary activity and submissions of the completed activities.
Statistical significance was found in the improvement of overall test scores after using Inspiration as a plenary activity. Comparison of the Inspiration plenary to the Review Worksheet/Discussion plenary indicated no significant difference in the plenaries; however, the Inspiration plenary yielded consistently higher improvements varying from 0.1% to 4.0%. Analysis of the cognitive domain performance indicated that using Inspiration as a plenary produced statistically significant improvements in Understanding and Knowledge, in five of the six trials performed for each. Higher Order Process improvements were shown to be statistically significant in three of the six trials.

Students participating in the Inspiration plenary displayed on-task behaviour that was statistically higher than the on-task behaviour of the students participating in the Review Worksheet/Discussion plenary. A one-way ANOVA comparison determined statistically significant differences existed between the groups participating in Inspiration and Review Worksheet/Discussion plenary activities. No statistically significant difference in on-task behaviour was found between Group One Inspiration and Group Two Inspiration, or between Group One RW/D and Group Two RW/D.

The plenary activity completion rates for Group One and Group Two were compared and a statistically significant difference was indicated. The groups displayed significantly higher plenary completion rates when they participated in the Inspiration plenary. No statistically significant difference existed between Group One and Group Two.

The next section will present and analyze the qualitative data collected from the completed questionnaires.

Qualitative Findings

This section will analyze and discuss the qualitative findings collected. Qualitative analysis of the students' course preparation, test preparation practices, and personal
preference for plenary activities was facilitated by a post-course questionnaire. The questionnaire was divided into four sections. The first three sections of the questionnaire were used to collect data and to analyze the questions presented in Chapter 1.

The first section of the questionnaire was designed to analyze student preparation in order to compare the groups. The second section was designed to determine student study and test preparation habits. The third section was used to identify the students' perspectives regarding the plenary activities. Collectively the qualitative findings will be used to analyze student perception regarding the use of Inspiration and Review Worksheet/Discussion plenary activities and provide evidence to help answer the question: Does a student believe that using Inspiration allows him/her to direct his/her own learning and provide him/her with a better understanding of the concepts?

**Student Perspective of the Plenary Activities Related to Learning and Concept Understanding**

**Section One: Student Preparation**

The Student Preparation questionnaire section contained six items to identify prior academic achievement, prior introduction to webbing and Inspiration, ability to use a computer and the Internet, and personal ability to guide his/her own studying/learning. The first item allowed the student to provide multiple answers, identifying each of the senior academic courses he/she had taken or was taking. The second through sixth items elicited single responses.

The first group returned 16 out of 19 questionnaires while the second group returned 24 out of 25. Analysis of the questionnaires showed that all but one of the students had previously taken or was currently taking a senior science course other than Biology 12. In Group One 14 out of the 16 students had previously completed English 11 and the other two
were currently enrolled in English 11. Twenty-two Group Two respondents indicated they had successfully completed English 11 and two were currently enrolled. The students currently enrolled in English 11 were approached and asked directly about their English level, as they had not indicated either English 11 or 12 on the questionnaire. Twelve out of 16 (75.0%) Group One students and 18 out of 24 (75.0%) of the Group Two students completed Principles of Mathematics 11. Analysis of the previous course completion suggested that both groups had the necessary academic and comprehensive abilities to successfully complete Biology 12.

Questionnaire items, regarding technology/computer use, determined that all of the students felt they possessed average or above average abilities in computer and Internet use. The groups did differ in prior introduction to webbing and Inspiration. Thirteen out of 16 (81.3%) Group One students had completed some form of webbing but only 8 out of 16 (50.0%) had used Inspiration. In comparison, 21 out of 24 (87.5%) Group Two students had a prior introduction to webbing and 17 out of the 24 (70.8%) had used Inspiration. The numbers were not correlated to the test results but were used to suggest similarity in the sample groups. Inspiration plenary completion rates for Group One were 90.8% and for Group Two were 89.9%. Previous introduction to Inspiration did not affect plenary output.

The last Student Preparation questionnaire item identified the student’s perspective on his/her ability to direct his/her own learning. In Group One, all but five students felt they possessed average or above average ability to direct their own learning. Further analysis identified all but one of the aforementioned students completed all of the plenary activities, and four students demonstrated improved post-test scores compared to the pre-test scores. The student who did not submit any completed plenary activities indicated that he/she did not study and only did what was needed in class. In Group Two, one student indicated he/she did
not possess the ability to direct his/her own learning. The other students in the group believed they possessed average or above average ability to direct their own learning. The Group Two student who believed he/she did not possess the ability to guide his/her own learning indicated that he/she preferred the Inspiration plenary. This student participated in five of the six plenary activities, completed and submitted two of the Inspiration plenary activities and failed to submit the three RW/D plenaries.

Section Two: Student Study and Test Preparation Habits

This questionnaire section contained five questions. Students were asked to mark all choices that applied to them, resulting in multiple answers to many of the questions. Students were also verbally informed that they could add to the lists if they chose and should completely explain their choice for clarification purposes.

Question One: Identifying preference for individual or group study. Findings from the first question of this section suggested that the majority of students prefer to study on their own. Twenty-seven of 40 (67.5%) students preferred to study on their own, five out of 40 (12.5%) preferred small groups of one or two students, one (2.5%) student reported he/she preferred group work, one (2.5%) reported he/she did not study, and six (15.0%) students declared they preferred to study on their own or in small groups. No qualification for the students' answers was asked and reasons for preference were not declared.

Question Two: Types of resources and study techniques used by students. The second question attempted to determine the types of resources students commonly access in order to attain knowledge and understanding prior to a test. All of the students, but one, indicated they used a variety of resources and study techniques. The most common study aid was the use of class notes. Thirty-six out of 40 (90.0%) respondents indicated they relied on their class notes as their main study tool. After the use of class notes, a group of relatively equally-used study
aids and techniques emerged, including: summarizing notes (42.5%), answering review questions/completing review worksheets (35.0%), reviewing assignments (30.0%), participating in question and answer discussions (30.0%), reviewing past quizzes (30%). The lowest used study tools were reviewing the learning outcomes (7.5%) and producing/reviewing webs (5.0%). Three students wrote in answers not available as choices; of these, two indicated they used flashcards and one student indicated he/she did not study.

Question Three: Student preference for teacher input. The third question identified student preference for teacher input prior to a unit test. All of the students, except one, indicated a variety of teacher behaviours they liked. Teacher behaviours students liked included, in order of preference, when the teacher: wrote out a complete list of Things to Know (80%), reviewed the learning outcomes (55%), provided worksheets and questions (52.5%), used pictures, diagrams, and videos to review (42.5%), or used games (20%). One student chose to indicate he/she did not study and the teacher behaviours were inconsequential to his/her review.

Question Four: Student time commitment to study and review. The fourth question identified student time commitment to study and review. The largest proportion of students indicated that they studied two to three nights prior to a test. Fifteen out of 40 (37.5%) studied for more than 30 minutes per night for two to three days prior to the test, while 11 out of 40 (27.5%) indicated that they studied 30 minutes per night for two to three days before a test. The rest of the participants indicated the following: nine (22.5%) respondents studied for as much as possible the night before the test, two (5%) respondents studied for less than 30 minutes every night, two (5%) respondents studied for more than 30 minutes every night, and one (2.5%) respondent stated he/she did not study.
Question Five: Student extracurricular time commitment. The fifth question identified the personal time commitments students had beyond school. Student participation in extra-curricular activities and commitments to work were identified and grouped as follows: less than 10 hours per week (17.5%), 10-20 hours per week (45%), 20-30 hours per week (27.5%), and more than 30 hours per week (10%). The high extra-curricular/work commitments result in less study/review time outside of class.

Section Three: Review Activity Assessment

The review activity assessment involved five questions designed to give students a chance to voice their opinion on the two main types of plenary activities being compared. All of the respondents completed this section. 36 of the 40 students elaborated on his/her answers with written reasoning. Compilation of the answers resulted in identification of three distinct groups: students who preferred teacher guided reviews, students who preferred another review method, and students who preferred using Inspiration.

Question One: Identifying Student Plenary Preference. The first question directly asked what plenary activity students preferred to participate in at the end of a unit. Twenty-seven of the 40 (67.5%) students indicated that they preferred a teacher-guided review that included worksheets and discussion, 7 of the 40 (17.5%) students indicated they preferred using another method, and 6 of the 40 (15%) preferred using Inspiration. The comments that accompanied the results were generally written in a positive manner supporting the student’s position and a few students elaborated on why they disliked the other methods.

Students who preferred teacher-guided reviews indicated they liked having someone tell them what was on the test and believed the teacher conveyed all of the necessary information in the discussions and test outlines. This fact was evidenced when a student stated, “I listen because the teacher knows what is on the test”. and another stated he/she
preferred the teacher guided approach. "because the teacher is the teacher and any or all questions you have he/she can answer". The students believed that the teacher made the test and would not miss anything during the review or write extra questions they did not need to review.

In reference to the worksheets, students felt the worksheets contained questions that may be asked on the test, as well as, all the information necessary to cover. Students believed that worksheets focused their efforts and forced them to review the material in a way that increased their knowledge and understanding. One student stated he/she preferred "to complete review worksheets because it engages my thoughts", while another declared, "…doing worksheets it’s repetitive and you actively seek out the answers in your text and notes causing you to read and review."

Several students, who preferred the Review Worksheet/Discussion plenary, supplied reasoning against the use of Inspiration and other plenary methods. A general dislike for using the computer was noted by several students and one stated, "I just find most students including myself copy and paste or use info we copy from text and don’t internalize it." In specific reference to Inspiration, several students suggested that they rushed through to complete the projects, did not cover everything, and never looked back at their finished webs. As confessed by one student. "To tell the truth, I never really used Inspiration to study."

Several respondents believed, if they completed their own review, they might miss important information or overlook concepts. This finding was demonstrated when a student claimed, "If I make my own study plan I usually forget something I didn’t put in."

The students who preferred another plenary method supplied two main alternative methods. Five of the seven respondents suggested they preferred to rewrite and summarize their notes and four of the seven stated that they would read and review the text material in
order to complete their understanding and expand upon the information supplied in class. One student stated, "I find seeing my words written and taking the time to rephrase and summarize my own notes forces me to understand the general idea of the topic. I then skim through the text book to pick out the details I will have missed in my notes." Another student stated, "I already know most of the material in my notes as the teacher has explained it all so I prefer to get some more information and a different learning technique from the book."

The students, in the Another Method group, indicated a preference for individual study. Many felt that they did not focus when completing the review worksheets nor while completing the Inspiration projects in the computer room. To this end, a student stated, "I feel in class, I tend to lose focus easily, on my own I can actually focus and study properly."

The least-preferred plenary activity was the use of Inspiration. The six students who preferred Inspiration provided a variety of reasons for their choices. Three students suggested that Inspiration allowed them to repeatedly review their notes and access other sources of information when they required help. Other sources of information cited included: the teacher and various Internet sites. One student quoted, "I preferred this method because it allowed me to review notes. Then for stuff that I didn't completely understand I could ask the teacher about it or go on the Internet." Other reasons included the "entertainment factor", citing it as interesting to search for notable information and use different media. The students also reported that they appreciated having the ability to create something personal; as suggested by one student, "You got to make up your own web-type diagram."

*Question Two: Student perspective on plenary type and test preparation.* The second question asked the students which plenary they believed prepared them better for the unit test. Three main groups were determined as 17 of the 40 (42.5%) students believed that teacher-guided reviews prepared them best, eight of 40 (20%) chose Inspiration, and eight of
40 (20%) believed that using another method would be best. Three subgroups emerged: two of 40 (5%) students indicated teacher guided and another method, two of 40 (5%) students indicated teacher-guided and Inspiration, and three of 40 (7.5%) students indicated another method and Inspiration. Most of the students answering this question expanded on the reasoning provided in Question One; however, 10 students simply referred to the reasoning in Question One.

For the *Teacher Guided* preference group, several students suggested reasoning previously mentioned. The belief that teachers were specific and went over everything was iterated by several students, as was the belief that review worksheets forced students to repeat and review what was needed, and the benefit of discussion was listed. One student stated,

> When we go through reviews out loud in class with guided worksheets it gives us time to ask lots of questions and gives us a way better idea of what is on our test- also when the teacher is talking you almost always pick up important things you’ll need to know just by listening.

Five of the six respondents, who preferred *Inspiration*, believed Inspiration better prepared them for tests. Of the five, four simply referred to the reasoning they stated in Question One for response to Question Two. The respondent who added to his/her answer stated that, “It is very organized and well structured and I can’t organize anything if it is on paper.” Two respondents who preferred teacher-guided reviews believed Inspiration better prepared them for tests both citing that they felt Inspiration allowed them to teach themselves and to put information into their own words, facilitating memory recall.

The group that preferred *Another Method* reiterated the belief that rewriting and rewording notes, reading the text, and studying on their own worked best for test preparation. One member of the original group suggested using quiz or question/answer sessions with small groups of individuals also helped clarify topics and identify materials he/she did not
know. Adding to this group were three students who preferred teacher-guided activities and who preferred Inspiration. The reasoning supplied by each member mirrored the reasoning previously stated.

The subgroups that appeared cited reasons mentioned in the preceding text. The three students that chose a combination of Inspiration or Another Method of review originated in the Another Method group of Question One. As well, one of the Inspiration or Teacher-Guided respondents originated in the Inspiration group and the other in the Teacher-Guided group. The two Teacher Guided or Another Method respondents originated in the Teacher-Guided group. The recognition of the benefits of various review methods by some students could suggest that students have been exposed to a variety of review methods and have experienced success with each review method.

*Question Three: Identifying student effort on plenary activities.* Reasoning for the last three questions was mirrored by information previously supplied in Question One and Two. Question Three asked students to identify which plenary method they put more effort into completing. Twenty (50%) indicated they put more effort into completing the teacher-guided review, nine (22.5%) reported they put more effort into completing the Inspiration activities, eight (20%) that they put more effort into completing another method of review, two (5%) stressed that they put equal effort into completing the teacher-guided and Inspiration activities, and one student indicated he/she used an equal amount of effort to complete all of the plenary activities including writing and summarizing his/her notes.

*Question Four: Student perception of choice for self-expression.* The fourth question asked the students to identify which method they believed provided them with more choice and opportunity for self-expression. Twenty-two of the 40 (45%) respondents indicated they believed Inspiration allowed for more self-expression while 8 of 40 (20%) chose Teacher-
guided reviews, 8 of 40 (20%) chose Another Method, and one student indicated the Teacher guided or Another Method provided more choice or self-expression. Reasoning was minimal and directed at identifying the types of alternate plenaries that they felt provided them with choice. To this extent, the preparation of flashcards and review notes was indicated.

**Question Five: Student indication of future use of Inspiration.** The final question of the review Activity Assessment section asked whether or not students would be willing to use Inspiration again. Twenty-four of 40 (60%) students indicated they would use Inspiration again and 16 of 40 (40%) students said they would not use Inspiration again. Of the respondents who said they would use Inspiration, one stated that he/she would only use the program if he/she had to and would not use the program on his/her own. No extra reasoning was provided by any of the students.

**Observational Notes**

A number of observational notes were taken during the study to identify issues that could affect the implementation, or effect of the plenary. Access to the computer, attendance, student participation during the plenary, plenary submission, and student grouping were identified as possible issues to consider during the study. My personal observations were recorded and summarized.

The school contained three computer labs (i.e., two computer labs and a set of 30 computers available in the library) available for booking. Booking is on a first-come basis requiring teachers to plan in advance and follow the needed timeline. Many of the programs available to the students in the school are not accessible from the students’ homes.

Attendance during the year is an issue. School-related activities, illness, and participation in extra curricular activities often take students out of class. Care was taken to monitor student attendance and only count those students that participated in the pre-test, full
plenary, and post-test. Each student participating in the plenary activity should have benefited from the discussions, and should have submitted a plenary. Completed Inspiration plenaries were submitted as electronic files or as documents exported to Microsoft Word™. The Review Worksheet/Discussion submissions were the completed worksheets.

Monitoring during the RW/D and Inspiration activities indicated that each student was completing the assigned task, with or without refocusing. However, student plenary submission was not 100% and in some cases, plenary submissions were not complete. Copying to complete the plenary occurred in both the Inspiration and RW/D activities, but appeared to be more prevalent during the RW/D activities. During the RW/D, many students completed minimal amounts on their own, choosing to wait for the discussion portion of the plenary where 60% of the worksheet answers were discussed and used to advance into higher-level process concepts. Many of the students participated in off-task discussions, during the RW/D plenary, that often resulted in more off-task activities unless I refocused the students participating in the off-task behaviour.

During the plenary activities, resources and time were factors students were aware of. An informal survey indicated that 2 of 50 students, in the two Biology 12 classes, had home access to the Inspiration program. Student recognition of this could have resulted in increased focus during the plenary, as students would not be able to complete the plenary without school access. To alleviate the problem, students were encouraged to complete notes and identify diagrams for use in the plenary prior to the assigned activity time. Observation suggested students failed to implement this suggestion.

In the first Inspiration plenary, students in both Group One and Group Two worked individually to prepare the review submission, and used peer- and student/teacher discussion to identify areas for clarification or to locate materials. Many students indicated that
completing the plenary in the allotted time was difficult. Several students indicated he/she used time after school or at lunch to finish.

In the second and third Inspiration plenary activities, many students formed groups and used division of labor techniques to complete the plenary. After completing their sections, the individuals in the groups, shared their findings with the group, copying and pasting to complete one plenary submission. The individuals then discussed what they learned within the group. Each individual in the group then modified his/her plenary submission to clarify points and provide a personal touch.

*Summary of the Qualitative Findings*

The qualitative findings were determined by the information collected from the course questionnaire. The first section of the questionnaire asked the students to identify academic and technological/computer capabilities. The student answers suggested that Group One and Group Two were similar. Both groups contained a varied group of students who had the academic and computer abilities to be successful in Biology 12.

The second section identified the study habits of the students. Students’ answers indicated most students began studying two to three days before the test and they preferred to study on their own. When studying, most students relied on class notes and personally prepared note summarizations. A lower proportion of students preferred to complete review worksheets, review old assignments, and/or participate in discussions. Most students preferred teachers to provide them with a list of Things to Know, review Intended Learning Outcomes, or provide review worksheets. For example, 82.5% of students indicated they spent 10 hours or more participating in extra-curricular activities.

Student responses, to the third section of the questionnaire, indicated 67.5% of the students preferred using Teacher Guided (RW/D) activities and 15% preferred Inspiration as
a plenary activity. The students preferred having someone indicate what would be on the test and believed the teacher would only tell what they needed to know. Students who preferred Inspiration liked the entertainment factor and the ability to create something personal. Students who did not prefer Inspiration, cited computer issues and the possibility of omitting important information while preparing the Inspiration plenary, as reasons for their disapproval.

Students' answers indicated they realized the benefits of the plenary activities. Specifically, 42.5% of the students believed RW/D activities best prepared them for the test, while 20% believed Inspiration plenary activities were best. As well, 12.5% of the students believed the use of Inspiration was equal to RW/D or Another Method in test preparation.

Fifty percent of the student responses indicated they put more effort into completing RW/D plenary activities than the Inspiration activities. Additionally, 22.5% of the students believed they used more effort to complete the Inspiration plenary and 5% indicated they put equal effort into each plenary. For self-expression, more students believed Inspiration allowed students better opportunities to express themselves, and 60% of the students indicated they would use Inspiration in the future.

Personal observations identified several considerations that should be acknowledged when analyzing the plenary activities. The availability of computers and software was limited in the school and the students needed to focus and complete their Inspiration activity during class or in the school on their own time. Copying and student discussion occurred in both activities; however, off-task discussion was more prevalent in the RW/D activity and many students had to be refocused. During the second and third Inspiration plenary, groups formed. The individuals in the groups divided the plenary sections, completed their sections, shared and discussed the completed sections, and modified the plenary for clarification and
personalization before submission. All of the students participating in the plenary activity were observed completing the tasks but plenary submissions were not one hundred percent.

This section presented the qualitative findings that will be used to analyze the questions posed in Chapter 1, and support, or refute, the hypotheses. The next section will present other findings that were collected during the study.

Other Findings

The first section presented the quantitative findings collected during the study. The second section presented the qualitative findings collected from the student questionnaire. This section will present other findings that may support or refute the hypotheses. In this section, the effect of the Review Worksheet/Discussion plenary on test scores will be presented. Following an overall review of the RW/D, the analysis of the effects of the RW/D plenary on the individual cognitive domains will be discussed. The final analysis will compare the effects of the Inspiration to the RW/D plenary activity, in respect to the individual cognitive domains.

Effects of the Review Worksheets/Discussion Plenary Activity on Test Scores

The review worksheet plenary was used for both Group One and Group Two in the second unit (Digestion), for Group Two in the third unit (Circulation), for Group One in the fourth unit (Respiration) and fifth unit (Expiration), and for Group Two in the sixth unit (Nervous System). Pre-tests were administered two days before the post-tests. The plenary activity began immediately after the pre-test and was completed the next day, except for the Respiratory unit. The post-test was administered the day after the plenary. For the Respiratory unit the post-test was administered two days after the pre-test. The class time spent on the plenary activity was the same as the other units but the number of days used was
increased by one. Students were allowed to use their completed plenary for study purposes and were encouraged to do so.

The raw data for each of the trials were graphed and a Pearson product moment correlation coefficient for a sample \( (r) \) was calculated and displayed with each graph. Each of the post-test versus pre-test graphs indicated a high correlation between the data. Students who scored high on the pre-test generally scored higher on the post-test. The \( r \)-values ranged from .546 to .770 with root mean square errors varying from .104 to .147. The positive slope of the linear fit lines combined with the positive y-intercept for each graph, and the fact that most plotted points were higher up than right, indicated improvement occurred. The post-test scores were generally higher than pre-test scores. The only graph not displaying a linear fit line with a positive y-intercept was the Circulation unit graph; however, the steep positive slope of the line (i.e., \( m = +1.149 \)) compensated to display an overall group improvement. Figures 12-17 display the pre-test/post-test raw scores as percentages in decimal form.

Further analysis of the data occurred using directional dependent \( t \)-tests. The \( t \)-tests were completed to assess the effects of the plenary on student achievement and were used to test the hypothesis: If a student uses review worksheets and discussion, as a plenary activity, then his/her test scores will improve. For each of the units the following null hypothesis (\( H_0 \)) and alternative hypothesis (\( H_1 \)) were used in the Pre-Post test comparisons,

\[ H_0: \mu_{\text{Pre}} \geq \mu_{\text{Post}} \quad \text{or} \quad \mu_{\text{Pre}} - \mu_{\text{Post}} \geq 0 \quad \text{or} \quad \mu_D \geq 0 \]

\[ H_1: \mu_{\text{Pre}} < \mu_{\text{Post}} \quad \text{or} \quad \mu_{\text{Pre}} - \mu_{\text{Post}} < 0 \quad \text{or} \quad \mu_D < 0 \]

Each of the \( t \)-tests used alpha level (\( \alpha \)) = .05 for determining significance.
Figure 12. Group One post-test versus pre-test scores for the Digestion unit after using Review Worksheets/Discussion. The scores are percentages displayed in decimal form. The graph displays a correlation with $r = .770$ and RMSE = .102.

Figure 13. Group Two post-test versus pre-test scores for the Digestion unit after using Review Worksheets/Discussion. The scores are percentages displayed in decimal form. The graph displays a correlation with $r = .610$ and RMSE = .132.
Figure 14. Group Two post-test versus pre-test scores for the Circulation unit after using Review Worksheets/Discussion. The scores are percentages displayed in decimal form. The graph displays a correlation with $r = .770$ and RMSE $= .125$.

Figure 15. Group One post-test versus pre-test scores for the Respiration unit after using Review Worksheets/Discussion. The scores are percentages displayed in decimal form. $r = .546$ and RMSE $= .104$. 
Figure 16. Group One post-test versus pre-test scores for the Excretion unit after using Review Worksheets/Discussion. The scores are percentages displayed in decimal form. The graph displays a correlation with $r = .683$ and RMSE = .143.

Figure 17. Group Two post-test versus pre-test scores for the Nervous unit after using Review Worksheets/Discussion. The scores are percentages displayed in decimal form. The graph displays a correlation with $r = .637$ and RMSE = .147.
Table 12 presents the results of the analysis. Each unit displayed an increase in the
post-test score. The post-test score improvement varied from 6.6% for the Circulation unit to
21.4% for the Respiration unit. The improvement for each was determined to be statistically
significant as each of the observed \( t \)-scores was below the calculated critical value. The effect
size for the individual tests ranged from -0.524 to -1.200.

Table 12

*Pre- and post-test analyses of the Review Worksheet/Discussion plenary for six units of Biology 12.*

<table>
<thead>
<tr>
<th>Unit</th>
<th>Digestion Group 1</th>
<th>Digestion Group 2</th>
<th>Circulation Group 2</th>
<th>Respiration Group 1</th>
<th>Excretion Group 1</th>
<th>Nervous Group 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>( M_{pre} )</td>
<td>0.571</td>
<td>0.548</td>
<td>0.468</td>
<td>0.572</td>
<td>0.553</td>
<td>0.402</td>
</tr>
<tr>
<td>( s_{X_{pre}} )</td>
<td>0.209</td>
<td>0.143</td>
<td>0.128</td>
<td>0.213</td>
<td>0.186</td>
<td>0.169</td>
</tr>
<tr>
<td>( M_{post} )</td>
<td>0.656</td>
<td>0.678</td>
<td>0.534</td>
<td>0.786</td>
<td>0.631</td>
<td>0.495</td>
</tr>
<tr>
<td>( s_{X_{post}} )</td>
<td>0.154</td>
<td>0.194</td>
<td>0.191</td>
<td>0.120</td>
<td>0.189</td>
<td>0.186</td>
</tr>
<tr>
<td>( \sum D_i )</td>
<td>-1.450</td>
<td>-2.925</td>
<td>-1.450</td>
<td>-3.425</td>
<td>-1.250</td>
<td>-2.050</td>
</tr>
<tr>
<td>( \sum D_i^2 )</td>
<td>0.410</td>
<td>0.786</td>
<td>0.415</td>
<td>1.211</td>
<td>0.431</td>
<td>0.676</td>
</tr>
<tr>
<td>( n )</td>
<td>17</td>
<td>25</td>
<td>22</td>
<td>16</td>
<td>16</td>
<td>22</td>
</tr>
<tr>
<td>( \overline{D} )</td>
<td>-0.085</td>
<td>-0.117</td>
<td>-0.066</td>
<td>-0.214</td>
<td>-0.078</td>
<td>-0.093</td>
</tr>
<tr>
<td>( \sum (D_i - \overline{D})^2 )</td>
<td>0.286</td>
<td>0.443</td>
<td>0.319</td>
<td>0.478</td>
<td>0.334</td>
<td>0.485</td>
</tr>
<tr>
<td>SD (s_D)</td>
<td>0.134</td>
<td>0.136</td>
<td>0.123</td>
<td>0.178</td>
<td>0.149</td>
<td>0.152</td>
</tr>
<tr>
<td>Var. (s^2)</td>
<td>0.018</td>
<td>0.018</td>
<td>0.015</td>
<td>0.032</td>
<td>0.022</td>
<td>0.023</td>
</tr>
<tr>
<td>SE (s_{\overline{D}})</td>
<td>0.032</td>
<td>0.027</td>
<td>0.026</td>
<td>0.045</td>
<td>0.037</td>
<td>0.032</td>
</tr>
<tr>
<td>( t_{obs} ) value</td>
<td>-2.629</td>
<td>-4.304</td>
<td>-2.507</td>
<td>-4.799</td>
<td>-2.096</td>
<td>-2.875</td>
</tr>
<tr>
<td>( t_{cv}^\dagger )</td>
<td>-1.746</td>
<td>-1.711</td>
<td>-1.721</td>
<td>-1.753</td>
<td>-1.753</td>
<td>-1.721</td>
</tr>
<tr>
<td>( p ) (one-tailed)</td>
<td>.009 &lt;.001</td>
<td>.010 &lt;.001</td>
<td>.027 .005</td>
<td>.027 .005</td>
<td>.027 .005</td>
<td></td>
</tr>
</tbody>
</table>

Note: \( t_{cv} \) calculated at \( p = 0.05 \) for a one-tailed \( t \)-test.
Effects of the Review Worksheet/Discussion Plenary on the Cognitive Domains

The review worksheet/discussion plenary was used for both Group One and Group Two in the second unit (Digestion), for Group Two in the third unit (Circulation), for Group One in the fourth unit (Respiration) and fifth unit (Expiration), and for Group Two in the sixth unit (Nervous System). The cognitive domains were analyzed using the six different units. Before test administration, the pre- and post-tests were constructed using set proportions of Knowledge, Understanding and Higher Order Process questions. Student test scores were categorized according to their pre- and post-test results in the cognitive domains and one-tailed dependent t-tests were performed. The results of the analyses are presented in Table 13, 14, and 15.

For each of the cognitive areas the following null- and alternative hypotheses were set

\[ H_0: \mu_{\text{Pre}} \geq \mu_{\text{Post}} \quad \text{or} \quad \mu_{\text{Pre}} - \mu_{\text{Post}} \geq 0 \quad \text{or} \quad \mu_D \geq 0 \]

\[ H_1: \mu_{\text{Pre}} < \mu_{\text{Post}} \quad \text{or} \quad \mu_{\text{Pre}} - \mu_{\text{Post}} < 0 \quad \text{or} \quad \mu_D < 0 \]

For each of the tests the critical value was determined for a one-tailed test with \( \alpha = 0.05 \).

Understanding

Data collection for the RW/D plenary indicated an average increase in Understanding post-test scores between 1.6% and 23.8%. Statistical significance was determined in four of the six samples as indicated by the observed \( t \)-scores in Table 13. The average increase in Understanding ranged from 8.2% to 23.8 % for the samples that displayed statistical significance in post-test improvement. The four samples displaying statistical significance included: Group One digestion (\( p = .013 \)), Group Two Digestion (\( p < .001 \)), Group Two Circulation (\( p < .001 \)), and Group One Respiration (\( p < .001 \)). For these findings the effect size varied from -0.600 to -1.219.
Table 13

Pre-/post-test analyses of Understanding for the Review Worksheet/Discussion plenary.

<table>
<thead>
<tr>
<th></th>
<th>Dig. U</th>
<th>Dig. U</th>
<th>Circ. U</th>
<th>Resp. U</th>
<th>Excr. U</th>
<th>Nerv. U</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Group 1</td>
<td>Group 2</td>
<td>Group 2</td>
<td>Group 1</td>
<td>Group 1</td>
<td>Group 2</td>
</tr>
<tr>
<td>$M_{Pre}$</td>
<td>0.578</td>
<td>0.584</td>
<td>0.417</td>
<td>0.547</td>
<td>0.609</td>
<td>0.451</td>
</tr>
<tr>
<td>$s_{X_{pre}}$</td>
<td>0.193</td>
<td>0.199</td>
<td>0.159</td>
<td>0.240</td>
<td>0.182</td>
<td>0.215</td>
</tr>
<tr>
<td>$M_{Post}$</td>
<td>0.660</td>
<td>0.756</td>
<td>0.536</td>
<td>0.785</td>
<td>0.625</td>
<td>0.478</td>
</tr>
<tr>
<td>$s_{X_{post}}$</td>
<td>0.172</td>
<td>0.116</td>
<td>0.211</td>
<td>0.116</td>
<td>0.234</td>
<td>0.213</td>
</tr>
<tr>
<td>$\sum D_i$</td>
<td>-1.399</td>
<td>-4.289</td>
<td>-2.616</td>
<td>-3.815</td>
<td>-0.250</td>
<td>-0.605</td>
</tr>
<tr>
<td>$\sum D_i^2$</td>
<td>0.416</td>
<td>1.762</td>
<td>0.691</td>
<td>1.484</td>
<td>0.366</td>
<td>0.767</td>
</tr>
<tr>
<td>$n$</td>
<td>17</td>
<td>25</td>
<td>22</td>
<td>16</td>
<td>16</td>
<td>22</td>
</tr>
<tr>
<td>$\bar{D}$</td>
<td>-0.082</td>
<td>-0.172</td>
<td>-0.119</td>
<td>-0.238</td>
<td>-0.016</td>
<td>-0.028</td>
</tr>
<tr>
<td>$\sum(D_i - \bar{D})^2$</td>
<td>0.301</td>
<td>1.026</td>
<td>0.380</td>
<td>0.574</td>
<td>0.362</td>
<td>0.750</td>
</tr>
<tr>
<td>$SD$ (sD)</td>
<td>0.137</td>
<td>0.207</td>
<td>0.135</td>
<td>0.196</td>
<td>0.155</td>
<td>0.189</td>
</tr>
<tr>
<td>Var. (s^2)</td>
<td>0.019</td>
<td>0.043</td>
<td>0.0181</td>
<td>0.038</td>
<td>0.024</td>
<td>0.036</td>
</tr>
<tr>
<td>$SE$ (sD)</td>
<td>0.033</td>
<td>0.041</td>
<td>0.029</td>
<td>0.049</td>
<td>0.039</td>
<td>0.040</td>
</tr>
<tr>
<td>t_{obs} value</td>
<td>-2.473</td>
<td>-4.149</td>
<td>-4.147</td>
<td>-4.875</td>
<td>-0.402</td>
<td>-0.683</td>
</tr>
<tr>
<td>$t_c$</td>
<td>-1.746</td>
<td>-1.711</td>
<td>-1.721</td>
<td>-1.753</td>
<td>-1.753</td>
<td>-1.721</td>
</tr>
<tr>
<td>p (one-tailed)</td>
<td>.013</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>.347</td>
<td>.251</td>
</tr>
<tr>
<td>d (effect)</td>
<td>-0.600</td>
<td>-0.830</td>
<td>-0.884</td>
<td>-1.219</td>
<td>-0.101</td>
<td>-0.146</td>
</tr>
<tr>
<td>Power</td>
<td>.321</td>
<td>.644</td>
<td>.640</td>
<td>.750</td>
<td>.073</td>
<td>.094</td>
</tr>
</tbody>
</table>

The Group One Excretion unit and the Group Two Nervous System unit samples indicated improvement in Understanding of 1.6% and 2.8% respectively; however, these values were not statistically significant for post-test improvement in understanding. A post-hoc power analysis determined the power for the Group One Excretion unit test was 7.3% and the power for the Nervous System unit test was 9.4%. These power levels indicate that the trials were underpowered.

Knowledge

For the Knowledge cognitive domain, pre-test mean scores ranged from 47.7% to 81.3% and post-test mean scores ranged from 63.1% to 91.7%. Five of the six trials indicated post-test improvement compared to pre-test scores for the corresponding unit. The average improvement varied from 10.4% to 21.0%. Table 14 displays the observed t-score for each unit. The t-score for each unit, except the circulatory unit, was lower than the corresponding critical t-value, and indicated statistically significant improvement in Knowledge achievement. The effect size ranged from -0.448 to -0.830.

The Circulatory unit trial did not indicate statistical significance. The pre-test Knowledge score was 68.2% and the post-test Knowledge score was 65.7%, creating a pre-post test difference of 2.5%. The power for this trial was 7.4%. The low power score suggests that the trial was underpowered.

Higher Order Process

For the Higher Order Process cognitive domain, five of the six trials indicated improvement. The improvement in test scores for Higher-Order Process questions averaged between 2.9% and 23.4%. However, only two of the six trials, Group One Respiratory trial and the Group Two Nervous System, indicated statistically-significant improvement in Higher Order Process scores after the RW/D plenary. The t-scores, displayed in Table 15, for
Table 14

*Pre-/post- test analyses of Knowledge for the Review Worksheet/Discussion plenary.*

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Group 1</td>
<td>Group 2</td>
<td>Group 2</td>
<td>Group 1</td>
<td>Group 1</td>
<td>Group 2</td>
</tr>
<tr>
<td><em>M</em>_pre</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.647</td>
<td>0.584</td>
<td>0.682</td>
<td>0.813</td>
<td>0.547</td>
<td>0.477</td>
</tr>
<tr>
<td>s*&lt;sub&gt;x&lt;/sub&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.279</td>
<td>0.199</td>
<td>0.234</td>
<td>0.194</td>
<td>0.277</td>
<td>0.298</td>
</tr>
<tr>
<td><em>M</em>_post</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.791</td>
<td>0.756</td>
<td>0.657</td>
<td>0.917</td>
<td>0.757</td>
<td>0.631</td>
</tr>
<tr>
<td>s*&lt;sub&gt;x&lt;/sub&gt;*&lt;sub&gt;post&lt;/sub&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.161</td>
<td>0.116</td>
<td>0.227</td>
<td>0.095</td>
<td>0.168</td>
<td>0.212</td>
</tr>
<tr>
<td>ΣD*&lt;sub&gt;i&lt;/sub&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>-2.444</td>
<td>-4.289</td>
<td>0.556</td>
<td>-1.667</td>
<td>-3.361</td>
<td>-3.389</td>
</tr>
<tr>
<td>ΣD*&lt;sub&gt;i&lt;/sub&gt;*&lt;sub&gt;2&lt;/sub&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1.276</td>
<td>1.762</td>
<td>1.721</td>
<td>0.983</td>
<td>2.419</td>
<td>2.424</td>
</tr>
<tr>
<td>n</td>
<td>17</td>
<td>25</td>
<td>22</td>
<td>16</td>
<td>16</td>
<td>22</td>
</tr>
<tr>
<td>D̄</td>
<td>-0.144</td>
<td>-0.172</td>
<td>0.025</td>
<td>-0.104</td>
<td>-0.210</td>
<td>-0.154</td>
</tr>
<tr>
<td>Σ(D*&lt;sub&gt;i&lt;/sub&gt; - D̄)*&lt;sub&gt;2&lt;/sub&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.925</td>
<td>1.026</td>
<td>1.707</td>
<td>0.809</td>
<td>1.713</td>
<td>1.902</td>
</tr>
<tr>
<td>SD (s_D)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.240</td>
<td>0.207</td>
<td>0.285</td>
<td>0.232</td>
<td>0.338</td>
<td>0.301</td>
</tr>
<tr>
<td>Var. (s*&lt;sub&gt;2&lt;/sub&gt;)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.058</td>
<td>0.043</td>
<td>0.081</td>
<td>0.054</td>
<td>0.114</td>
<td>0.091</td>
</tr>
<tr>
<td>SE (s_B)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.058</td>
<td>0.041</td>
<td>0.061</td>
<td>0.058</td>
<td>0.085</td>
<td>0.064</td>
</tr>
<tr>
<td>t*&lt;sub&gt;obs&lt;/sub&gt; value</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>-2.466</td>
<td>-4.149</td>
<td>0.416</td>
<td>-1.794</td>
<td>-2.487</td>
<td>-2.401</td>
</tr>
<tr>
<td>t*&lt;sub&gt;cv&lt;/sub&gt; †</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>-1.746</td>
<td>-1.711</td>
<td>-1.721</td>
<td>-1.753</td>
<td>-1.753</td>
<td>-1.721</td>
</tr>
<tr>
<td>p (one-tailed)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>.013</td>
<td>&lt;.001</td>
<td>.658</td>
<td>.047</td>
<td>.013</td>
<td>.013</td>
</tr>
<tr>
<td>d (effect)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>-0.598</td>
<td>-0.830</td>
<td>0.089</td>
<td>-0.448</td>
<td>-0.622</td>
<td>-0.512</td>
</tr>
<tr>
<td>Power</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>.320</td>
<td>.644</td>
<td>.074</td>
<td>.214</td>
<td>.323</td>
<td>.314</td>
</tr>
</tbody>
</table>

Note: Dig. = Digestive System, Circ. = Circulatory System, Resp. = Respiratory System, Excr. = Excretory System, Nerv. = Nervous System, K = knowledge. *t*<sub>cv</sub> was calculated at † *p* = .05 for a one-tailed *t*-test.
the Respiratory and Nervous System units indicated statistical significance with \( p \)-values of \(.003 \) and \(<.001 \) respectively, and suggested respective effect sizes of \( d = -0.803 \) and \( d = -0.847 \).

The \( t \)-scores referenced in Table 15, indicated no statistical difference was present in the pre-test and post-test scores for the Group One and Group Two Digestion unit trials, the Group Two Circulation trial, nor the Group One Excretion trial. The power values, calculated for the Digestion unit and Circulation unit trials, ranged from 7.2\% to 7.9\%. The Excretion trial had a power of 17.1\%. The low power calculations suggested the trials were underpowered.

Comparisons of the Effects of the Plenary Activities on Cognitive Domains

Independent \( t \)-test comparison of the Inspiration plenary to the Review Worksheet/Discussion plenary indicated no statistical significance existed when comparing the differences of pre-test to post-test overall scores. The data collection procedures allowed the collection of combined overall test scores and individual cognitive domain data that could be analyzed and compared. Table 16, 17, and 18 summarize the data collected to compare the effects of Inspiration and RW/D on achievement in the individual cognitive domains. The calculated \( t \)-scores do not surpass the set critical \( t \)-values for any of the comparisons indicating no statistically significant differences were present. The low power scores suggest the tests were underpowered.

Statistical significance was not indicated; however, differences did seem to occur. The Inspiration and RW/D cognitive domain comparisons are graphically displayed in Figures 18, 19, and 20. The graphs indicate Inspiration produced more improvement in Understanding and Knowledge in three out of four trials. The RW/D plenary produced larger improvements in Higher Order Process in three out of four trials.
Table 15

*Analyses of Higher Order Process scores for the Review Worksheet/Discussion plenary.*

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Group 1</td>
<td>Group 2</td>
<td>Group 2</td>
<td>Group 1</td>
<td>Group 1</td>
<td>Group 2</td>
</tr>
<tr>
<td>$M_{Pre}$</td>
<td>0.456</td>
<td>0.480</td>
<td>0.409</td>
<td>0.406</td>
<td>0.0391</td>
<td>0.182</td>
</tr>
<tr>
<td>$s_{X_{Pre}}$</td>
<td>0.333</td>
<td>0.322</td>
<td>0.197</td>
<td>0.315</td>
<td>0.258</td>
<td>0.158</td>
</tr>
<tr>
<td>$M_{Post}$</td>
<td>0.485</td>
<td>0.515</td>
<td>0.392</td>
<td>0.641</td>
<td>0.492</td>
<td>0.392</td>
</tr>
<tr>
<td>$s_{X_{Post}}$</td>
<td>0.224</td>
<td>0.226</td>
<td>0.205</td>
<td>0.237</td>
<td>0.216</td>
<td>0.198</td>
</tr>
<tr>
<td>$\sum D_i$</td>
<td>-0.500</td>
<td>-0.875</td>
<td>0.375</td>
<td>-3.750</td>
<td>-1.625</td>
<td>-4.625</td>
</tr>
<tr>
<td>$\sum D_i^2$</td>
<td>1.313</td>
<td>3.234</td>
<td>0.953</td>
<td>2.156</td>
<td>1.328</td>
<td>2.266</td>
</tr>
<tr>
<td>$n$</td>
<td>17</td>
<td>25</td>
<td>22</td>
<td>16</td>
<td>16</td>
<td>22</td>
</tr>
<tr>
<td>$\overline{D}$</td>
<td>-0.029</td>
<td>-0.035</td>
<td>0.017</td>
<td>-0.234</td>
<td>-0.102</td>
<td>-0.210</td>
</tr>
<tr>
<td>$\sum(D_i - \overline{D})^2$</td>
<td>1.298</td>
<td>3.204</td>
<td>0.947</td>
<td>1.277</td>
<td>1.163</td>
<td>1.293</td>
</tr>
<tr>
<td>$SD (s_D)$</td>
<td>0.285</td>
<td>0.365</td>
<td>0.212</td>
<td>0.292</td>
<td>0.279</td>
<td>0.248</td>
</tr>
<tr>
<td>Var. ($s^2$)</td>
<td>0.081</td>
<td>0.133</td>
<td>0.045</td>
<td>0.085</td>
<td>0.078</td>
<td>0.062</td>
</tr>
<tr>
<td>$SE (s_{D})$</td>
<td>0.069</td>
<td>0.073</td>
<td>0.045</td>
<td>0.073</td>
<td>0.070</td>
<td>0.053</td>
</tr>
<tr>
<td>$t_{obs}$ value</td>
<td>-0.426</td>
<td>-0.479</td>
<td>0.377</td>
<td>-3.213</td>
<td>-1.459</td>
<td>-3.973</td>
</tr>
<tr>
<td>$t_{cv}^*$</td>
<td>-1.746</td>
<td>-1.711</td>
<td>-1.721</td>
<td>-1.753</td>
<td>-1.753</td>
<td>-1.721</td>
</tr>
<tr>
<td>$p$ (one-tailed)</td>
<td>.338</td>
<td>.318</td>
<td>.645</td>
<td>.003</td>
<td>.083</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>$d$ (effect)</td>
<td>-0.103</td>
<td>-0.096</td>
<td>0.080</td>
<td>-0.803</td>
<td>-0.365</td>
<td>-0.847</td>
</tr>
<tr>
<td>Power</td>
<td>.075</td>
<td>.079</td>
<td>.072</td>
<td>.454</td>
<td>.171</td>
<td>.608</td>
</tr>
</tbody>
</table>

Note: Dig. = Digestive System, Circ. = Circulatory System, Resp. = Respiratory System, Excr. = Excretory System, Nerv. = Nervous System, H = Higher Order Process. $t_{cv}$ was calculated at $^* p = .05$ for a one-tailed t-test.
Table 16

Pre- and post-test comparative results for the Inspiration plenary and Review Worksheet/Discussion plenary for the Understanding cognitive domain.

<table>
<thead>
<tr>
<th>Students</th>
<th>Circ</th>
<th>Resp</th>
<th>Excr</th>
<th>Nerv</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inspiration Group ((\bar{D}_{insp}))</td>
<td>-0.163</td>
<td>-0.226</td>
<td>-0.073</td>
<td>-0.052</td>
</tr>
<tr>
<td>SD (s_D)</td>
<td>0.174</td>
<td>0.188</td>
<td>0.193</td>
<td>0.177</td>
</tr>
<tr>
<td>n_1=</td>
<td>19</td>
<td>23</td>
<td>24</td>
<td>19</td>
</tr>
<tr>
<td>Review Group ((\bar{D}_{rev}))</td>
<td>-0.119</td>
<td>-0.239</td>
<td>-0.016</td>
<td>-0.028</td>
</tr>
<tr>
<td>SD (s_D)</td>
<td>0.135</td>
<td>0.196</td>
<td>0.155</td>
<td>0.189</td>
</tr>
<tr>
<td>n_2=</td>
<td>22</td>
<td>16</td>
<td>16</td>
<td>22</td>
</tr>
<tr>
<td>(s_{pooled}^2)</td>
<td>0.024</td>
<td>0.037</td>
<td>0.032</td>
<td>0.034</td>
</tr>
<tr>
<td>(s_{\bar{D}_1-\bar{D}_2})</td>
<td>0.048</td>
<td>0.062</td>
<td>0.058</td>
<td>0.058</td>
</tr>
<tr>
<td>t_{obs}</td>
<td>-0.912</td>
<td>0.207</td>
<td>-0.995</td>
<td>-0.427</td>
</tr>
<tr>
<td>t_{cv}^*</td>
<td>-1.685</td>
<td>-1.688</td>
<td>-1.686</td>
<td>-1.685</td>
</tr>
<tr>
<td>df</td>
<td>39</td>
<td>37</td>
<td>38</td>
<td>39</td>
</tr>
<tr>
<td>p</td>
<td>.184</td>
<td>.581</td>
<td>.163</td>
<td>.336</td>
</tr>
<tr>
<td>d</td>
<td>0.283</td>
<td>0.068</td>
<td>0.326</td>
<td>0.131</td>
</tr>
<tr>
<td>Power (one-tailed)</td>
<td>.225</td>
<td>.075</td>
<td>.263</td>
<td>.109</td>
</tr>
</tbody>
</table>

Note: \(\bar{D}\) = mean difference, Circ = Circulatory, Resp = Respiratory, Excr = Excretory, Nerv = Nervous, \(t\) = Student's t-value, \(\alpha = .05\).
Table 17

*Pre- and post-test comparative results for the Inspiration plenary and Review Worksheet/Discussion plenary for the Knowledge cognitive domain.*

<table>
<thead>
<tr>
<th>Students</th>
<th>Circ</th>
<th>Resp</th>
<th>Excr</th>
<th>Nerv</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inspiration Group ((\bar{D}_{\text{insp}}))</td>
<td>0.067</td>
<td>-0.198</td>
<td>-0.303</td>
<td>-0.227</td>
</tr>
<tr>
<td>SD ((s_D))</td>
<td>0.197</td>
<td>0.301</td>
<td>0.344</td>
<td>0.375</td>
</tr>
<tr>
<td>(n_1=)</td>
<td>19</td>
<td>23</td>
<td>24</td>
<td>19</td>
</tr>
<tr>
<td>Review Group ((\bar{D}_{\text{rev}}))</td>
<td>0.025</td>
<td>-0.104</td>
<td>-0.210</td>
<td>-0.154</td>
</tr>
<tr>
<td>SD ((s_D))</td>
<td>0.285</td>
<td>0.232</td>
<td>0.338</td>
<td>0.301</td>
</tr>
<tr>
<td>(n_2=)</td>
<td>22</td>
<td>16</td>
<td>16</td>
<td>22</td>
</tr>
<tr>
<td>(s_{pooled}^2)</td>
<td>0.062</td>
<td>0.076</td>
<td>0.117</td>
<td>0.114</td>
</tr>
<tr>
<td>(s_{\bar{D}_1-\bar{D}_2})</td>
<td>0.078</td>
<td>0.090</td>
<td>0.110</td>
<td>0.106</td>
</tr>
<tr>
<td>(t_{obs})</td>
<td>0.540</td>
<td>-1.049</td>
<td>-0.845</td>
<td>-0.687</td>
</tr>
<tr>
<td>(t_{cv}^*)</td>
<td>-1.685</td>
<td>-1.687</td>
<td>-1.686</td>
<td>-1.685</td>
</tr>
<tr>
<td>(df)</td>
<td>39</td>
<td>37</td>
<td>38</td>
<td>39</td>
</tr>
<tr>
<td>(p)</td>
<td>.704</td>
<td>.150</td>
<td>.201</td>
<td>.248</td>
</tr>
<tr>
<td>(d)</td>
<td>0.171</td>
<td>0.350</td>
<td>0.273</td>
<td>0.215</td>
</tr>
<tr>
<td>Power (one-tailed)</td>
<td>.134</td>
<td>.283</td>
<td>.213</td>
<td>.166</td>
</tr>
</tbody>
</table>

Note: \(\bar{D}\) = mean difference, Circ = Circulatory, Resp = Respiratory, Exer = Excretory, Nerv = Nervous, \(*\) \(\alpha=0.05\).
Table 18

*Pre- and post-test comparative results for the Inspiration plenary and Review Worksheet/Discussion plenary for the Higher Order Process cognitive domain.*

<table>
<thead>
<tr>
<th>Students</th>
<th>Circ</th>
<th>Resp</th>
<th>Excr</th>
<th>Nerv</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inspiration Group ((\bar{D}_{jasp}))</td>
<td>-0.099</td>
<td>-0.283</td>
<td>-0.042</td>
<td>-0.164</td>
</tr>
<tr>
<td>SD (s_D)</td>
<td>0.245</td>
<td>0.288</td>
<td>0.226</td>
<td>0.309</td>
</tr>
<tr>
<td>n_1=</td>
<td>19</td>
<td>23</td>
<td>24</td>
<td>19</td>
</tr>
<tr>
<td>Review Group ((\bar{D}_{rev}))</td>
<td>0.017</td>
<td>-0.234</td>
<td>-0.102</td>
<td>-0.210</td>
</tr>
<tr>
<td>SD (s_D)</td>
<td>0.212</td>
<td>0.292</td>
<td>0.279</td>
<td>0.248</td>
</tr>
<tr>
<td>n_2=</td>
<td>22</td>
<td>16</td>
<td>16</td>
<td>22</td>
</tr>
<tr>
<td>(s^2_{pooled})</td>
<td>0.052</td>
<td>0.084</td>
<td>0.062</td>
<td>0.077</td>
</tr>
<tr>
<td>(s_{D_1-D_2})</td>
<td>0.071</td>
<td>0.094</td>
<td>0.080</td>
<td>0.087</td>
</tr>
<tr>
<td>(t_{obs})</td>
<td>1.143</td>
<td>-0.512</td>
<td>0.748</td>
<td>0.526</td>
</tr>
<tr>
<td>(t_{cv}^{*})</td>
<td>-1.685</td>
<td>-1.687</td>
<td>-1.686</td>
<td>-1.685</td>
</tr>
<tr>
<td>df(^{'})</td>
<td>39</td>
<td>37</td>
<td>38</td>
<td>39</td>
</tr>
<tr>
<td>(p) (one-tailed)</td>
<td>.870</td>
<td>.306</td>
<td>.770</td>
<td>.699</td>
</tr>
<tr>
<td>(d)</td>
<td>0.506</td>
<td>0.169</td>
<td>0.236</td>
<td>0.164</td>
</tr>
<tr>
<td>Power</td>
<td>.462</td>
<td>.127</td>
<td>.176</td>
<td>.127</td>
</tr>
</tbody>
</table>

Note: \(\bar{D}\) = mean difference, Circ = Circulatory, Resp = Respiratory, Excr = Excretory, Nerv = Nervous, \(^{*}\)\(p\) (one-tailed)
\(\alpha=0.05\).
Figure 18. A comparison of cognitive improvement in Understanding for the Inspiration and the Review Worksheet/Discussion plenary activities. The mean difference between post-test and pre-test scores was calculated for each unit and graphed as percentage improvement.

Figure 19. A comparison of cognitive improvement in Knowledge for the Inspiration and the Review Worksheet/Discussion plenary activities. The mean difference between post-test and pre-test scores was calculated for each unit and graphed as percentage improvement.
Figure 20. A comparison of cognitive improvement in Higher Order Process for the Inspiration and the Review Worksheet/Discussion plenary activities. The mean difference between post-test and pre-test scores was calculated for each unit and graphed as percentage improvement.

**Summary of Other Findings**

The collection of pre- and post-test scores for all of the units allowed me to further analyze the RW/D plenary. The RW/D plenary activity produced statistically significant improvement in post-test scores for each unit observed. Analysis of the effects of the RW/D plenary activity on cognitive domains was completed. Each trial demonstrated improvement, ranging from 1.6%-23.8%, in Understanding; however, only four of the six trials indicated statistically-significant improvement. Statistically significant improvement in Knowledge, ranging from 10.4% to 21.0%, was indicated in five of the six trials. No improvement in knowledge was indicated for the Circulatory unit. Improvement, ranging from 2.9% - 23.4%, was indicated in five of the six trials for Higher Order Process; however, statistical significance was indicated in two of the trials.
The plenary effects on the cognitive domains were compared and analyzed. Directional independent t-tests determined no statistically significant differences between the cognitive domain outcomes for the two plenary activities. The Inspiration plenary produced larger improvements in Understanding and Knowledge, in three of four trials, and the Review Worksheet/Discussion plenary produced higher improvements in Higher Order Process, in three of four trials. Statistical significance was not indicated for the improvements; however, the low power values suggest that the trials could have been underpowered.

Chapter Summary

Chapter 4 identified the quantitative, qualitative, and other findings that will be used to answer the questions posed in Chapter 1. The quantitative findings will be used to answer the first five questions and the qualitative findings will be used to answer the sixth question in the next chapter. The other findings will support the quantitative and qualitative findings and will be used to support the conclusions or suggest further need for research in Chapter 6.

The quantitative findings indicated that a statistically significant improvement in overall post-test scores occurred in each trial. Compared to the Review Worksheet/Discussion plenary, the Inspiration plenary produced larger improvements; however, the improvements were not statistically significant. The analysis of the cognitive domains indicated that the Inspiration plenary produced statistically-significant improvements in Knowledge and Understanding in five of six trials, and statistically-significant improvement for Higher Order Process was determined in three of six trials. The levels of on-task behaviour and plenary completion were statistically higher in students participating in the Inspiration plenary compared to the Review Worksheet/Discussion plenary.
The qualitative findings were collected from student questionnaires and classroom observations. The qualitative findings indicated Group One and Group Two had the academic and computer abilities to be equally successful in Biology 12. The questionnaire indicated most students began studying two to three days prior to a test, preferred to study alone, and mainly relied on their class notes as a study aid. Additionally, 82.5% of the students suggested they preferred that the teacher supplied them with a list of concepts to know. Most students participated in 10 or more hours of extracurricular activities, or work, per week. The findings suggest the time spent in the class, two to three days prior to the unit test, should be used to focus and review.

In response to the plenary activity preference, most students indicated they preferred the Review Worksheet/Discussion plenary. They preferred to have the teacher tell them what they needed to know and believed the teacher would not tell them anything extra that they did not need to study. Students who preferred the Inspiration plenary appreciated the entertainment factor and liked being able to create something for themselves. Student responses indicated that they recognized the benefits of plenary activities. Fifty percent of students believed they put more effort into completing the Review Worksheet/Discussion plenary, whereas 22.5% of the students believed they used more effort to complete the Inspiration plenary. Inspiration was considered to allow for more self-expression compared to Review Worksheet Discussion plenaries, and 60% of the respondents indicated that they would use Inspiration again.

Personal observations during the plenary activities suggest that computer and software availability must be considered before using the Inspiration plenary. Copying and discussion occurred in both plenary activities. The Inspiration plenary promoted more on-
task discussion and plenary sharing, while the Review Worksheet/Discussion activity resulted in copying without discussion and off-task discussions.

The Other Findings section of Chapter 4 discussed the Review Worksheet/Discussion and compared the cognitive domains of the Inspiration and Review Worksheet/Discussion plenary activities. Statistically-significant improvement was calculated in the overall post-test scores. Analyses of the cognitive domains indicated statistically-significant improvement in four of the six trials for understanding and five of six trials for knowledge. Improvement in Higher Order Process was seen in five of six trials; however, statistically-significant improvement was only indicated in two of the six trials.

Cognitive domain comparison between the Inspiration and Review Worksheet/Discussion plenary indicated no statistically-significant difference was present in any of the cognitive domains. The Inspiration plenary produced higher improvements in Knowledge and Understanding in three of four trials. The Review Worksheet/Discussion plenary indicated higher improvement in Higher Order Process in three of the four trials.

Chapter 4 identified the findings. Chapter 5 will present the analysis of the findings and present the interpretation of these results, cross-referenced with the literature. The questions from Chapter 1 will be answered and the conclusions will be supported by the results and interpretations and presented in Chapter 6.
CHAPTER 5 – ANALYSIS OF THE FINDINGS

Chapter 1 introduced the relevance and use of plenary activities, described several types of plenary activities, introduced the problem and questions to be studied, outlined the hypotheses to be tested, identified limitations, and presented several key terms. Chapter 2 reviewed the professional literature. The current theory of knowledge construction was outlined, evidence to support the need to create proper plenary activities for the completion of lessons and units was presented, and the lack of research in the understanding of plenary use was identified. Chapter 2 also outlined the benefits and drawbacks of using graphic organizers and concept maps, identified the need for students to actively engage in learning, and outlined the possible benefits gained by using multimedia and computer technologies. Chapter 3 presented the research procedures, identified the research population and described the data collection and analysis procedures. Chapter 4 presented the research findings outlining the quantitative data, qualitative data, and extra findings that were obtained during the administration of the study. This chapter will analyze the findings and cross-reference the findings with the research literature in an attempt to better support or refute the hypotheses.

The analysis of the findings will occur in an order similar to the presentation of the findings. The first section will review the quantitative findings. The quantitative findings will be analyzed and cross-referenced with the literature, various qualitative findings, and observational notes. Interpretations of the quantitative findings will be used to analyze the first five questions presented in Chapter 1. The second section will present interpretations of the qualitative findings. The qualitative interpretations will review student preparation for the course, student study and test habits, and the students' perception of the two plenary activities used in the study. The third section will analyze the Other Findings that reviewed the effects of the use of Review Worksheets and Discussion on the cognitive domains as well
as the cognitive domain effects of Inspiration compared to The Review Worksheet/Discussion plenary.

Analysis of the Quantitative Findings

This section will involve cross-referencing the findings to the literature in an attempt to answer four of the questions identified in Chapter 1. Analysis of the Quantitative Findings will be conducted in a similar order presented in the Findings. Integration of some of the Other Findings will be used to support the complete analyses of the various questions. The first analysis will attempt to identify factors that could allow Inspiration to improve test scores. The second analysis will identify the factors that could allow the Review Worksheet/Discussion plenary to improve test scores and compare the improvements demonstrated by Inspiration to the improvements demonstrated after using the Review Worksheet/Discussion activity. The third analysis will identify factors that could be responsible for the improvement in each of the three cognitive domains: Understanding, Knowledge, and Higher Order Processes. The last quantitative analysis will compare time on-task behaviours and activity completion rates for the Inspiration and Review Worksheet/Discussion plenary activities.

Does the Use of Inspiration Improve Test Scores?

The pre-test/post-test comparisons for the six units indicated that statistically significant improvement occurred in each unit after administration of the Inspiration plenary. These findings were consistent with results presented by Boon et al. (2005). The improvement could be a result of the encoding benefits of creating a graphic organizer and/or the constructivist nature of the plenary.

Improvement in post-test assessment could have resulted from the internalization of knowledge that occurred because of the computer nature of the Inspiration program.
Inspiration is a computer-based mapping tool that could allow learners to focus on the learning and not the construction process. Bruillard and Baron (2000) and De Simone, Schmid, and McEwan (2001) suggested that this is a major advantage of computer-based mapping tools. Inspiration use could allow the learner the opportunity to collect, construct, re-order, and reorganize his/her thoughts in order to internalize the mental operations gained during various lessons and then create structures that could be externally represented. This process of internalization could have resulted in the improvement that occurred on the post-test assessment.

The constructivist nature of the Inspiration plenary activity could have improved knowledge assimilation that could have led to higher post-test scores. The Inspiration plenary involved completion of a graphic organizer with outline notes and discussion with peers and the instructor for clarification and guidance. The active nature of the Inspiration plenary in both the construction of the organizer and discussion of the concepts fulfills a number of constructivist criteria for developing knowledge. The Piagetian constructivists could claim that the Inspiration activity could provide the student a media to allow active assimilation of the operations developed through experience and the social transmission of the lessons/discussions before internal equilibration. Inspiration could then provide a physical externalization for displaying the structures and relations the learner had internally transformed or integrated into his/her higher understanding. The use of Inspiration could have improved knowledge assimilation that could be demonstrated by the higher post-test scores.

The Inspiration plenary, as a social constructivist activity, could have improved summative assessment scores because of the increased intrapersonal communication that may have occurred during the activity. Vygotsky and persons following his theories could suggest
the improvement in post-test scores was due to the social nature of the plenary and lessons within the unit. The introduction of the unit learning outcomes or implementation of the pre-test could identify the current development of the student and present the perceived future development levels, setting the zone of proximal development (Vygotsky, 1978). Social interaction during the plenary would occur through discussion and computer interaction. The interpersonal communication could then allow the learner to clarify operations and transform the interpersonal operations into intrapersonal processes such as logical memory, concepts, and understanding. This social constructivist process could result in statistically significant higher post-test scores displayed.

The post-test improvement could also be partially attributed to the individual and cognitive nature of Inspiration. The use of a plenary that can be molded to provide individual support for a variety of learners must be considered when choosing a closing activity as the zone of proximal development for each student could be different. Giles et al. (2006), and Ornstein (1994) suggested that educators should attempt to create activities that actively engage both higher and lower achieving learners so each may benefit and develop. Inspiration provides an activity that is designed by the student and therefore may appeal to the lower and higher achieving learners. The learner also controls the amount of social interaction with knowledgeable peers or adult experts. Peer and adult guidance could then be customized to meet the needs of students and provide the just in time support suggested by the participants in the De Simone et al. (2001) study. The ability of Inspiration to cognitively engage the student in a self-directed/individual focus could improve post-test assessment.

The improvement in summative assessment could be a result of the active thinking process that required students to review familiar knowledge and develop relationships. Mayer (2004) could present a non-constructivist approach and contend post-test improvement was
due to the cognitive focus of the Inspiration plenary that promotes learning by thinking. Inspiration engages the learner and promotes the selecting, organizing, and integration of knowledge essential to developing understanding. The active cognitive engagement of the learner in creating his/her graphic organizer could have resulted in higher post-test scores.

The self-directed and customizability of the Inspiration plenary could have met the needs of more learners and improved summative assessment scores. Inspiration could be customized to suit the learning style of the student. Leutner (2001) and Mayer (2001) suggested that both visualizers and verbalizers benefit from the use of multimedia technology. Inspiration invites the learner to use both visual and textual representations to identify the knowledge that has been assimilated. Users can also include links to various websites and/or audio/video files. Tactile learners may also benefit from the active input, re-ordering, and integration of nodes and links. Meeting the needs of learners in various fashions could ensure more internalization of mental operations into higher structures.

*Inspiration Compared to Review Worksheets/Discussion Activities*

The second question involved comparing the pre-test/post-test improvements of the Inspiration plenary to the Review Worksheet/Discussion (RW/D) plenary. The RW/D plenary involved completing assigned review worksheets while engaging in peer and teacher guidance. The RW/D plenary was completed over a two-day period. The activities on the second day included a review of the answers for the worksheets and a teacher led discussion interjected with student derived questions and a verbal exploration of concepts. The RW/D plenary results indicated statistically significant improvement for all six trials comparing post-test to pre-test results. These results were similar to the findings comparing post-test to pre-test results for the Inspiration plenary.
Four units were used to compare the pre-test/post test improvements demonstrated using the two plenary activities. The units used for direct comparison included the: Circulatory, Respiratory, Excretory, and Nervous Systems. The findings demonstrated statistically significant improvement in post-test scores for both the Inspiration and RW/D plenary activities. Comparative analysis of the results suggested that the Inspiration plenary produced higher average improvements of 0.1%, 2.2%, 4.0%, and 1.4%, respectively, but the differences in improvement were not considered to be statistically significant. A power analysis suggested the trials were underpowered.

The lack of definitive improvement in comparing pre-test/post-test results between the two plenary activities may indicate that the type of activity used is not as important as the content taught. Sánchez and Válcarcel (1999) studied unit development and concluded that activity choice was complimentary to unit development but was not of primary importance. Harris (2007) also contended that using a variety of techniques benefited students as it allowed for variation in formative assessment and met the needs of the individual more often. These studies could indicate that different activities could produce similar improvements in assessment.

The Inspiration and Review Worksheet/Discussion plenary activities could have produced equal improvement in summative assessment as both plenary activities involved the active engagement of the learner in constructing knowledge. Mayer (2004) and Semb and Ellis (1994) contended that learning by thinking and the active involvement of learners in the learning process would promote learning and retention in all learners. The results of engaging the learner in the assimilation of knowledge could produce activities that were equally efficient at preparing the students to meet the unit requirements. The benefits of using Inspiration were identified in the analysis of the first question. The RW/D plenary, like the
Inspiration plenary, fulfilled a number of mastery learning and constructivist criteria that could have produced equal improvement in summative assessment.

The Inspiration and Review Worksheet/Discussion activities utilized mastery learning techniques and encouraged repeated formative assessment that could have resulted in improved summative scores. Students participating in the RW/D plenary were encouraged to use texts, notes, and discussion to complete the review worksheets. Answers to the worksheets were attained through the re-examination of previously covered material along with peer and teacher guidance/discussion before the main class discussion. Kulik, Kulik and Bangert-Drowns (1990) and Peladeau, Forget, and Gagné (2003) reported that using mastery techniques would produce higher examination scores. Both plenary activities encouraged the learner to attain feedback as he/she progressed through, and completed, the plenary activity. This produced repeated formative assessment/feedback opportunities and could be a factor in the higher achievement displayed by the improved pre-test/post-test differences attained after both plenary activities.

The constructivist nature of the Review Worksheet/Discussion plenary could have resulted in the improved post-test achievement demonstrated by the students. The RW/D plenary may be characterized as a constructivist approach to learning as it allowed the learner to review the operations that he/she had or had not internalized. Active engagement in the worksheet completion provided a means of externalizing what was known. The discussions that took place during and after the review worksheet completion could provide the social interaction that Vygotsky (1978) claimed is necessary to transform the interpersonal to the intrapersonal. The knowledge assimilation could then result in the higher post-test scores demonstrated in the study. As well the social transmission of knowledge during the plenary coupled with the experiencing may have provided the learner with enough knowledge
development to equilibrate and internalize the operations into structures as suggested by Piaget (1964). The increased knowledge assimilation and equilibration resulting from the constructivist nature of the Review Worksheet/Discussion plenary could have improved student post-test achievement.

*Inspiration Effects on the Cognitive Domains*

Improvement in summative assessment scores could have been a result of statistically significant improvements in one or more cognitive domains and non-significant gains or losses in one or more cognitive areas. Data was collected to identify the effect of the Inspiration plenary on the cognitive domains. The results of each cognitive domain finding will be analyzed separately.

*Understanding*

Improvement in Understanding was displayed in each of the six trials and statistical significance in improvement was seen in five of the six trials. The Nervous System unit had less than significant improvements; however, the post-test scores displayed an average improvement of 5.2% compared to the pre-test scores. A power analysis suggested that the Nervous System trial could have been underpowered.

The Inspiration plenary improved understanding as a result of improved conceptual relationships and comprehension that could have occurred during the plenary. The improvement in Understanding was consistent with the findings of Katayama and Robinson (2000), Robinson and Kiewra (1995), and Boon et al. (2005). The Understanding cognitive domain could be equivalent to the application domain mentioned in the Katayama and Robinson studies, and to the comprehension domain mentioned by Boon et al. The Katayama and Robinson studies concluded that study using graphic organizers produced improvement in application as well as conceptual
relations. The Boon et al. study concluded that using Inspiration produced improvement in comprehension. The improvement in Understanding could be due to improvements in comprehension and building conceptual relationships that could have developed as the student created his/her graphic organizer.

The improvement in Understanding could have occurred as a result of each student engaging in an active encoding process that allowed him/her to review, organize and reflect upon familiar content. The Robinson and Kiewra (1995) study contained limitations that were addressed in my study. Robinson and Kiewra limited the time used to read and study and did not allow the learner to actively engage in the construction of study material. Participants in the De Simone, Schmid, and McEwan (2001) study indicated that content familiarity was necessary when completing a concept map. In my study the information to be acquired was previously learned and the plenary was designed to select, collect, organize, integrate, and transform practical knowledge and operations into structures and higher understanding of the concepts. Participation in the plenary activity provided extra time to reflect on and organize information and could have placed less pressure on the students resulting in better post-test scores. This would be consistent with the decreased percentage of students feeling rushed in the Robinson and Kiewra (1995) study. The active engagement in the plenary activity, encoding of information, reflection on familiar content, and time to organize information could have provided the opportunity to improve Understanding.

Improvement in Understanding could have been a result of the encoding of practical knowledge and concept linking that occurred during the creation of the graphic organizer. The active creation of the graphic organizers could have provided the encoding benefits touted by Katayama and Robinson (2000), and used by Boon et al. (2005). The Inspiration plenary actively engages students in an attempt to improve knowledge construction. The
Inspiration plenary could provide improvement in understanding by engaging the students in transformation of their practical knowledge and internalized operations. The encoding process could allow for equilibration of operations and structures and this could have been responsible for the demonstrated improvement in the assessment of Understanding.

Knowledge

Statistically-significant improvement in Knowledge was observed in five of the six trials. The pre-test/post-test difference for the Circulatory Unit did not demonstrate improvement nor were the results statistically significant. A power analysis of the Circulatory System trial indicated that it could have been underpowered.

Improvement in Knowledge could have been the result of repeated review, analysis, and discussion of the content material. Improvement in factual knowledge was consistent with the findings presented by Robinson and Kiewra (1995) and Boon et al. (2005). The repeated review, analysis, and discussion that occurred during the creation of the graphic organizer could have produced the necessary means of improving practical knowledge and enhancing memory. This process could then translate into higher Knowledge post-test scores.

The Knowledge results of the Circulatory Unit students did not improve from the pre-test to the post-test scores. The lack of improvement was not statistically significant and indicates a need for further analysis. The circulatory unit is the largest of the units observed and includes conceptual knowledge that could be divided into three units: the Cardiovascular System, the Hematic system, and the Lymphatic system. The large size of the unit coupled with the limited time allotted to cover the unit could have made it difficult to assimilate all of the factual knowledge required. The participants in the De Simone et al. (2001) and Robinson and Kiewra (1995) studies indicated that limited time was a factor that could adversely affect knowledge assimilation and retention. The large size of the Circulatory unit, diverse topic
content, and limited time to cover the unit could have resulted in statistically non-significant improvement in the summative assessment of Knowledge.

**Higher Order Process**

Improvement in Higher Order Process was observed in five of the six trials. The Circulatory Unit did not show improvement. Statistical significance in improvement was demonstrated in three of the six trials, including: DNA/Group 2, Respiratory, and Nervous System. The DNA/Group 1, Circulatory, and Excretory trials displayed less than significant results. An analysis of the not significant trials indicated that the trials could be underpowered.

Higher Order Process scores demonstrated mixed results in improvement, possibly due to the inability of the student to clearly transform operations into structures. The mixed results appear to be consistent with the De Simone et al. (2001) and Robinson and Kiewra (1995) studies. The participants in the De Simone et al. study indicated that they thought concept mapping simplified content and led to higher understanding; however, the researchers in the study analyzed the concept maps produced and suggested that the participants failed to support the integrative arguments. The inability to externalize internalized understanding could suggest the lack of structural clarity or the lack of operation transformation. The lack of structural clarity could result in mixed results in Higher Order Process assessment scores.

The constructive process of completing the Inspiration plenary could provide the means for developing Higher Order Process abilities but a lack of social communication or the presentation of material beyond the current understanding of the students could result in mixed results in higher order process improvement. Vygotsky (1978) could argue that the limited amount of group discussion and formal sharing during the Inspiration activity may
have hindered the transformation of some operations into higher order processes. The limited interpersonal communication that occurred during the activity would have significantly decreased the intrapersonal action needed to completely internalize and produce the knowledge structures. As well, it is possible that some of the Higher Order Process concepts were beyond the abilities of the students at this time but with further development and learning those processes could be reached in the future. The presentation of material beyond the development level of the student or the lack of social communication could have resulted in the inconsistent improvement in Higher Order Process scores.

The inconsistent improvement in Higher Order Process scores could be due to a lack of structural development and equilibration. Piaget (1964) and constructivists following his theories could argue that development occurred in the construction of operations and practical knowledge but equilibration was not complete. The lack of structure development could be due to a lack of learner experience or due to a lack of time to complete equilibration. In both cases, if structure formation does not occur the appropriate response cannot be triggered, resulting in lower Higher Order Process scores on the post-test assessments.

Comparing Time On-task Behaviour and Activity Completion for Inspiration and Review Worksheet/Discussion Activities

On-task behaviour and plenary completion/submission rates were statistically significantly better for those students partaking in the Inspiration plenary compared to those students partaking in the RW/D plenary. The findings also indicated that students participating in the Inspiration plenary demonstrated consistent on-task behaviour over the observed timeframe whereas student behaviour for RW/D decreased with time. The observed results could have been due to the novel nature of using the computer and Inspiration
program, the active engagement while using the program, or the student acknowledgement of
the limited access time to the Inspiration program.

The increase in on-task behaviour during the Inspiration plenary could be due to the
entertaining student-centred approach to review that the Inspiration plenary activity provided.
Sandholtz, Ringstaff, and Dwyer (1997) reported that a student would display increased
initiative, enthusiasm, greater on-task behaviour, and an increase in the student taking
responsibility for his/her own learning if he/she were presented with a student-centred
learning approach. Participants in the DeSimone et al. (2001) and Boon et al. (2005) studies
indicated that they liked Inspiration and felt that it was an effective tool. The students also
felt Inspiration was enjoyable, encouraged creativity and collaboration, was flexible,
transportable, and easy to edit. Students in the Boon et al. (2005) study indicated they
believed they were more motivated during the use of Inspiration. Several participants of my
study expressed similar sentiments suggesting they believed Inspiration offered an
entertainment/fun factor and that Inspiration provided a means of creating and organizing
his/her knowledge in an individual manner. The increased focus observed during the
Inspiration plenary could be explained by these factors.

The increased focus and completion/submission rates demonstrated for the Inspiration
plenary may also be due to the limited time available to access the Inspiration program and
the computer labs. Only one student in my study reported he/she had access to the Inspiration
program outside of school time. This factor could have been a determining factor in the
submission of completed plenary assignments as the students were able to discuss and focus
on task completion without the intervention of outside sources or the perception that he/she
could complete the assignment during his/her own time. The acknowledgement of time
limitations and computer availability could have improved student focus and on-task behaviour.

Limited access to Inspiration and computers could have lead to increased attentiveness and process adaptation during the plenary. Several students found it difficult to complete the Inspiration plenary in the allotted time resulting in the need to use time outside the allotted class time. Personal observations indicated that students adapted a process to prevent the use of time outside of the classroom. Adaptation occurred as students began to work together, each working on a section then discussing their section as they collected the Inspiration into one document. Individuals could then change the document if they chose to do so. This modification of behaviours to complete a task would be similar to the evolutionary development of knowledge suggested by Piaget (1964) and the social interpersonal communication presented by Vygotsky (1978) in their respective writings.

Inspiration plenary activities were collected, assessed for completion, and used for grading purposes at the end of the plenary sessions. The students were given two days to complete each plenary activity. Most of the students submitted completed concept maps electronically at the end of the second class and made hard copies of their graphic organizers/outlines for themselves. The student concept maps were reviewed during construction process and teacher and peer input was provided as requested. The completed concept maps were not marked and returned before the post-test. This may have resulted in the overlooking of some conceptual errors that could have lead to lower post-test scores.

The Review Worksheet/Discussion (RW/D) plenary activities concluded with the completed review assignment being marked in class, submitted for mark recording, and returned before the end of the day. Late submission of some worksheets did occur and personal observations indicated that students were more likely to copy other students' work
or provide a minimal amount of work and effort when trying to complete the review worksheets. The lack of on-task behaviour, initiative, and motivation displayed by students during the RW/D plenary could have directly affected the completion/submission of the review worksheets. The lower completion/submission rates and on-task focus of the students displayed during the RW/D plenary could explain the differences in achievement between pre-test/ post-test scores when comparing the Inspiration and RW/D plenary activities. The pre-test/ post-test differences were not shown to be statistically significant however the higher improvement values indicated by the Inspiration results in four out of four trials may suggest a need for further study.

The completion/submission of the Inspiration plenary and lack of completion/submission of the review worksheets is interesting as copying and sharing of ideas occurred during both activities. The students were given a chance to physically complete all of the worksheets during the discussion but many failed to do so. Further study could be needed to determine whether the higher completion/submission rates seen in the Inspiration plenary was due to the ability of students to more easily copy and paste information from one document to another than the physical copying that occurs on the review worksheets or due to other non-declared reasons.

The improvement in post-test scores after the Review Worksheet/Discussion plenary could be due to the increased social communication that occurred during the discussion period of the plenary activity. On-task behaviour was determined during my study in order to address the limitation declared by Robinson and Kiewra (1995) in their study. In my study, on-task behaviour was only determined during the construction of the graphic organizers and the completion of the review worksheets. There was no systematic collection of on-task behaviour during the discussion portion of the RW/D plenary. My personal observations
suggest that the students were attentive and actively involved in the exchange of information and the discussions that occurred. This active involvement could have provided the necessary social interpersonal communication advocated for by social constructivists. The interpersonal communication could have led to the intrapersonal communication necessary to assimilate the concepts. The discussion could have allowed internalization of the knowledge even though the written externalization was not submitted. The increased social communication during the discussion period of the Review Worksheet/Discussion plenary could have improved post-test assessment scores even though plenary submissions were not presented.

*Summary of the Analysis of the Quantitative Findings*

The use of Inspiration, as a plenary activity, allowed the individual learners to collect, construct, re-order, and reorganize their thoughts in order to internalize the mental operations. Inspiration actively engaged the learner in a manner consistent with constructivist methodologies and as such, the learner becomes engaged in the learning process and actively seeks to internalize concepts. The active creation of operations could be a result of equilibration, intra-personalization of social communications, or the individual and cognitive nature of the plenary. The outcome of the increased cognition and assimilation of knowledge was statistically significant improvement in post-test scores.

The Inspiration plenary findings and the Review Worksheet/Discussion plenary findings indicated that the RW/D plenary were both able to produce statistically significant improvements on post-test scores. Comparative Analysis indicated that no statistically significant difference in pre-test/post-test improvements occurred, supporting Sánchez and Válcarcel (1999) contention that the choice of activity was not of primary importance and Harris’ (2007) contention that a variety of techniques helped attend the needs of more learners more often.
The two plenary types used in my study contained a variety of attributes consistent with mastery and constructivist theories: including active engagement, repeated formative assessment, knowledge construction, and social interaction. The use of either plenary could then result in the active assimilation of knowledge operations into higher structures. The internalization of the concepts could then result in improvement displayed on the summative assessments.

The displayed effects of Inspiration on the cognitive domains were consistent with the findings of others (De Simone, Schmid, & McEwan, 2001; Katayama & Robinson, 2000; Robinson & Kiewra, 1995; Boon et al., 2005). The active development of the graphic organizers and outlines combined with formative interventions, and discussion could have increased the likelihood of the learners assimilating and internalizing concepts. The active engagement could lead to the improvement displayed in Understanding (application) and Knowledge (Factual) attainment. The mixed results obtained in Higher Order Process were consistent with the findings of De Simone et al. (2001) and Robinson and Kiewra (1995) and could have been a result of the limited opportunity for discussion. The limited interpersonal discussion may have deterred the intrapersonal communication needed to completely develop the higher mental processes.

The final quantitative analysis compared student on-task behaviour and activity completion for the two plenary types. Learners participating in the Inspiration plenary demonstrated statistically significantly better on-task behaviour and activity completion consistent with the findings of Sandholtz, Ringstaff, and Dwyer (1997). Increased on-task behaviour and completion could have been: a result of an increased sense of entertainment and self-direction, from an acknowledgement of the limited time available with the
Inspiration program, or from the adaptable nature of the students during the completion of the Inspiration plenary.

On-task behaviour and completion rates could have factored into the non-statistically significant improvements demonstrated by the Inspiration plenary compared to the RW/D plenary. Attentional data were not recorded during the discussions. Personal observations suggested that the students were attentive and focused. The increased focus during the discussions could have provided the social interpersonal communication that could have resulted in intrapersonal communication and the development of higher mental processes.

Analysis of the Qualitative Findings

This section will cross-reference the questionnaire findings with the Observational Note Findings and the literature. The section will be presented in two parts. The first part will look at student academic and technical preparation. The second part will analyze student declared study and test preparation habits integrated with the students’ perceptions and assessment of the two review activities.

Student Preparation

A post-hoc survey of the courses completed by the students was performed to ascertain the academic and comprehensive abilities of students. The variety of course combinations indicated that the students would be capable of completing Biology 12. The variety of completed courses suggest that the students did not share a common mental development level and that each student could have his/her own zone of proximal development which could vary depending upon the unit being covered. Students with a strong chemistry background could have less difficulty with chemical processes but could find the anatomical and physiological process more difficult if they had not completed the Biology 11 course. Lesson and plenary development were varied and could have
accommodated the individual abilities, interests, needs, and learning styles of the students within the groups. The use of a variety of strategies was consistent with the contentions proposed by Harris (2007) in his study.

The survey of student familiarity and comfort/confidence in computer use suggested that each participant in my study believed he/she possessed average or above average computer ability. The majority of participants also indicated they had previously used/created graphic organizers or concept webs and more than 50% of the students had been introduced to Inspiration. Familiarity with graphic organizers was not considered in the De Simone, Schmid, and McEwen (2001) study nor the Robinson and Kiewra (2000) study. Training in web design and the use of Inspiration was provided to the participants of the De Simone et al. (2001) study; however, the participants in the De Simone, Schmid, and McEwen (2001) study indicated a need for more training and feedback in the use of web design and Inspiration. Inspiration training was introduced, practiced and good concept map design was discussed in my study in order to compensate for this perceived need. As well, peer and teacher mentoring, just in time feedback on Inspiration use, and good gestalt principles were available throughout my study. This expert guidance could have provided the motivation to complete the plenary as well as provide the social interaction necessary to construct the operations needed to be developed before internalization and knowledge structure formation occurred.

The more student-centred approach of the Inspiration plenary could have resulted in the students displaying more initiative and increased enthusiasm while completing the Inspiration plenary. The construction of the graphic organizers and completion of the review worksheets depended upon the student’s own personal motivation and ability to guide his/her own learning. The majority of students indicated they believed they were capable of directing
their own learning. The findings indicated six students believed they were incapable of
directing their own learning. Analysis of the findings indicated that one student did not
complete any plenary activities, four students completed all of the plenary activities and one
completed the two Inspiration plenary activities for which they were present but failed to
complete/submit the RW/D plenary activities. Sandholtz, Ringstaff, and Dwyer (1997) could
contend that the students demonstrated increased initiative, enthusiasm, and on-task
behaviour and were more likely to complete the Inspiration plenary as the Inspiration plenary
was a more student-centred plenary approach compared to the RW/D plenary.

Student Study and Test Preparation Habits and Review Activity Assessment

The majority of participants indicated that they preferred to study on their own
(67.5%), study their notes (90%), and prefer having teachers provide a written list of things
to know (80%) or learning outcomes prior to the test. The questionnaire findings also
indicated that the majority of students (67.5%) preferred the teacher-guided Review
Worksheet/Discussion plenary to the multimedia related Inspiration plenary. These findings
were contrary to the findings of Jonassen (2001) who suggested learners preferred the use of
multimedia instructional material. Students indicated they believed Inspiration was engaging
but cited a preference for the RW/D plenary, as they believed the teacher could answer their
questions and would impart only the needed information.

Student comments suggested that they believed the review worksheets and
discussions were beneficial as the worksheets forced the students to repeat and review, while
the discussions allowed students to explore concepts together and the teacher could provide
the answers to cover all of the learning. The active nature of compiling information, focusing
on what is important, and what has been learned is consistent with Wintergill’s (2000)
description of the key components of a plenary activity. The social discussion occurring
within the RW/D plenary could supplement the knowledge necessary to construct the intrapersonal processes that could lead to higher/better concept understanding.

Students who chose Inspiration as the preferred plenary method suggested that Inspiration was engaging and allowed them to actively construct information in an attempt to assimilate knowledge. Questionnaire responses, from my students, were consistent with the participants of the De Simone, Schmid, and McEwan (2000) study and the Boon et al. (2005) study. The participants of my study who preferred Inspiration appreciated having the ability to review their notes and organize the material as they felt. Inspiration was thought to be entertaining, allowed the student to construct his/her own concept map, and engage the student in discussions with peers, the teacher, or through the Internet. As well, the majority of participants (45%) believed that the Inspiration plenary allowed them more opportunity for self-expression than the RW/D plenary. The ability to direct and regulate one’s own learning and the engagement of the learner in the active construction and transformation of knowledge is consistent with constructivist methodologies presented by Piaget (1964) and Vygotsky (1978).

Several student responses to the questionnaire questioned the effectiveness of the Inspiration plenary. A few participants cited several negative aspects of the use of multimedia techniques consistent with the De Simone et al. (2001), Jonassen (2001), and Sandholtz et al. (1997) studies. The prominent negatively-focused comment indicated the students had a feeling of being rushed to complete the material in the time provided. Several other negative aspects of multimedia use not previously mentioned by De Simone et al. (2001), Jonassen (2001), and Sandholtz et al. (1997) were listed in the qualitative responses of the participants of my study. Several students suggested that they did not have confidence in their own abilities to determine the important information and believed that they would
miss something. One student indicated he/she believed that excessive copying and pasting of material was performed and the copy/paste process would prevent the internalization of knowledge, and another student suggested that he/she never revisited his/her plenary once the assignment was complete. These findings may suggest a limitation on the effectiveness of the plenary; however, it could be argued that the engagement in the activity itself could provide the necessary review to transform operations into structures.

Many students indicated that their available time to study outside of class was limited. The majority of the students (82.5%) indicated that they participated in work or extra-curricular events that utilized 10 or more hours per week and 37.5% indicated they participated in work or extra-curricular events that utilized 20 or more hours per week. These findings could suggest class time is needed to be used in order to assure that review occurred.

The necessity for the inclusion of a plenary activity at the end of a unit could also be supported by the findings indicating the majority of participants (87.5%) studied more in the two to three days prior to a test rather than consistently through the unit. The plenary activity could provide the extra time to actively review and revisit material and could increase retention and understanding as contended by Rogers (2007) in his study. Harris (2007) also suggested that review was needed in order to assess what was learned and what students still needed to learn. The use of class time at the end of a unit and prior to the summative could provide the extra time to partake in a plenary when the student is more inclined to review.

The final question of section three on the questionnaire asked students to indicate if they would consider using Inspiration as a plenary activity in the future. Sixty percent of the participants indicated that they would use Inspiration again. This declaration may appear counter to findings as the majority preferred RW/D; however, the finding could also suggest that the individual students recognize the benefit of Inspiration as their marks did improve.
The finding that the majority of students in my study would use Inspiration again was consistent with the presented findings from the De Simone et al. (2001) study. In the De Simone et al. study the participants suggested that they would use Inspiration based concept mapping as an organizational to guide creation, organize notes, plan and structure tasks. The participants in my study did not provide any reasoning his/her decision to use Inspiration in the future.

Summary of the Analysis of the Qualitative Findings

The student findings data indicated that the students had the academic and technical abilities to be successful in Biology 12 but the individual student achievements were quite varied suggesting a wide range of mental development levels and various zones of proximal development that would need to be met during the course. Training for the use of Inspiration and web design was completed and students received the just in time feedback that participants in the De Simone et al. (2001) study indicated was necessary.

Analysis of the students’ perceptions of their ability to direct their own learning appeared to contradict the findings. Four students who suggested they could not direct their own learning did complete all of the plenary activities and one student completed the Inspiration plenary but not the RW/D plenary. Sandholtz, Ringstaff, and Dwyer (1997) contended that students were more receptive of a student-centred activity such as Inspiration rather than the more teacher-directed approach using the review worksheets.

The questionnaire was also designed to determine student study and test preparation habits as well as assess the plenary activities. Plenary inclusion at the end of a unit could be supported by the findings that most students have limited time available outside of the classroom and mainly review for summative assessments in the two to three days just prior to the assessment. The findings suggest that participants in my study prefer to: study on their
own, study by reviewing their notes, have the instructor provide a list of test objectives prior to the test, and preferred the teacher-guided Review Worksheet/Discussion plenary over the Inspiration plenary.

Participant rationale provided to support the use of the RW/D plenary included: opportunity to actively engage in the learning by repeatedly reading and reviewing material, confidence that the teacher would supply the student with the needed information, and the active use of discussion. Participants who preferred Inspiration believed that the plenary was able to provide an individual learning experience that was entertaining and actively engaged the learner in the production of a personalized graphic organizer. Inspiration also provided an opportunity for self-expression and social discussion. Several negative aspects of using Inspiration were cited in the Participant responses. These negatives included: an inability to determine what information was important, the possibility that students may miss something, the use of copy and paste techniques, and the lack of use of the finished graphic organizer. The majority of students stated that they would be willing to use Inspiration in the future.

Analysis of the Other Findings

A complete analysis of the improvements in tests scores produced by the Review Worksheet/Discussion plenary was completed in the first section of this chapter. This section will analyze the improvements in the cognitive domains attained by using the Review Worksheet/Discussion plenary. The section will also compare the effects of Inspiration and Review Worksheet/Discussion on the cognitive domains.

Effects of the Review Worksheet/Discussion Plenary on the Cognitive Domains

Improvement in summative assessment scores could have been a result of statistically significant improvements in one or more cognitive domains and non-significant gains or losses in one or more cognitive areas. Data was collected to identify the effect of the Review
Worksheet/Discussion plenary on the cognitive domains. The results of the Understanding and Knowledge findings will be analyzed together and the Higher Order Process analysis will occur separately.

**Understanding and Knowledge**

Improvement in Understanding was seen in all six of the trials for the Review Worksheet/Discussion (RW/D) plenary. Statistically-significant improvement was demonstrated in four out of six trials including the two Digestion trials, the Circulatory trial, and the Respiratory trial. Statistically significant improvement for Understanding was not demonstrated by the findings for the Excretion or Nervous System units. A power analysis indicated that the Excretion and Nervous System trials could have been underpowered.

Statistically-significant improvement for Knowledge was demonstrated in five of six trials. The Circulatory System trial did not demonstrate improvement. A power analysis indicated that the trial could have been underpowered.

The Review Worksheet/Discussion plenary activity improved Understanding and Knowledge in most units. The Review Worksheet/Discussion plenary fulfilled a number of constructivist parameters that allowed students to become actively engaged in his/her knowledge development and learning. The review process could have allowed students to reconstruct the external activities internally in order to develop the various operations and structures that could then be reiterated on the post-test. Equilibration (Piaget, 1964) or intrapersonalization (Vygotsky, 1978) could have occurred as the learner actively engaged in plenary completion and discussion. The increased internal assimilation of information could have led to the improved Knowledge and Understanding assessment scores.

The Review Worksheet/Discussion plenary could have improved Understanding and Knowledge by encouraging the student to repeatedly review and analyze the content material.
The use of review worksheets and discussion could be considered a form of mastery learning used as a final attempt to increase Understanding and Knowledge before the summative assessment. If this were true then the post-test improvements would have been consistent with the findings of the Kulik, Kulik, and Bangert-Drowns (1990) and Péladeau, Forget, and Gagné (2003) studies. They suggested that mastery learning techniques provided higher examination scores and reduced variation. The mastery-learning style provided by the Review Worksheet/Discussion plenary could have improved Understanding and Knowledge.

The improvement in Knowledge and Understanding could also have been due to the structured approach of the review worksheets. The strong guidance coupled with prior learning could have provided each student with an effective instructional approach as declared by Kirschner, Sweller, and Clark (2006) in their study. The worksheets were designed to guide the student through the learning outcomes and could have ensured the attainment of Knowledge and Understanding.

*Higher Order Process*

Improvement in Higher Order Process was demonstrated in five of the six trials; however, statistically significant improvement was only demonstrated in the Respiratory and Nervous System trials. The Circulatory system trial did not show improvement in the Higher Order Process cognitive domain. A power analysis of the non-statistically significant findings suggested that the trials were underpowered.

The improvement in Higher Order Process may be a direct result of the revisiting of the learning outcomes through active review or may have been due to the extra discussion that occurred throughout the plenary. Several students indicated that he/she believed the discussions were beneficial and that listening to the teacher provided information that was necessary. Vygotsky (1978) could suggest that the discussion provided the social
communication necessary to transform knowledge to the intra-personal. The increased intrapersonal communication could have resulted in improved Higher Order Process scores.

Comparisons of the Effects of the Plenary Activities on Cognitive Domains

Analysis of the findings indicated that no statistically-significant differences in improvement existed between the Inspiration and Review Worksheet/Discussion plenary activities. A comparative analysis of the cognitive domains indicated that there was no statistically significant difference in improvement between the Inspiration and Review Worksheet/Discussion plenary in any of the cognitive domains. However, the Inspiration plenary produced more improvement in Understanding and Knowledge in three of four trials, while the RW/D produced more improvement in Higher Order Process in three out of four trials. A power analysis indicated the statistical tests were underpowered.

The findings were not statistically significantly different but may lead to speculation as to the benefits of each plenary type. Semb and Ellis (1994) suggested that instructional strategies that engage the student could result in different memories and retention in the learner. The use of constructivist activities with different approaches could provide advantages in different cognitive areas. The Inspiration plenary allowed the learner to interpret, organize, and construct external representations of his/her internalized information which led to increased knowledge and understanding similar to the findings of the Katayama and Robinson (2000) and Robinson and Kiewra (1995) studies. The Review Worksheet/Discussion plenary provided an opportunity for the learner to assess and build his/her current operational base and to improve his/her higher mental processing through the larger discussion component. The interpersonal communication presented in the RW/D plenary involved more students. The increased social component could be the stimulus Vygotsky (1978) claimed was needed to provide the intrapersonal transformation necessary
for the development of higher mental processes. The development of relationships during the construction of the graphic organizer could better improve Knowledge and Understanding while the increased social communication of the Review Worksheet/Discussion plenary could better improve Higher Order Process.

Summary of the Analysis of the Other Findings

The Review Worksheet/Discussion plenary demonstrated statistically significant improvement in the Knowledge and Understanding cognitive domains in most trials. Improvement in Higher Order Process was demonstrated but only two trials showed statistical significance. The RW/D plenary may be considered a constructivist activity that actively engages students in an attempt to assimilate previously developed knowledge operations into internal structures. The interpersonal social communication displayed during the discussions is a component that Vygotsky (1978) could argue is necessary to allow for intrapersonal communication before higher mental processes can develop.

A comparison of the cognitive domain development between the two plenary activities showed no statistically-significant difference in the ability to improve post-test scores for Understanding, Knowledge, or Higher Order Process. The Inspiration and Review Worksheet/Discussion plenary activities could both be considered constructivist activities. It could also be suggested that the Inspiration plenary provided a greater opportunity for students to interpret, organize, and construct knowledge leading to an improvement in Knowledge and Understanding, while the discussion component of the RW/D plenary provided more interpersonal communication that could have lead to the assimilation of operations into higher mental activity and an improvement in Higher Order Process.
Chapter Summary

The quantitative, qualitative and other findings were analyzed and the interpretations were presented in Chapter 5. Inspiration could be considered to be a constructivist activity that could improve post-test scores by engaging students in the construction, organization, and discussion of concepts. Participants found Inspiration to be a student-directed activity that was engaging, entertaining, and allowed for self-expression during the construction of the graphic organizers. The high rate of on-task behaviour and activity completion, as well as the active and individual nature of Inspiration could lead to improved equilibration and internalization of operations and structures.

The Review Worksheet/Discussion plenary could also be thought of as a constructivist activity or as a mastery activity. The majority of participants indicated they preferred the RW/D plenary as it provided an opportunity to repeatedly read and review and the discussion allowed them to explore concepts they knew and/or did not know with assurance that the teacher could give them the correct answers. The active nature of the RW/D plenary allowed the students to assimilate the practical knowledge and operations that he/she had previously acquired into structures and higher mental processes.

A comparison of the two plenary activities indicated that each had its own strengths and weaknesses. The Inspiration plenary showed more improvement when comparing pre-test to post-test scores but the results were not statistically significant. Students participating in the Inspiration plenary demonstrated greater on-task behaviour and plenary completion/submission rates which could have contributed to the improvement in summative assessment. Comparison of the cognitive domains suggested that the Inspiration plenary may better improve Understanding and Knowledge, while the RW/D plenary could better improve Higher Order Process.
Chapter 5 presented an interpretation of the findings cross-referenced with the literature. The questions from Chapter 1 will be answered in Chapter 6. The conclusions presented in Chapter 6 will be supported by the findings and the interpretations.
CHAPTER 6 – CONCLUSION

Chapter 1 introduced the need for plenary use, outlined various plenary types, identified the problem and questions to be studied, stated the hypothesis to be tested, described several limitations, and identified various key terms. Chapter 2 presented a brief overview of the professional literature relevant to the construction of knowledge and practice of learning. Chapter 2 also outlined the present perception toward the inclusion of plenary activities, the lack of study involved with plenary use, the use of graphic organizers in learning, and the role of technology and multimedia in knowledge acquisition. Chapter 3 described the research populations, research procedures, and the data collection and analysis procedures. Chapter 4 presented the quantitative, qualitative, and extra research findings collected during the implementation of the research procedures. Chapter 5 analyzed the data and proposed several interpretations of the results that identify the rationale for the conclusions to answer the research questions presented in Chapter 1. This chapter will present the conclusions and will propose rational explanations for the two primary and four secondary questions presented in Chapter 1.

Conclusions to the Problems and Questions

This section will be used to present conclusions and explanations for the two major problems and four minor questions that were identified in Chapter 1. The conclusions will be presented in the order in which the problems and questions were presented.

Problem 1: To what extent, does the use of Inspiration, as a plenary activity, improve test scores in Biology 12?

The data from the six pre-test/post-test trials suggest that using Inspiration as a plenary activity does improve post-test scores. The results for each of the six trials were statistically significant. The post-test results displayed improvements between 6.7% and
23.6%. These results corresponded to effect sizes ranging from 0.457 to 1.430. The indicated improvement was consistent with the findings presented by Boon et al. (2005) in his study.

A variety of factors could be responsible for the improved post-test scores demonstrated by the participants in the Inspiration plenary. Factors that could have improved post-test scores include: the active engagement of the student in a multimedia activity, the constructive nature of the activity, the individualization and customizability of the plenary, the promotion of learning by thinking (Mayer, 2001), the increased time-on-task behaviour, and the increased completion/submission rates of the Inspiration plenary. These factors may have individually or collectively contributed to the improvement in knowledge acquisition and conceptual development.

The computer nature of the Inspiration program allowed students to benefit from the collection, creation, and organization of knowledge structures while simultaneously benefiting from the encoding benefits inherent with creating a graphical organizer. The customizable and individual focus of the Inspiration plenary could have allowed the needs of a variety of students, high and low achievers, as well as visualizers and verbalizers, to be met (Giles et al., 2006; Leutner, 2001; Mayer, 2001; Mayer, 2004; Ornstein, 1994). The plenary actively and cognitively engaged the student and allowed him/her to internalize operations and conceptual knowledge. The student could then externalize those knowledge constructs in a physical representation that could be shared.

The constructivist nature of the Inspiration plenary activity could have been responsible for the improved post-test scores. The Inspiration plenary actively engaged the students. Piaget (1964) could contend that Inspiration provided a means to actively assimilate operations through experience and social transmission leading to internal equilibration. The social constructivist could also submit that the post-test improvement resulted from the social
interaction occurring throughout the Inspiration plenary. The social interaction could allow
the student to develop and transform interpersonal operations into intrapersonal processes
(Vygotsky, 1978). Peer and adult/student interactions could have also provided the
opportunity for *just in time* support (De Simone et al., 2001) needed to further develop
knowledge operations and structures. The internalized structures may then be displayed
externally as the physical constructs presented by relationships displayed on the graphic
organizers. The active engagement and knowledge construction could have lead to post-test
improvement.

Post-test improvement could be due to the high *on-task behaviour* and plenary
completion/submission rates exhibited by the students during the plenary activity.
Engagement in the creation of the graphic organizer could allow students to identify the
necessary relationships for transforming operations into structures and the focused social
interaction could reconfirm and enhance the learning process. The high level of student focus
during the activity could lead to increased internalization of the concepts and aid in the
assimilation of knowledge necessary to develop understanding.

*Problem 2: To what extent, does the use of Inspiration, as a plenary activity, more
significantly improve test scores when compared to the use of review worksheets and
lecture/discussion activities?*

The Inspiration plenary did not prove to be better at significantly improving test
scores when compared to the Review Worksheet/Discussion plenary (RW/D). A comparative
analysis of four units was performed. The analysis suggested that the Inspiration plenary
produced higher average improvements of 0.1% to 4.0% but the differences in improvement
were not considered to be statistically significant. A power analysis suggested the trials were
underpowered.
The rejection of the hypothesis suggesting Inspiration was superior to the Review Worksheet/Discussion plenary could be due to the strength of the Review Worksheet/Discussion plenary and not the failure of Inspiration to produce higher results. The Inspiration and Review Worksheet/Discussion plenary activities involved the active engagement of the learner and it could be argued that both plenary activities support a constructivist view of knowledge acquisition. The individualized and customizable strengths of the Inspiration plenary provided each learner with the necessary tools to construct knowledge operations and structures while the directed nature of the Review Worksheet and larger interpersonal communication component during the class discussion could have provided the necessary environment to transform interpersonal communications into intrapersonal constructs (Vygotsky, 1978). The constructivist nature of both plenary activities provided strengths that could have resulted in similar statistically significant post-test improvement.

Improvement in post-test scores could have been aided by active engagement of the learner, the mastery learning techniques, and the internalization that could have occurred in the completion of the each plenary. In both plenary activities the learner was actively involved in the cognitive process as he/she used mastery learning techniques to review, identify, confer on, and re-examine past content. Completion of the plenary could have allowed the externalization of internalized knowledge. The RW/D plenary externalization of internalized operations occurred in the form of completed worksheets and answers attained during the class discussion. These externalizations could be comparable to the submitted graphic organizers and individual communication for the Inspiration plenary.

The lack of definitive findings reflect the findings of Harris (2007), Mayer (2004), Sanchez and Valcarcel (1999), and Semb and Ellis (1994). Harris (2007) advocated that
learners benefit most when instructors use a variety of techniques. Sanchez and Valcarcel (1999) suggested that activity choice was complimentary to unit development and was not of primary importance. The findings are also consistent with Mayer (2004), and Semb and Ellis (1994), who contend that the active engagement of the learner is a necessary factor that promotes learning and retention. The findings in my study and the findings listed suggest Inspiration and Review Worksheet/Discussion plenary activities could be equally efficient at preparing the student for summative assessment.

Question 1: Does the use of Inspiration, as a plenary activity, significantly improve knowledge, understanding, or higher order achievement for test scores?

Participation in the Inspiration plenary did statistically significantly improve achievement in Knowledge and Understanding, but had mixed effects on higher order processing. Statistically-significant improvement in Knowledge achievement was demonstrated in five of six trials, with improvement ranging from 19.8 % to 53.8 % correlating to effect sizes ranging from 0.659 to 2.477. Statistically-significant improvement in Understanding achievement was demonstrated in five of six trials, with improvement ranging from 7.3 % to 22.6 % correlating to effect sizes ranging from 0.228 to 2.477. The Higher Order Processing domain experienced improvement in five out of six trials but statistically significant improvement was only demonstrated in half the trials. The improvement in Higher Order Processing ranged from 4.2% to 28.3 % with effect sizes ranging from 0.184 to 0.983. Several of the trials were underpowered and further research may need to be performed to completely conclude the effects of the Inspiration plenary on Higher Order Processing.

The improvement in Knowledge and Understanding was consistent with Katayama and Robinson (2000), Robinson and Kiewra (1995), and Boon et al. (2005) and could be
attributed to the constructivist nature of the plenary, the active engagement in the plenary, the encoding benefits of creating the graphic organizer, familiarity with the curricula content, and/or the repeated review, analysis and discussion of the material. The Inspiration plenary engaged the student in an encoding process that involved the review, analysis, and discussion of previously presented materials. This active process provided the students with the opportunity to: select, collect, organize, integrate, and transform practical knowledge and operations into structures. The transformation of the student's practical knowledge and internalized operations was externalized as the completed graphic organizer and led to the demonstrated improvement in Knowledge and Understanding.

Improvement in Higher Order Processing was demonstrated in five of six trials ranging from achievement improvement of 4.2% to 28.3% with effect size ranging from 0.184 to 0.983. Statistically-significant improvement occurred in three of six trials. The mixed results were consistent with previous research by De Simone et al. (2001) and Robinson and Kiewra (1995). The lack of improvement could have resulted from the inability of the student to develop structural clarity or operational transformation of the required concepts. This could have been due to limited formal discussion, the Higher Order Processes being beyond the student's present zone of proximal development, or due to the limited time available to complete equilibration of the knowledge. Social constructivists could claim that the limited occurrence of interpersonal communication would lower intrapersonal communication resulting in the inability to completely internalize and produce the knowledge structures (Vygotsky, 1978). The unit lessons and plenary could have led to the construction of operations and practical knowledge but equilibration was not complete. The lack of equilibration could have been compounded by a lack of experience and time.
These factors could then result in a lack of improvement in Higher Order Process achievement.

*Question 2: Does the use of Inspiration, as a plenary activity, significantly improve time on task when compared to the use of review worksheets and lecture/discussion activities?*

The Inspiration plenary was significantly better than the Review Worksheet/Discussion plenary at maintaining student on-task behaviour. The observed on-task behaviour rates of the students began in a comparable range but after the initial settle in period students participating in the Inspiration plenary became more focused and engaged maintaining a perfect or near perfect on-task behaviour over the data collection time frame. The on-task behaviour of the students participating in the Review Worksheet/Discussion plenary deteriorated from the beginning of the plenary to the end of the data collection. Fifty-four percent of the class was on-task at the end of the data collection.

The statistically-significant difference in on-task behaviour between the Inspiration plenary and the Review Worksheet/Discussion plenary could be due to a number of factors. The improvement in on-task behaviour demonstrated during the Inspiration plenary could have resulted from: the novel nature of using the computer and the Inspiration program, the entertainment/fun factor and individual creativity allowed by the plenary, the acknowledgement of limited access to the computers and Inspiration program, and/or the active engagement required to complete the task due to the individual student-centred approach perceived by the students.

The improvement in on-task behaviour was consistent with past studies. Students in my study echoed similar sentiments to the students in the De Simone et al. (2001) and Boon et al. (2005) studies, proclaiming that the Inspiration plenary motivated them as the program was enjoyable, well organized, encouraged creativity and collaboration, was flexible,
transportable, and was easy to edit. Student responses to the questionnaire also acknowledged the personal nature of Inspiration as it actively engaged the learner in a student-centred approach that allowed him/her to teach himself/herself and put information into his/her own words. Sandholtz, Ringstaff, and Dwyer (1977) suggested that a more student-centred approach would increase on-task behaviour. These factors could have increased student focus and on-task behaviour.

The lack of focus during the Review Worksheet/Discussion plenary could have been due to: an increased opportunity for interpersonal communication, a sense of being able to complete the worksheets outside of class time, or a lack of motivation to complete the work by the student. Several students noted that copying was prevalent and students would often share the workload to complete the tasks more quickly. This process then provided more time for on-task discussion but usually led to off-task behaviour. The engagement factor of the worksheets could also be at fault as there was less motivation to complete the work in class when students believed they could complete the work on their own or he/she could wait for the answers during the discussion/answer sessions. Each of these factors could lead to increased off-task behaviour and once the behaviour began more students could be drawn into behaviours that were more student preferred but less academically beneficial.

Question 3: Does the use of Inspiration, as a plenary activity, significantly improve activity completion when compared to the use of review worksheets combined with lecture/discussion activities?

The Inspiration plenary did significantly improve activity completion rates when compared to the Review Worksheet/Discussion plenary. The average completion/submission rate of the Inspiration plenary was 90.4% while the average completion/submission rate for the Review Worksheet/Discussion plenary was 74.5 percent. The completion/submission
rate for the RW/D plenary could have been inflated as an unexpected occurrence resulted in one group receiving an extra day to complete the required plenary. The plenary completion/submission rates for both plenary types decreased over the completion of the course, the completion/submission rate for the first unit was higher than the last unit.

Most of the students indicated that they preferred to review on their own and the Inspiration plenary may have provided the directive they needed to focus themselves. The increased focus displayed by students participating in the Inspiration plenary may have contributed to the ability of the students to complete and submit their work. The students may have considered the Inspiration plenary to be more engaging and provided them with the freedom to create personal plenaries. The creation of the graphic organizer could also have provided the students with a sense of accomplishment, as they were solely responsible for their own finished products. The increased motivation and enthusiasm to finish the plenary would be consistent with contentions posed by Sandholtz, Ringstaff, and Dwyer (1997) in their research.

The lower RW/D completion/submission rates could have been due to the lack of ownership by the students in the worksheet completion, the lack of motivation to review and find the answers on their own, the perception that the discussion was the key factor in the review, or the perception that the worksheets could be done easily on their own outside of class time. Each of the review worksheets was reviewed in class and students were given ample time to submit their worksheets including partially-completed worksheets. The lower completion submission rates could have played a factor in lowering the post-test achievement of the students. Further study may be warranted to correlate Review Worksheet completion rates with post-test results.
Question 4: Do students believe that using Inspiration provided them more choice, allowed them to direct their own learning, and provide them with a better understanding of the concepts studied?

The student questionnaire results indicated that the majority of students felt the Inspiration plenary provided more opportunity for self-expression and for directing and regulating the individual's own learning. Students who preferred Inspiration expressed ideas consistent with the De Simone, Schmid, and McEwan's (2000) study and the Boon et al. (2005) study. Students' comments proclaimed that Inspiration allowed them the freedom to review notes and organize information in a manner useful to the individuals and suggested Inspiration was entertaining and engaging, and promoted interpersonal communication as the plenary allowed communication between peers, between the student and teacher, and through the internet.

The questionnaire results indicated that students believed they were capable of directing their own learning but more students preferred to participate in the Review Worksheet/Discussion (67.5%) than the Inspiration plenary (15%). The majority of participants also believed that the Review Worksheet/Discussion plenary increased their understanding and prepared them better for summative assessments than did the Inspiration plenary. Several students suggested understanding could not be achieved using Inspiration as they would simply copy and paste answers without internalizing the information.

Student comments suggested that Inspiration was engaging but they felt the teacher was better able to direct them in attaining the correct answers during the RW/D plenary. The student comments indicated students believed they would miss information if they were left to perform a plenary on their own and preferred having the teacher guide them through discussion or directed work. Most students indicated that they believed the teacher guidance
invaluable and believed that the RW/D plenary made them focus better and promoted repetitive review, while the discussion allowed exploration of concepts. Several students also suggested the social component of the RW/D plenary may lead to intrapersonal development processes that could lead to higher/better concept understanding.

Summary of the Conclusions to the Problems and Questions

This section identified the two major problems and four questions that were used to guide the study. Chapter 4 presented the study results and Chapter 5 analyzed the data to present plausible explanations for drawing conclusions. A conclusion to each problem and question was presented and rationale was provided.

Using Inspiration as a plenary activity does improve assessment scores. The improvement in summative assessment could have been due to the constructivist nature of the plenary, the increased on-task behaviour displayed by the students during the plenary, improved completion rates, and/or the active creation and engagement. These factors may have worked individually or combined to improve operation and structure formation that could have led to equilibration and improved knowledge assimilation.

The Inspiration and Review Worksheet/Discussion plenary activities were equally efficient at improving summative assessment scores. Both activities could be considered to be constructivist in nature and lead to student engagement and active learning. The similar comparative assimilation of knowledge and understanding could be used to advocate that learners utilize a variety of techniques to internalize information.

The Inspiration plenary did improve Knowledge and Understanding but did not demonstrate statistically-significant improvement in Higher Order Processes. Improvement in Knowledge and Understanding could have been due to encoding benefits and the active engagement students displayed in creating their graphic organizers. Improvements could also
have occurred due to the repeated review, analysis, and discussions of the familiar curricular content. Lack of demonstrated improvement in Higher Order Processes could be a result of limited interpersonal communication, concepts being beyond the development zone of the student, or lack of time to internalize information.

Students participating in the Inspiration plenary demonstrated higher on-task behaviour and completion/submission of plenary assignments than did students participating in the Review Worksheet/Discussion plenary. The increased focus and completion could be a result of the nature of the review, the entertainment factor of the program, the student’s acknowledgement of time restrictions, and/or the ability of the students to work independently, seeking discussion only when they desired clarification. The RW/D plenary led to more interpersonal discussion that often resulted in off-task social communication. Students may also have believed that they achieved something when they completed their Inspiration plenaries but the same belief was not held for completion of the review worksheets.

Student responses indicated that they believed the Inspiration plenary provided them with a greater opportunity for self-expression and for regulating and directing their own learning. Questionnaire results also indicated that students preferred the Review Worksheet/Discussion plenary and believed the RW/D plenary developed better understanding. The students expressed a desire to participate in a teacher-guided review as most students believed the teacher knew what was to be assessed and could provide them with a directed review. Student responses indicated that they believed each student was capable of directing his/her own learning but comments suggested that the students had a sense of doubt in their own abilities to guide their own learning.
Other Conclusions, Study Impact and Further Research

This section will report other conclusions obtained during the study, identify the impact the study could have on educational practice and suggest further areas for research. The study involved the analysis of the Inspiration and Review Worksheet/Discussion plenary activities and the analysis of student perception to both plenary types and student review habits. This section will identify specific conclusions regarding the ability of the RW/D plenary to improve Understanding, Knowledge and Higher Order Process scores, a comparison of cognitive categories between Inspiration and RW/D plenary activities, and student perceived needs for review and study. The section will also identify the impact unit plenary use may have on instruction and the need for future study to clarify areas of plenary use.

Effect of Review Worksheet/Discussion on Cognitive Domains

The use of a Review Worksheet/Discussion plenary does produce statistically significant improvement in post-test scores. The post-test results demonstrated improvements between 6.6% and 21.4% over pre-test scores. The Review Worksheet/Discussion improvements were mainly in the Knowledge and Understanding cognitive domains. Statistically-significant improvement occurred in four out of six and five out of six trials respectively. Higher-Order Process improvement occurred in five of six trials but only two trials demonstrated statistical significance.

Improvement in the cognitive domains could occur due to a variety of factors provided by the RW/D plenary. The RW/D plenary uses techniques consistent with constructivists (Piaget, 1964), mastery style learning (Kulik, Kulik, & Bangert-Drowns, 1990; Péladeau, Forget, & Gagné, 2003), guidance-based activities (Kirschner, Sweller, & Clark, 2006), and social interaction (Vygotsky, 1978). Knowledge could increase as students
clarified concepts and practical information; Understanding could have improved while students interacted in the discussions or reviewed previous materials; and Higher Order Processes could have been improved through discussion and internalization of knowledge operations and structures. The directed nature of the worksheets and the open nature of the discussions engaged the students. The engagement in the activity could have resulted in equilibration (Piaget, 1964), or the increased social interaction could have resulted in intra-personalization (Vygotsky, 1978). These factors could have improved cognitive assessment scores on the summative assessment.

The RW/D plenary fulfilled many constructivist parameters allowing for internalization of various conceptual operations and structures. Students suggested the review worksheets focused them better and they put more effort into the completion of the worksheets, as they repeatedly reviewed their notes and the unit concepts. Several students also indicated that they believed the discussions were beneficial and that listening to the teacher provided information that was directed and necessary. Vygotsky (1978) could suggest that the discussion provided the social communication necessary to transform knowledge to the intra-personal.

Cognitive Domain Comparison between Inspiration and Review Worksheet/Discussion Plenary Activities

The Inspiration plenary and Review Worksheet/Discussion plenary did not produce statistically-significant differences in improvement for any of the cognitive domains. The Inspiration plenary displayed higher results in three of four trials for Understanding and Knowledge, and the Review Worksheet/Discussion plenary produced better results in three of four trials. These results could be indicative of the strengths of each plenary type.
The Inspiration plenary may be better at focusing the student and provide the self-direction that develops knowledge operations and structures. The internalization of concepts could occur as the student strived to better identify the necessary factual and relational data important in understanding the units as a unified whole. The creation of the graphic organizer could concentrate the student focus on key ideas and on identifying relationships which could result in higher assessment scores for Understanding and Knowledge.

The Review Worksheet/Discussion plenary could develop knowledge operations similar to those developed by the Inspiration plenary but may not lead to an equal amount of structural development and internalization. The review material is often covered in discrete packages and the student may gloss over certain concepts assuming he/she knows the material or misunderstanding the relational importance of the concept. If the review questions are considered as discrete packages the student may not develop the relationships needed to develop practical knowledge and conceptual understanding. This distinction could lead to lower assessment scores in Understanding and Knowledge.

Higher Order Process improvement appeared to increase more in students partaking in the Review Worksheet/Discussion plenary rather than the Inspiration plenary. The differences were not statistically significant but could be due to the larger interpersonal communication component of the RW/D plenary. The increased interpersonal communication could result in greater assimilation of higher processes. The Inspiration plenary did provide opportunity for interpersonal communication but was limited to small groups or individual student-teacher conversations. The small communication component could result in less sharing and lower improvement.
Student Perceptions and Review

The two to three days before a summative assessment are crucial to the assimilation of knowledge by students. Most students in my study indicated that they preferred to study on their own, participated in 10 or more hours of extracurricular activities, and would use the days just prior to a summative assessment as the time to fully review material. These findings indicate the importance of in-class review prior to the summative assessment. The days prior to the summative assessment appear to provide the time when the student transforms information through intrapersonal communication and equilibration. Providing the students with an engaging plenary increases operational and structural development that results in higher assessment scores as demonstrated by both Inspiration and Review Worksheet/Discussion plenary activities.

Questionnaire answers indicated that students used a variety of methods to review and reflect. Most students prefer having the teacher inform them of what they needed to know and would review their notes, rewrite, or summarize their notes, or work on review worksheets/assignments. Students acknowledged the need to focus on their reviews and preferred individual study citing that group work caused them to lose focus and stray off topic. Students are able to better meet their own academic needs if they use a variety of plenary activities. Students identified the need for partaking in a variety of plenary activities but did not identify the importance of interpersonal communication and discussion.

Student answers to the questionnaire also identified various personal misconceptions students had toward guiding their own learning. Student answers suggested that the students preferred the teacher-guided reviews as they believed the teacher would provide them with the need to know information and that the students might miss something if they guided their own learning. This student perception was not correct, as improvement in post-test scores
was comparable for the teacher-directed Review Worksheet/Discussion plenary and the more student-centred Inspiration plenary.

**Impact of the Study and Further Research**

My study may be used to support the necessity of unit review in the two to three days prior to the summative assessment for a unit. Student engagement in the form of plenary construction, repeated review of the facts and concepts, selection and organization of knowledge, and social communication of concepts must be considered when selecting the plenary to be used. Plenary activities that fulfill these criteria will provide the students with the opportunity to assimilate knowledge and assess better.

My study may support the need for student-centred plenary activities. The student-centred Inspiration plenary improved student assessments and provided the students with an alternate method of review and study. Several students reported that they preferred to study on their own and preferred to use their notes. The Inspiration plenary provides the students with another useful method to select knowledge, organize, and internalize information, and identify conceptual relationships that will improve their conceptual knowledge and understanding. The student-centred nature of the plenary can provide the basis for knowledge assimilation without the teacher. The Inspiration plenary could also be used in a self-directed manner in other subject areas and for future courses.

The study did identify the need for further research in a variety of areas. Time to review and when to review are important for students and teachers. Students have limited time available outside of class time and teachers have limited time to complete the required units. The days prior to the assessment were identified as important and students reported they would like more time to complete the Inspiration plenary. Further study may be completed to determine if partial completion of the Inspiration plenary could be performed.
while completing the units. At the end, the students could then use the review time to gather together a complete review and discuss openly their graphic organizers. This approach could further streamline the plenary process and could provide a larger interpersonal communication component that could lead to more intrapersonal communication and improvements in Higher Order Process.

Post-test scores demonstrated a lack of improvement during the Circulatory unit in the Knowledge and Higher Order Process cognitive domains for both the Inspiration and Review Worksheet/Discussion plenary activities. This unit was the largest of the units, covering three content-rich sections. The large size of this unit could have resulted in the students being too rushed to fully develop the practical knowledge necessary to improve on the Knowledge and Higher Order Process cognitive domains. Future research to identify the effects of unit size may be needed, as the large unit size and the lack of time to assimilate knowledge could have led to the lack of improvement.

Further research should also be done to separate the effects of the plenary activity and the out-of-class study that could have occurred. The student responses indicate they were most actively reviewing in the two to three days prior to summative assessment but no data were collected to identify the amount of external study performed by the individual. Without this information, it may be difficult to fully identify the assessment improvement directly related to the plenary.

**Summary of Other Conclusions, Study Impact, and Further Research**

The Review Worksheet/Discussion plenary does improve test scores and showed the highest improvements in the Knowledge and Understanding cognitive domains. The RW/D plenary engages the student in mastery style learning activity that encourages the student to review his/her notes and study materials. The RW/D plenary supports the social
constructivist view by engaging students in small and large group interpersonal communications. The open and guided discussions led to intrapersonal communications and improved knowledge assimilation.

The Inspiration and Review Worksheet/Discussion plenary activities displayed similar overall and cognitive domain improvements. A closer comparative analysis of the cognitive domains did not identify significantly-different results; however, improvement in Knowledge and Understanding was slightly higher on average in students participating in the Inspiration plenary while improvement in Higher Order Process was slightly improved in students participating in the Review Worksheet/Discussion plenary. The individual on-task behaviour and encoding of relationships provided by the Inspiration plenary could be critical to the Inspiration plenary while the RW/D plenary provided the student with the increased interpersonal communication that could lead to higher processing and topic exploration. This finding could suggest a need for more research to be conducted in the strengths of each plenary.

My study recognized the need for future research in a number of areas important to plenary activities. The amount of time provided for unit plenary activities and summative assessment improvement, the individual effects of the plenary activity compared to the plenary activity coupled with home study, and the effects of unit size on plenary delivery and summative assessment improvement. More research into each of these areas could lead to the development of better plenary practice and improved student performance.

This study supports the necessity of unit review prior to summative assessment. Student comments can be used to conclude that the two to three days prior to the summative assessment are crucial to the internalization and equilibration of concepts. A student will use a variety of materials for studying but mainly rely on his/her notes, summarizations, and
review assignments/worksheets. Student responses suggested that students are often unsure of what to study and prefer the teacher to supply them with a list of topics to study believing that the teacher will only supply them with the important information.

Chapter Summary

Inspiration may be used in a student-centred unit plenary activity to improve summative assessment scores. Inspiration, when used as a plenary activity, promoted the assimilation of knowledge by engaging the student in the creation of a graphic organizer that provides the student with an opportunity for self-expression while directing and regulating learning. Student involvement/thinking was increased as the student reviewed his/her notes, partook in interpersonal communications, and developed relationships between concepts. The construction of knowledge improved the development of operations and structures. The increase in the internalization of knowledge could have resulted in the improved summative assessment scores.

The Inspiration plenary maintained higher student focus/ on-task behaviour and demonstrated higher plenary completion/submission rates than the Review Worksheet/Discussion plenary. The entertaining nature of the Inspiration plenary, pride in constructing something personal, individual focus with the ability to attain interpersonal communications as needed, and the acknowledgement of personal time restrictions could have been factors that increased student motivation and engagement during the Inspiration plenary. These factors could have improved the demonstrated on-task behaviour and completion rates and could also aid in improving assessment scores.

The Inspiration and Review Worksheet/ Discussion plenary activities produced similar test scores improvements. Both plenary activities possessed characteristics of constructivist and mastery activities. Engaged student learning was the focus of both plenary
activities. Students were encouraged to review familiar material, internalize and display their understanding by creating a graphic, or answering directed questions on worksheets and during discussion. The active nature of both activities could lead to similar development of knowledge operations and structures that could result in the production of similar improvements in summative assessment.

The Inspiration plenary and Review Worksheet/Discussion plenary were able to improve cognitive domain development. The plenary activities consistently demonstrated improvement in Understanding and Knowledge but had mixed results in Higher Order Process Improvements. The improvement in Knowledge and Understanding could be attributed to the constructivist nature of the plenary activities and the mastery style techniques that were used to encourage students to revisit the unit content. Similar results in improvement could be used to support the use of a variety of plenary techniques in order to meet the needs of various learners.

A comparison of the two plenary activities demonstrated that the improvement in each cognitive domain was not statistically significantly different between the two plenary types. However, the comparison did display trends that could indicate a further need for study of the strengths of each plenary. The Inspiration plenary produced slightly higher improvements in Understanding and Knowledge while the Review Worksheet/Discussion plenary produced slightly higher improvements in Higher Order Process areas. The higher Knowledge and Understanding scores could be due to Inspiration's focus on the organizing, interpreting, and constructing of external representations of the students' internalized information which lead to increased knowledge and understanding of the unit content and relationships that exist within the unit. The Higher Order Process improvements shown in the Review Worksheet/Discussion plenary could be due to the larger interpersonal
communication component present in the RW/D plenary. The increased social interaction could have led to a greater intrapersonal communication that may allow the student to explore issues at a higher level. It may be beneficial to research these findings further to identify key elements of each plenary. Identifying the strengths may lead to plenary modification or improvement.

Plenary activities are important in the formation of knowledge. Students utilized the days prior to the summative assessment to review and summarize notes, to complete review work, to discuss concepts, and to partake in various other teacher or student directed activities that could increase retention and understanding while strengthening weaknesses and dispelling misconceptions. The student preferred to have a series of learning outcomes provided and preferred teacher guidance to self-guidance. The students perceived the teacher as being the person with the expertise to direct them and feared that they would miss something if they were to guide their own review. This misconception was highlighted by the improvements in assessment demonstrated by the Inspiration plenary and the similar results found when comparing both plenary activities.

Plenary inclusion at the end of a unit is crucial to equilibration and knowledge assimilation. In many activities, whether they are individual or group based, we often begin by learning the basics, practising the skills until mastery then advance to learn new skills or integrate the mastered skills. At some point in time, we are asked to perform but before the performance there is usually one last chance to assess our understanding in a contextual form and where necessary, make changes to ensure perfection. In sports, that last chance may come as the exhibition game, or practice scrimmage, in theatre, the dress rehearsal, and in education, the unit review/plenary should occur before the summative assessment.
References


Appendix A

Sample student Inspiration with open notes and web links.

Table 2.3 DNA Structure Compared to RNA Structure

<table>
<thead>
<tr>
<th>DNA</th>
<th>RNA</th>
</tr>
</thead>
<tbody>
<tr>
<td>double strand</td>
<td>single strand</td>
</tr>
<tr>
<td>4 bases</td>
<td>4 bases</td>
</tr>
<tr>
<td>2 strands</td>
<td>1 strand</td>
</tr>
<tr>
<td>hydrogen bonds between bases are weaker</td>
<td>hydrogen bonds are stronger</td>
</tr>
</tbody>
</table>

Steps of DNA replication:
1. The two strands of DNA break apart, and hydrogen bonds between the base pairs are broken. An enzyme called helicase is used in this step.
2. DNA replication requires that a template strand is available. The template strand is read in the 5' to 3' direction, while the new strand is synthesized in the 3' to 5' direction.
3. The complementary nucleotides on each form new strands.

This process is catalyzed by an enzyme called DNA polymerase.
Appendix B

Sample Inspiration template provided to students.
Appendix C

Student Questionnaire

Biology 12 – Thesis Questionnaire

The purpose of this questionnaire is to identify student preparation for Biology 12, student prior learning, learning styles, review preference, and study habits. The information obtained from the collection of these data will be used in the analysis of my Master of Education thesis, to identify the effects of different review activities on knowledge retention and understanding. The information gathered from this questionnaire will remain confidential.

Please answer each of the following questions to the best of your ability.

Name: ____________________________

Student Number: ____________________________

Student Preparation:

1.) Place a mark (X) in the box to the left of each course you have completed prior to taking the Biology 12 course you are currently enrolled in.

- Biology 11
- Biology 12
- Chemistry 11
- Chemistry 12
- English 11
- English 12
- Principles of Math 11
- Principles of Math 12
- Physics 11
- Physics 12

2.) Prior to taking this Biology 12 course I:
- Had been introduced to webbing and webbing techniques.
- Had not been introduced to webbing and webbing techniques.

3.) Prior to taking this Biology 12 course I:
- had used the Inspiration™ software program.
- had not used the Inspiration™ software program.

4.) I feel that my ability to use a computer is:
- Better than most other students
- On par with the ability of most other students
- Below the abilities of most other students

5.) I feel my ability to use the Internet is
- Better than most other students
- On par with the ability of most other students
- Below the abilities of most other students
6.) I feel that my ability to guide my own studying and learn on my own is:
   - [ ] High.
   - [ ] Average.
   - [ ] Low.
Student Study and test preparation habits:
For each of the following make a mark in the space of each answer that applies to you (you may choose more than one).

1.) Before a test I prefer to study:
   - [ ] In a group.
   - [ ] With one or two classmates
   - [ ] On my own.

2.) When I study I:
   - [ ] Review my notes.
   - [ ] Review my quizzes.
   - [ ] Review my assignments.
   - [ ] Review the learning outcomes
   - [ ] Answer chapter or review questions.
   - [ ] Summarize and make review notes.
   - [ ] Re-draw diagrams and/or make webs.
   - [ ] Use question and answer sessions with my friends or others.

3.) I like it when the teacher
   - [ ] Reviews the learning outcomes before a test.
   - [ ] Writes out a complete list of things to know before the test.
   - [ ] Uses games to review testable material.
   - [ ] Provides worksheets and questions for me to answer.
   - [ ] Uses pictures, diagrams, and videos to review testable material.

4.) To prepare for a test I:
   - [ ] study 30 minutes or less every night.
   - [ ] study 30 minutes or less every night for two or three days before the unit test.
   - [ ] study more than 30 minutes every night.
   - [ ] study more than 30 minutes every night but only for two or three days before the unit test.
   - [ ] study for as many hours as possible the night before the test only.

5.) I participate in extra-curricular activities or work:
   - [ ] Less than 10 hours per week
   - [ ] 10 to 20 hours per week
   - [ ] 20 to 30 hours per week
   - [ ] 30 or more hours per week
Review Activity Assessment

Complete each of the following by selecting the answer that applies to you then supply reasoning in your own words

1.) At the end of a unit I prefer:
   □ To listen to a teacher guided review and complete review worksheets.
   □ To use Inspiration and create my own review.
   □ Another method (list in the space provided): __________________

List the reasons you felt the method you chose was preferred and why the other(s) were less preferred. (If you need more room please attach another sheet of paper with your comments.)

--------------------------------------------------------------------------------------------------------

--------------------------------------------------------------------------------------------------------

--------------------------------------------------------------------------------------------------------

2.) Which review method do you think prepared you better for unit tests?
   □ Listening to a teacher guided review and completing review worksheets.
   □ Using Inspiration and creating my own review.
   □ Another method (list in the space provided): __________________

Explain your choice. (If you need more room please attach another sheet of paper with your comments.)

--------------------------------------------------------------------------------------------------------

--------------------------------------------------------------------------------------------------------

--------------------------------------------------------------------------------------------------------

3.) Which review method did you put more effort into completing?
   □ Listening to a teacher guided review and completing review worksheets.
   □ Using Inspiration and creating my own review.
   □ Another method (list in the space provided): __________________

4.) Which method did you feel you had more choice and opportunity to express yourself in?
   □ Listening to a teacher guided review and completing review worksheets.
   □ Using Inspiration and creating my own review.
   □ Another method (list in the space provided): __________________
5.) If I were given a chance I:
   - Would use Inspiration™ again.
   - Would not use Inspiration™ again.
   - Another method (list in the space provided): ________________