

FORMATIVE EVALUATION OF A SOFTWARE  
PROTOTYPE WITH GRADES FIVE AND SIX  
STUDENTS ATTENDING SCHOOL IN THE  
NORTHWEST TERRITORIES

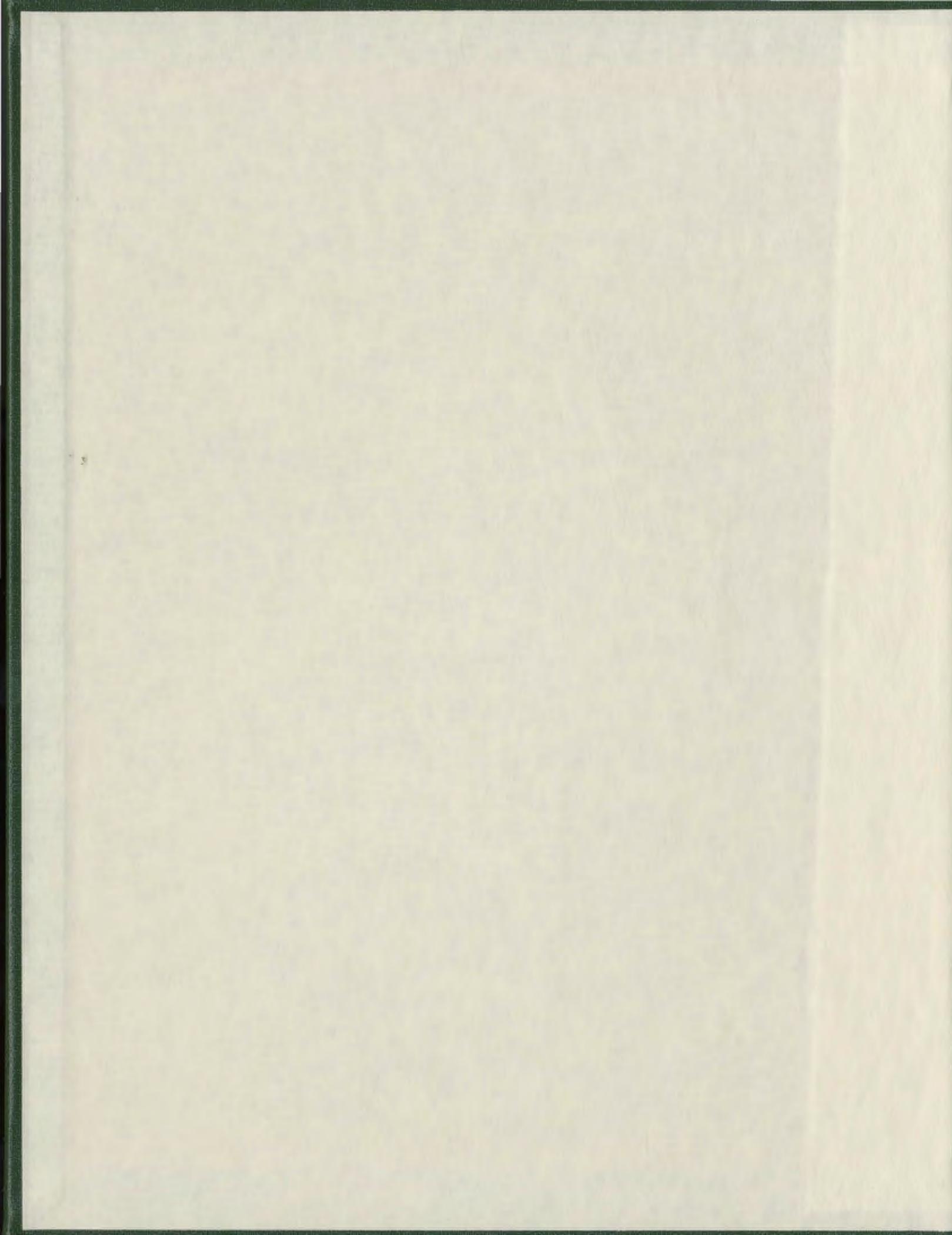
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**FORMATIVE EVALUATION OF A SOFTWARE  
PROTOTYPE WITH GRADES FIVE AND SIX STUDENTS  
ATTENDING SCHOOL IN THE NORTHWEST  
TERRITORIES**

by

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**A master's project submitted to the  
School of Graduate Studies in partial fulfillment of  
the requirements for the degree of  
Master of Education**

**Faculty of Education  
Memorial University of Newfoundland**

**July, 2001**

**St. John's**

**Newfoundland**

Memorial University of Newfoundland

ABSTRACT

FORMATIVE EVALUATION OF A SOFTWARE  
PROTOTYPE WITH GRADES FIVE AND SIX STUDENTS  
ATTENDING SCHOOL IN THE NORTHWEST TERRITORIES

The focus of this master's project was a formative evaluation of the software prototype "Rainforests of the World" developed by the writer with Dene and non-Dene students attending grades five and six in a northern rural community. The purpose of a formative evaluation was to determine how the prototype could be improved to benefit its users. The evaluation procedure followed the three-stage model developed by Alessi & Trollip (1991); namely the Quality Review, the Pilot Test and a Validative Stage. The Quality Review with subject matter experts and instructional design expert comments was completed in November 1995. This project focused on the Pilot Test with three students and the Validation Stage with twelve students. Protocol analyses and semi-structured interviews were used to answer the validation question: How do Dene and non-Dene students in grades five and six learn about the facts and layers from the "Rainforests of the World" software prototype? Individual students sat with the investigator at the rainforest computer program. Students thought aloud as they used the program to learn about rainforests of the world. Their verbal reports and computer mouse activities were recorded on videotape. It was expected that results from the data that students would learn by the integrating prior knowledge of rainforests with constructivist learning tasks embedded in the computer program.

## TABLE OF CONTENTS

TITLE PAGE.....	i
ABSTRACT.....	ii
TABLE OF CONTENTS.....	iii
LIST OF FIGURES AND TABLES.....	v
<i>Chapter 1: INTRODUCTION.....</i>	<i>1</i>
Problem Addressed by the Project.....	1
Extant Learning Resources.....	1
Curricular Issues.....	2
Rationale.....	3
Summary.....	4
<i>Chapter 2: Review of the Literature.....</i>	<i>5</i>
Terminal Objective of the Prototype.....	5
Design of Prototype.....	6
Structure of the Software Prototype.....	8
Design of Workbook.....	10
Formative Evaluation of Materials.....	11
Summary.....	12
<i>Chapter 3: Methodology.....</i>	<i>13</i>
Participants.....	13
Materials.....	15
Formative Evaluation Plan.....	17
Stage 1: Quality Review.....	17
Design of the Quality Review.....	17
Procedure for the Quality Review.....	18
Results of the Quality Review.....	18
Stage 2: The Pilot Test.....	19
Design of the Pilot Test.....	19
Procedure for the Pilot Test.....	19
Results of the Pilot Test.....	20
Stage 3: The Validation.....	20
Design of the Validation Stage.....	21
The Process Coding Scheme.....	22
The Content Coding Scheme.....	24
Procedure for the Validation Stage.....	25
Step 1: Installation.....	25
Step 2: Consent and Sampling.....	25

Step 3: Training on Verbal Protocols.....	25
Step 4: Verbal Protocol Review.....	26
Step 5: Explorer Centre.....	26
Step 6: The Task.....	27
Step 7: Semi-structured Interview.....	27
Results of the Validation Stage.....	27
Process Protocols.....	28
Content Protocols.....	31
Summary.....	33
Validation of the Learning Process.....	33
Intention.....	34
Attention.....	34
Questioning.....	35
Evaluating.....	36
Validation Interviews.....	37
Validation of Rainforest Knowledge.....	40
Summary.....	41
 <i>Chapter 4: Recommendations</i> .....	 42
Contributing Factors.....	44
Limitations.....	45
Summary.....	46
 References.....	 48
 Appendices.....	 53
Appendix A.....	53
Appendix B.....	54
Appendix C.....	55
Appendix D.....	56
Appendix E.....	57
Appendix F.....	58
Appendix G.....	62
Appendix H.....	64
Appendix I.....	65
Appendix J.....	66
Appendix K.....	67
Appendix L.....	68

## LIST OF FIGURES AND TABLES

### *Figure #*

**Figure 1: Facts Menu Screen Print from “Rainforests of the World” prototype.....32**

**Figure 2: Sample Workbook page from “Rainforests of the World” prototype.....40**

### *Table #*

**Table 1: Raw Summary Data Validation Stage of the “Rainforests of the World”.....29**

**Table 2: Evaluation Results on Comparisons of Process Verbalizations.....30**

**Table 3: Correlations between Segment Data and Participant Characteristics.....34**

## *Chapter 1*

### INTRODUCTION

Chapter one was an introduction to a proposed project for partial fulfillment of the Master of Education Degree in Computer Education. First, a brief explanation will be presented on the problem addressed by this project. Second, the chapter will report the deficiencies of the extant learning resources in helping students attending grades five and six in the Northwest Territories. Third, relevant curricular issues for teachers of grade five and six in the Northwest Territories will be discussed as a context and background for the problem. Lastly, a rationale will be given for conducting formative evaluation of a new prototype called "Rainforests of the World" with grades five and six students attending school in the Northwest Territories.

#### **Problem Addressed by the Project**

A brief explanation is presented here on the problem addressed by this project. At the present time, students attending grades five and six in the Northwest Territories have few resources from which to learn the requisite facts and layers about tropical rainforests of the world. An appropriate learning resource was therefore sought to provide these students with instruction and feedback about the requisite facts and layers of tropical rainforests in the world.

#### **Extant Learning Resources**

In the view of the researcher, there were deficiencies in the quantity of extant learning resources for grades five and six in the Northwest Territories. The present learning

resources addressed the general topic only and did not focus specifically on the requisite facts and layers of tropical rainforests in the world. For example, a recent CD-ROM developed by the National Geographic Society presented general information about tropical rainforests in the world. Other resources included books (e.g. "Joy of Nature"), software programs, (e.g. "Encarta," "The New Grolier Multimedia Encyclopaedia"), and videos (e.g. "The Rainforest Imperative"). While these materials filled an important void in the education of grades five and six about the rainforests none focused directly on viewing the facts and layers of a tropical rainforest.

### **Curricular Issues**

A discussion of curricular issues for teachers of grades five and six in the Northwest Territories was important in understanding the context and background for the problem addressed in this master's project. Teachers of grades five and six in the Northwest Territories tended to adopt resources that were familiar and readily available. The Dene philosophy regarding their relationship to the land and all of its wildlife, spiritual connection, other people and themselves can be interrelated with rainforest issues, namely: multiculturalism, education of Dene and Non-Dene, ownership of the land, language and religion (Dene Kede, 1993). These curricular issues, which can be interconnected to the global issues associated with the rainforests and approached in a holistic manner of learning that is best, suited to the learning styles of Dene students (Martin, 1990; Tamaoka, 1986).

### **Rationale**

A rationale was required for conducting a formative evaluation of a new software prototype on rainforests with grades five and six students attending school in the Northwest Territories. The rationale for conducting a validation of the prototype "Rainforests of the World" was to provide critical information about how to modify the prototype to improve student learning and interaction with computer-based instruction. This prototype, called "Rainforests of the World" (Whenham, 1995), was developed as partial fulfillment for the graduate course 6615 Educational Software Prototyping and Evaluation at Memorial University of Newfoundland. The first stage in the evaluation of this software prototype was the Quality Review that intended to eliminate correctable errors. The prototype was reviewed by a subject content expert and instructional design expert and revisions were made based on feedback from these experts. The second stage was the Pilot Test, conducted with representatives of the target audience. Two volunteers completed the prototype as learners. Feedback from these users provided information from which to debug the prototype and correct obvious problems.

The third stage was the Validation, whereby the prototype was formatively evaluated as a viable learning resource in the classroom setting. In this stage, students' interactions and verbal protocols were recorded, segmented and transcribed into cognitive episodes. The data was grouped and analyzed statistically along content and process dimensions. The results of the evaluation were expected to provide critical information about how to modify the software prototype to improve student interaction. Recommendations were presented for changes in the prototype and for further research.

## **Summary**

**Chapter one was an introduction to a project for partial fulfillment of the Master of Education Degree in Computer Education. The software prototype was developed as partial fulfillment for a graduate course in Computer Education. A formative evaluation of the prototype was proposed with grades five and six students attending school in the Northwest Territories. The rationale for developing the prototype and conducting the formative evaluation was to focus on information gathered during the Validation Stage and make recommendations on revisions necessary during the implementation of the prototype regarding student interaction and learning. Chapter two is an explanation of the prototype and review of the extant literature.**

## *Chapter 2*

### REVIEW OF THE LITERATURE

Chapter two was a review of the literature and explanation of the prototype software "Rainforests of the World." Chapter two begins with an explanation of the terminal objective of the prototype. Next, was an explanation of the design features implemented in the prototype for effective computer-based instruction followed by a description of the materials that accompany the prototype. Finally, the purpose of the evaluation was presented as well as the evaluation model and the interview questions that were used in the formative evaluation of the materials.

#### **Terminal Objective of the Prototype**

A successful software prototype focuses on a few specific objectives rather than trying to incorporate a wide range of objectives (Alessi & Trollip, 1991; Hannafin, 1989; Kulik & Kiluk, 1991; Duchastel, 1993-94; Hannafin & Peck, 1988; Park & Hannafin, 1993). The terminal objective of the prototype was to engage students in a computerized tutorial of the facts and layers of the rainforests of the world. The challenge lay in how to approach the topic from an appealing perspective for students in upper elementary grades (i.e., grades five and six). The intrigue of unusual animals (e.g., bandicoot), fish (e.g., piranha), reptiles (e.g., red-and-blue poison-arrow frog), insects and spiders (e.g., tarantula, stickbug), birds (e.g., rainbow bee-eater), flora and fauna (e.g., orchids, hot lip plant), fungi (e.g., liverwort), and vegetation (e.g., brazil nuts), as well as the massive trees that have been growing for centuries that also contribute to the livelihood of people (e.g., rubber tapping, oils, soaps), are fascinating topics for these grade levels.

### **Design of Prototype**

The design of the prototype "Rainforests of the World" was conducted in four steps, as suggested in Alessi & Trollip (1991, p. 274); namely, 1) elimination of ideas, 2) task and concept analysis, 3) preliminary lesson description, and 4) evaluation and revision of design.

The first activity in designing the prototype was to eliminate unusable ideas. This activity involved determination of (a) the characteristics of the student population (Northwest Territories, in this case), (b) the relationship of design ideas to the rainforest content, (c) the amount of time required to learn the content by these students, and (d) the restrictions of the computer program. The remaining ideas were analyzed to determine suitable teaching sequences and to produce relevant details of the lesson. Second, task analysis was an integral part of software prototype design. It was an outline of events that described the flow of the prototype. Concept analysis was also done to determine the appropriate subject matter. The lesson description integrated the content and the instruction design ideas into a single, purposeful work-in-progress. Objectives expected of the student while interacting with the prototype were clearly stated following the title page. Keywords such as imagination, instinct and creativity were suggested as well as remembering a nature walk, other school subjects, or hobbies to assist in responding to the questions. The students were told to think of the prototype as an adventure or journey and to keep a journal of their thoughts (see appendix A).

The prototype's textual construction begins with students becoming familiar with the four unique layers of tropical rainforests by providing graphics and questions that will create an image of what a tropical rainforest might be like. Realistic graphics with

accompanying text were used to stimulate descriptive responses from students without them actually being in the heart of a tropical rainforest. The graphics in the prototype were not redundant to the text, but effectively integrated with the text to provide more information to enhance learning (Park & Hannafin, 1993). While interacting with the prototype, students would learn information to contribute opinions or problem solving ideas to the controversial decisions pertaining to the future of these forests. There was prompting and feedback throughout the program for guidance in responding to the questions posed throughout the program. Effective prompting and feedback provided a method for emphasizing critical information and useful to ensure important information is learned and interpreted properly (Park & Hannafin, 1993). The students were expected to draw upon their perception skills, prior knowledge and experiences to come to a consensus as to what the questions were asking. When new knowledge is integrated with existing knowledge learning will become more meaningful (Park & Hannafin, 1993; Wittrock, 1986; Seifert, 1994; Pressley & McCormick, 1995).

Temporal sound prompts were added to the prototype to focus the participant's attention and to improve the interaction with the content in the prototype. Temporal sound is an informational sound strategy that provides highlights and details about future and past events occurring during the interaction with the prototype (Mann, 1995b). "The digitized sound is considered to be temporal when spoken instructions and directions are provided about a future event or feedback about the past, creating a synergistic relationships with the wording in the visual presentation" (Mann, 1995a, p. 403). Information contained in past events interprets the knowledge presented in text. Information about future events presents the feedback at a general level, showing fundamental and representative of

complex relationships (Mann, 1995b). Digitizing sound for the prototype was a two-step process first having to prepare a document to receive the sound prompt using the authoring system "Toolbook." Secondly, the sound production software "WaveStudio" was used to digitize the sound using the procedure suggested in Mann (1996a). The sound files were then linked to the prototype "Rainforests of the World."

### **Structure of the Software Prototype**

One advantage with this prototype was its ability to give the student choices to learn the information about rainforests (Park & Hannafin, 1993; Alessi & Trollip, 1991). The students were introduced to menus to access navigational paths to learn the information. Each path offered a slight variation to learn the unique characteristics of a tropical rainforest. The particular approach that students choose to learn the information was within their control.

Park and Hannafin (1993) suggest that the acquisition of knowledge would be better learned if students have multiple methods of learning the topic. Once a category is chosen, the information is sequentially linked offering only "go back" or "go to next page" options. This was meant to lessen the potential of going astray within the chosen category (Grabinger, Dunlap & Johanssen, 1992). The paths were succinct, therefore easier for the students to remember previous screen; direct so students know where they are within the path and informative since each path focuses on specified content, therefore guiding students in the necessary path of information about the topic (Grabinger et al., 1992). As an example, students had two choices on how they would like to learn about a tropical rainforest (see appendix B). Once that option was selected, another menu would appear with more specific choices. (Note: If a student chooses Layers, this menu

would represent each of the four layers of a tropical rainforest: Forest Floor, Understory, Canopy and Emergent – appendix C.) Once a student had selected from the second menu (e.g., Forest Floor), the sequential links would take effect and a linear path to learn the information about the forest floor. When a student had completed a path within the prototype, the option to continue with that same menu was available or the student could choose to access another path from the menu.

Elaborative links were also available to students within the linear path of each subcategory. Elaborative links provide more detail to the student on a specific topic (Grabinger et al., 1993). This linkage among the nodes would reflect the various ways in which the prototype would be used by each student (Park & Hannafin, 1993). Elaborative links were made visible through words that were typed bold or coloured. For example, a graphic representing the Forest Floor in accompaniment with text asking, “Look for some common adjectives among the plants and animals.” (Note: The word *adjective* in this prototype is red, therefore indicating an elaborative link, to be accessed by a button located at the bottom of the screen (see appendix D). Accessing this link would activate a help screen to jog the student’s memory.

Two-tiered questions were implemented into characteristics of the learning environment. Students interacting with the prototype would encounter questions such as “Let’s make comparisons between the colouring of the animals on the forest floor to other layers of the rainforest” (see appendix E). Deep-level questions lend themselves very well to partial feedback. “Rainforests of the World” takes partial feedback into great consideration by offering students just enough information to respond to a question. An example of partial feedback can be demonstrated with responses such as “Did you think

of...?" and "What else are you able to think of...?" Responses such as these are situated throughout the program drawing upon the metacognitive skills of students in a non-threatening environment (Park & Hannafin, 1993).

### **Design of Workbook**

A student workbook accompanied the prototype enabling students to keep a record of their responses and a reference during class discussions or perhaps when inquiring about the rainforest without the use of the prototype. The information learned from the prototype can then be elaborated explicitly by the students and may enhance learning (Park & Hannafin, 1993). Seifert (1993) and Pressley & McCormick (1995) refer to this strategy as elaborative interrogation, whereby students can integrate new information with prior knowledge creating a stronger association between the topic and its characteristics. Since the prototype was intended to be used within a thematic approach, a journal would become useful with other classroom activities or discussions regarding the rainforests. Participation was also emphasized in the Dene curriculum initiating informal interaction with others, assertiveness, narration, asking about others and giving advice which can be considered as part of the generative learning process of the Dene (Zoe, 1990).

The layout of the workbook replicated the layout of the prototype to alleviate potential disorientation, by the student, that may result from transferring a response from the screen to the workbook. The exact question asked in the software prototype was expressed as such in the workbook. The graphics were representational to the category being discussed as suggested in Reiber (1994). There were activities in the workbook that provide additional prompts when responding to some of the questions in the prototype. A

workbook was also considered appropriate for the teacher to monitor whether the students are assimilating the content (Alessi & Trollip, 1991). The layout of the workbook corresponds closely with the software prototype for one other reason. Individual teachers, principals, and students, intending to implement the prototype will likely browse the workbook before screening the prototype (Alessi & Trollip, 1991). Therefore if the workbook resembles the dominant features of the prototype then those intending to use it would have a better idea of the content the software prototype delivers.

### **Formative Evaluation of the Materials**

Assessment of this prototype would follow the three stages of a formative evaluation outlined by Alessi & Trollip (1991), namely the Quality Review stage, Pilot Test stage and Validation stage. A formative evaluation focused on recommendations for improving the prototype and on the revisions necessary during the implementation of the prototype to improve learning. The evaluation for this prototype would focus on learner interactions.

The Validation stage would utilize observation and interview methods, as suggested by Knussen, Tanner and Kibby (1991). Results from observations were collected from comments noted by the evaluator during the evaluation from recorded tapes. The observation method alone was considered as nonfactual and subjective in the evaluation process; therefore the interview method would accompany the observation approach. Questions suggested for an interview were based on Barker and King (1993), which were considered to be the most frequently concerned issues in the evaluation of educational software. They set out to identify quality properties that seemed characteristic to good learning products (see appendix F). A student Explorer Centre (SEC) captured students

on videotape, which recorded what they were doing. The physical video taped evidence was advantageous to the results of the evaluation. Having every moment of the student's interaction recorded, alleviated any possible memory lapse, the evaluator endured as well as being able to lesson the subjectivity often associated with evaluation methods upon deciphering the results of the evaluation.

### **Summary**

Chapter two was a review of the literature and description of the design features implemented in the development of the prototype for effective computer-based instruction as well as a description of the documentation that accompanies the prototype. Chapter three reports on the methodology for the proposed formative evaluation.

## *Chapter 3*

### **METHODOLOGY**

Chapter three was a description of the formative evaluation of computer-based instructional materials designed specifically for students attending grades five and six in the Northwest Territories. Unlike most educational research methodologies that use student data to determine the amount of support for a research hypothesis, a formative evaluation methodology uses student data to improve the instructional materials. In this formative evaluation, the selection and description of the participants was explained first.

#### **Participants**

A combination of twelve Dene and Non-Dene students (4 males, 8 females) ranging from ages 11 through 13 were selected from grade five and six classrooms situated in a rural community in Northwest Territories. The selection was based on teacher opinions about student academic background and abilities. Four of these students were average readers, five below average readers, and three well below average readers. Six of the twelve students were considered to be in a "special needs" category. The socio-economic make-up of the community is 87 percent Dene, 3 percent Metis and 9 percent non-native with a total population of 1662 people (T-STAT, 1996). The growth rate of the community was 3.6 percentage points above the national average and the average age of the population was quite young with 35 percent under fifteen and 84 percent under forty-five years of age as opposed to 20 percent and 66 percent respectively for the national averages.

The family structure of the community was closely related to the national average family make-up in terms of marriage and common law versus single parent family structure. The

average family size was considerably higher at 4.4 people per dwelling compared to the national average of 2.6. More than 43 percent of dwellings had 5 or more people compared to only 10.3 percent nationally. One other interesting factor of the Dene family in this community was that since 1991 the ratio of home language (language spoken at home) to mother tongue was down to 67.5 percent in 1996 from 81.7 percent in 1991 (T-STAT, 1996). Thus, one factor noticed in the school was students were entering school without a good grasp of either their native language or English. This played an important role in choosing students to participate in the study since, there were no above average readers available for the study.

The success rate for completing High School in the community was well below the national average over 69.8 percent of the population over 15 have some high school education compared to 34.8 percent nationally. The participation rate of people attending school in the fifteen to nineteen age groups was 10 percent below the national average while the rate for twenty to twenty-four year old age groups was almost 23 percent below the national average (T-STAT, 1996). This persistent low education rate would have had an effect on what prior knowledge and language experience each participant brought to the software prototype.

In 1996 the unemployment rate for the community stood at 32.4 percent opposed to the Territorial average of 11.7 percent and a national average of 10.1 percent. Government was by far the largest employment sector at 51 percent of the jobs. While the average family income was only approximately \$6,000 less than the national average in 1996, the number of households earning less than \$20,000 per year was 34.7 percent compared to 23.9 percent nationally (T-STAT, 1996). This under-employment of the participants'

parents or guardians coupled with low-income levels may have had an effect on each participant in the array of experiences brought to the prototype.

Family life in the community was not easy for children. Dysfunctional households that were large with low incomes can create an inhibiting environment for positive educational experiences and language. According to More (1999) such students are more likely to learn through Global, Imaginal, Concrete and Reflective learning styles.

Therefore, a structured, caring and nurturing environment / household were necessary to provide children with the appropriate educational skills conducive for learning.

A meeting was held with the two teachers of the grade five and six classes to discuss which students would be best suited to meet the range of abilities to participate in the validation stage. Once a list of students was agreed upon those students were asked if they would like to participate in the project. Participants were selected from the best potential students, average students, and students who had academic problems, as suggested in Alessi & Trollip (1991), and in Barker & King (1993). There would be no difference had other students been chosen for the project given the make-up of the participants. The range of abilities will determine whether the “Rainforests of the World” (Whenham, 1995) computer program would meet the needs of the entire target population.

### **Materials**

The materials included a newly created, computer-based prototype called “Rainforests of the World”, a Student Workbook, and an Instructor’s Manual (Whenham, 1995). This prototype was developed to teach grade five and six Dene and Non-Dene students living in the Northwest Territories about tropical rainforests. The designer researched several

issues concerning the importance of instructional design for effective educational computer-based instruction to achieve this goal. The prototype of "Rainforests of the World" was congruent with many instructional design features suggested by Alessi & Trollip (1991), Kulik & Kulik (1991), Duchastel (1993-94), and Park & Hannafin (1993) for effective educational design software.

"Rainforests of the World" (Whenham, 1995) presented instruction, practice, and feedback about rainforests in four categories. In this formative evaluation project, only the fourth of a four-category software prototype was examined with grades five and six Dene and Non-Dene students. This prototype enhances metacognitive skills of students requiring them to become actively aware of their thinking when learning information regarding the issues of the rainforests, though this belief remains untested.

Participants were required to construct a solution to an educational problem using the terminology and framework. For example, why do you think plants and animals are darker in colour on the forest floor? Every problem was comprised of four parts: an objective node, a problem statement node, translation node, and an analysis node. Each participant was provided with access to the software prototype, a workbook and a pencil with eraser, printed instructions and Optional Structured Reading Outlines, as suggested by van den Berg & Watt (1991). Sequential linking in this prototype permitted only two options: the next node or the previous node as suggested in Grabinger et al. (1992). A flowchart of the prototype is located in appendix G. The revised approach presented the material and guided participants without engaging them in extended practice and assessment.

### **Formative Evaluation Plan**

The design of this Master of Education project is a formative evaluation, with the purpose of answering the question, “how can the Rainforests of the World computer program and support materials be improved”? Unlike most research and some forms of evaluation designed to study “learning process” or “outcomes”, “instructional effectiveness” or “efficiency”, or “whether or not certain criteria were met”, formative evaluation is designed to determine “how a particular set of instructional materials can be improved” (Patton, 1986).

In this master project, the Alessi & Trollip’s (1991) model of formative evaluation of Computer-Based Instructional material was adopted. The Alessi and Trollip model of Computer-Based Instruction has had favourable reviews in the literature (Greenberg, 1992) and at the Amazon.com Website in 1998 by one reviewer in Belgium, and another in 1999 by a reviewer in the United States. Greenberg (1992) found this model to be effective and practical for software evaluation. Alessi and Trollip’s (1991) formative evaluation model has three stages, namely: Quality Review, Pilot Test, and Validation.

#### **Stage 1. The Quality Review**

Quality Review was the first stage in the formative evaluation of the “Rainforests” prototype recommended in Alessi and Trollip (1991). The purpose of the Quality Review was to eliminate correctable errors.

#### **Design of the Quality Review**

Two subject matter experts, two instructional design experts (chosen for their knowledge of the rainforest and familiarity with Alessi & Trollip’s model) and one participant from

the target audience examined the prototype separately. The instructional design expert's role in the Quality Review stage was to peruse the "Rainforests of the World" computer prototype and see it adhered to the criteria outlined in Alessi and Trollip (1991).

### **Procedure for the Quality Review**

Two subject matter experts analyzed the prototype making certain surface features, questions and menus, invisible functions, and off-line materials. Next, the two subject matter experts were asked to examine the instructional materials. The subject matter experts looked at the kinds of questions being asked and the quality of feedback found in the prototype. Issues of pedagogy included the navigational process and the amount of student control. They also reviewed the subject matter and language and grammar.

### **Results of the Quality Review**

Revisions were made following feedback from the experts (see appendix H). A few modifications resulted in the restructuring of some questions, revising the page numbering scheme, modifications in the size and colours of buttons, as well as creating and naming a button. A graphic was replaced as a result of poor quality, graphic changes were made in the workbook, and sound was also added to the prototype.

The goals, objectives and content were clearly explained to the participant and the fact that the prototype's intention to work as a learning environment within the classroom was highly favourable to the evaluators. The off-line material, such as a student workbook, was an asset for the student and teacher. The teacher's manual was praised for including technical aspects of the prototype as well as presenting additional activities to learn about the rainforests. The Quality Review was completed in November-December 1995.

Revisions were made following the quality review for subsequent implementation in the pilot test.

### **Stage 2. The Pilot Test**

Pilot Testing was the second stage in the formative evaluation of the “Rainforests” prototype recommended in Alessi and Trollip (1991). The purpose of the pilot test was to debug the prototype and to correct obvious problems observed by the target audience, as suggested in Alessi and Trollip (1991).

#### **Design of the Pilot Test**

The pilot test was conducted using the seven-step procedure outlined in Alessi & Trollip (1991), namely: selection of the participants, explanation of the procedure, determine prior knowledge of participants, observe participants using the prototype, interview participant, assess learning, and revision of the prototype. The evaluator observed and solicited comments from the three participants to be involved with the pilot test.

#### **Procedure for the Pilot Test**

The participants were asked to proceed through the program using the workbook and following the directions asked in the prototype. They were required to think aloud as they used the prototype. Verbal feedback guidelines were generated spontaneously during these trial runs. The participants were told that while they were interacting with the prototype they would be observed by the investigator and recorded at all times by the Explorer Centre. Each participant was asked a variety of questions (Barker & King, 1993) pertaining to the content and operation of the lesson at the end of the session (see appendix F).

### **Results of the Pilot Test**

Revisions were made during the trials for subsequent implementation in the validation stage. Three suggestions for improvement of the “Rainforests of the World” computer program were proposed from the Pilot Test.

The first suggestion proposed from the Pilot Test regarded the sound that was added to the program. Some of the pilot test participants thought the voice was speaking too quickly in certain areas of the program. Those sections identified in the program were changed to speak in a slower more consistent manner.

The second suggestion proposed from the Pilot Test was to add more graphics in the program. Participants liked the graphics that were in the program, but wanted some more to be added in order to help them answer the questions being asked in the program. The areas were identified then modified accordingly.

The final suggestion proposed from the Pilot Test regarded the workbook. Participants were confused in the workbook because they did not know what section of the workbook they were in, therefore suggested a title page be added to help identify the different sections in the workbook. Title pages were created and added to the workbook for the participants of the validation stage.

### **Stage 3. The Validation**

Validation was the final stage in the formative evaluation of the “Rainforests” prototype recommended by Alessi and Trollip (1991). At this stage, the prototype was analyzed on how well it worked in the real instructional setting. According to Alessi and Trollip (1991), the purpose of the validation was to verify the pilot test in the real situation and to

assess those participants who span the ranges of abilities outside the target audience. It was the goal of the validation stage to ensure the participant learned what was intended from the software prototype. Alessi and Trollip (1991) agreed that the validation stage was a summative evaluation; they recommended that it was part of the revision process not an evaluation of a “developed” product. The best validation was one in which the participant can use the computer program’s information in the setting for which the designer of the program had intended, as suggested by Alessi and Trollip (1991).

### **Design of the Validation Stage**

Explorer Centres were used in the validation stage to collect, segment and analyze the participants’ verbalizations within a classroom setting. Explorer Centres were individual computer/video workstations where a computer and a microphone were linked to a videotape recorder (Mann, 1996a, 1997c). The Explorer Centre recorded what the participants’ were doing on the screen as well as what they were saying about what they were doing. The physical video taped evidence was advantageous to the results of the evaluation having every moment of the student’s interaction recorded. This alleviated any possible memory lapses the evaluator endured as well as being able to lessen the subjectivity often associated with evaluation methods upon deciphering the results of the evaluation.

The analysis of verbal reports was informed by the results of earlier research (More, 1999; Martin, 1990; Tamaoka, 1986) gathered on group behavior with Dene students. Dene students tend to learn in a global (holistic) nature as opposed to the compartmentalizing of subject areas, the way Non-Dene students often do. Moreover,

studies of learning styles have revealed important information in educational computing and human-computer interaction (Mann, 1995a).

Segmented transcripts were used in coding the verbal reports. The coders discussed the coding scheme. The video recordings were often referenced to detect what was happening for verbal reports such as, "If I try this ...." In this case, perhaps a textual feature was selected as a placeholder (Mann, 1996b). A number of segments of this kind were used to model the coding process. All of the verbalizations were coded by the investigator, one third of which were recorded independently. Both coding schemes were applied separately to the verbal segments; first, to the four information types without reference to the specific components of the task; then to the thirty-four content segments. An overall agreement of 89 percent between the two coders was achieved.

Participants' verbalizations were coded on two dimensions: the type of verbalization (acknowledgement or attention) and the type of task mentioned (highlights or details). Two coding schemes were applied to the verbal segments, as described in Mann (1995a), Mann (1997c).

*The process coding scheme.* Using the first coding scheme, relevant process segments from the participants' verbalizations were classified within four information types without reference to the specific components of the task.

Intention Segments (Chan, Burtis, Scardamalia & Bereiter, 1992; Ericsson & Simon, 1984). Intention segments imply that the presentation was noticed without necessary mindfulness of the information. Although participants respond to both content information and to program directions that require appropriate decisions,

the responses consist of associative reactions to the information without dealing with the information. The following segments would qualify under the intention category: "I need to click here to find out what it says."

Attention Segments (Ericsson & Simon, 1984). Attention segments imply that the full intent of the presentation was understood. This meaning of attention was suggested by Ericsson and Simon (1984) to indicate that the participant is examining some aspect of the current situation. The following segment would qualify under the attention category: "So, she wants me to write first and compare afterward."

Interrogative Segments (Chan, Burtis, Scardamalia & Bereiter, 1992).

Interrogative segments should be questions relevant to a presentation using one's general knowledge. The following segment would qualify under the interrogative category: "What should I do now."

Evaluative Segments (Chan, Burtis, Scardamalia & Bereiter, 1992; Ericsson & Simon, 1984). Evaluative segments indicate agreement or disagreement with a presentation and recalls personal knowledge to support or contradict the presentation. The following segments qualify under the evaluation category:

"These models are not really that different from each other;" "The voice makes me want to say it out loud first;" and "The words that are in different colours are common to the forest floor."

The criterion-related validity of the four information types concerned the efficacy with which these types could predict behaviour on a well-specified, predetermined criterion

(Borg & Gall, 1989). The four types have been documented in the peer-reviewed research (Chan, Burtis, Scardamalia & Bereiter, 1992; Ericsson & Simon, 1984) and were therefore considered to be well specified, predetermined criterion.

***The content coding scheme.*** Using a second coding scheme, relevant content segments from the participants' verbalizations were classified according to thirty-four specific components of the task; namely, twenty-two highlights and twelve details.

**Highlights Segments** Highlights segments refer to the main idea or epitome (Reigeluth, 1991) in a presentation. These include directing a participant's attention to names of the layers of a tropical rainforest to be displayed on the next screen. A highlights segment is not an analysis or critique.

**Details Segments** Details segments refer to the elaboration on the main idea (Reigeluth, 1991); on the following screen each layer will be pronounced as the participant reads the names of the four layers of a tropical rainforest.

The same procedure for determining content validity of the materials and test items in a previous study (Mann, in press; 1993) was applied to the thirty-four content segments used in this study. The content was reviewed by an instructional design expert in evaluation. Concerning the criterion-related validity of the thirty-four content segments, framework of Alessi & Trollip's computer-based instructional model (1991) was considered to be well specified predetermined criterion.

All of the verbalizations were coded by the investigator, one third of which were recorded independently. Both coding schemes were applied separately to the verbal segments; first, to the four information types without reference to the specific

components of the task; then to the thirty-four content segments. Written transcripts of the participants' videotapes were used while viewing the videotapes to aid in the segmentation procedure.

### **Procedure for the Validation Stage**

The procedure for conducting the validation stage of the formative evaluation was informed by previous evaluations conducted in natural settings (Mann, Newhouse, Pagram & Campbell, 2000; Mann, 1997b). A number of activities were done simultaneously and the final schedule established at the mutual convenience of the participants, classroom teacher and the investigator.

***Step 1. Installation.*** With the consent of the school principal, a computer, headphones and videotape recorder were installed in an area of the classroom and partitioned from the rest of the class.

***Step 2. Consent and Sampling.*** Next, the consent of the Director (see appendix I), Principal (see appendix J) and Parents (see appendix K) were acquired. Over the course of two weeks of the validation stage, twelve students from the class were asked one-at-a-time by their teacher to sit at the computer with the investigator to "learn something new on the computer". For verbal instructions for the participants and notes the investigator were used to guide the participants (see appendix L). The participants were selected according to the process mentioned earlier.

***Step 3. Training on Verbal Protocols.*** Participants were informed individually that the investigator was interested in how they proceeded through the software prototype to arrive at their answers. The verbal instructions were not read from a prepared script,

but were previously rehearsed and consistently explained to each participant. Using an Explorer Centre, the investigator modeled the task using the computer program called "Language Explorer" (Nordic Software, Inc., 1995), while thinking aloud. Participants then practiced with the Language Explorer program and were asked to describe aloud what they were thinking, doing, attending to, or planning in the course of solving a problem. During this practice, the investigator interacted freely with the participants, offering suggestions and encouraging them to verbalize their thinking. When both the participant and investigator were satisfied with the participants' use of protocol, the evaluation then proceeded to the next step. Each participant took on average fifteen minutes for this practice.

***Step 4. Verbal Protocol Review.*** Upon completion of the practice program the videotape was rewound and played back to the participants. This gave the investigator the opportunity to show the participants how their responses were acquired, thus providing positive feedback to the participants on the importance of their verbalizations.

***Step 5. Explorer Centre.*** Using an Explorer Centre, the participants in these trials were required to proceed through the software prototype while following the instructions and thinking aloud. One hour was allotted to thinking aloud with the prototype. Each participant in these trials was required to proceed through the computer program while following the instructions and writing in the workbooks. Their verbalizations were videotape recorded and transcribed along with the investigator's notes about relevant nonverbal behaviours. The investigator presented no instruction or feedback at this time. Notes of the proceedings were maintained to clarify ambiguities in the recordings.

**Step 6. The Task.** Using the Explorer Centre, the participants were instructed to describe aloud what they were thinking, doing, attending to, or planning in the course of learning from “Rainforests of the World” software prototype. When each think aloud session commenced the investigator reminded the participant, “As you go through ‘Rainforests of the World’ software prototype, just tell me how you are getting your answers.” When the participant “froze,” the investigator asked one of the following questions to generate a verbal response: (a) What are you trying to do now?, (b) What makes you think so?, (c) How did you know that?, or (d) Why?

**Step 7. Semi-Structured Interview.** A semi-structured interview as suggested by Alessi & Trollip (1991) was administered immediately following the verbalization process in which the participants reconstructed the strategy they used in learning from the software prototype. Each session was conducted with one participant at-a-time, by the investigator. See appendix F for the list of Semi-Structured interview questions that were asked to each participant. It was anticipated that their verbal reports would concentrate primarily on information concerning their immediate attention. Therefore, additional information would be useful in any attempt to reconstruct more global intentions. In this interview, participants were encouraged to recall their own procedures for learning layers and facts for the “Rainforests of the World” software prototype.

### **Results of the Validation Stage**

The quantity of verbal reports varied considerably, both in terms of the learning process and the content, although the training helped to flatten this effect. Three segmentation guidelines were implemented. First, the verbal transcript was divided at each new thought. Second, grammatical cues that combined one or more ideas and verbs indicated

a separate sentence. Third, pauses and reflective utterances such as 'um' or 'ah' were interpreted as indications that participants were moving into a new thought. An independent rater repeated this procedure on one third of the verbal data according to the first rater's segmentation. There was a 93 percent agreement between the segmentation of the two raters.

Four categories were assigned to the process dimension (intention, attention, interrogation, evaluation), and two categories to the content dimension (highlights and details), as recommended in Mann (1997a). Since the coding dimensions overlapped, they were kept distinct. A single content segment could relate to a series of process segments. This coding scheme was intended to capture differences in how individuals dealt with the tasks and modalities, and to quantify these differences in a reliable way. Table 1 on page 29 shows the raw summary data of two coding dimensions from the validation stage of the Rainforests program.

*Process protocols.* The process protocol was one coding dimension used in this formative evaluation. Participants verbalized from an infinite number of possible process segments within four information types (intention, attention, interrogation and evaluation) without reference to the specific components of the task.

Table 1 on page 29 shows the raw summary data for the process segments based on the coding of the participants' responses. Twelve participants were involved in the validation stage. The age of the participants ranged from eleven to thirteen years old with an average age of 11.83 years. Eight female and four males participated in the evaluation. One third of the participants were average readers, forty two percent of the participants were below average readers and one quarter of the participants were well below average

readers. One half of the participants had no special needs while the other half had special needs. A total number of 1041 process protocols were generated by the participants taking part in the formative evaluation, broken down in the following manner: Intention 558 verbalizations, Attention 149 verbalizations, Interrogation 156 verbalizations and Evaluation 178 verbalizations.

Table 1. Raw summary data validation stage of the "Rainforest of the World Program"

Given Name	Age	Gender*	Reading Level**	Special Needs***	Process Segments				Content Segments	
					Int	Att	Interr	Eval	Highlight	Detail
Student 1	12	2	1	1	45	17	28	12	21	11
Student 2	11	1	2	1	48	6	11	22	20	12
Student 3	12	1	3	2	62	6	7	7	27	13
Student 4	12	2	1	1	20	23	30	21	22	11
Student 5	13	2	1	1	61	18	10	18	26	14
Student 6	11	2	3	2	39	8	7	1	14	6
Student 7	12	2	1	1	47	9	9	21	22	11
Student 8	12	2	2	1	54	8	12	14	23	11
Student 9	12	2	2	2	47	16	12	17	20	11
Student 10	11	2	2	2	41	7	10	13	19	10
Student 11	13	1	3	2	62	20	8	12	22	12
Student 12	11	1	2	2	32	11	12	20	22	12
<b>Totals</b>	11.83				558	149	156	178	21.50	11.17

\*Gender: 1 = Male, 2 = Female

\*\*Reading level: 1 = average reader, 2 = below average, 3 = well below average

\*\*\*Special needs: 1 = no special needs, 2 = special needs

Process verbalizations were expected to begin with Intention and Attention verbalizations, then Interrogation verbalizations and finally to Evaluation verbalizations. To verify this statement the data in Table 1 needed to be modified in order to clearly state whether the above statement was correct. For Example, Student 1 in Table 1 had 45 Intention verbalizations, 17 Attention, 28 Interrogation and 12 Evaluation verbalizations, but this table did not show when (what module of the computer program) the verbalizations took place. Therefore, a table that determined when the verbalizations took place as the participants progressed through the prototype was needed. The computer

program was divided into quarters, then the investigator counted the verbalizations made by each participant in each quarter of the computer program and combined those results for each quarter together. Those collective verbalizations resulted in Table 2. Therefore, the resulting data of Table 2 showed that the process verbalizations did not evolve as expected in the above statement.

**Table 2 Evaluation results on comparisons of process verbalizations**

<b>Verbalization Results</b>	<b>Intention</b>	<b>Attention</b>	<b>Interrogation</b>	<b>Evaluation</b>
1st quarter of participants verbalizations	107	55	61	31
2nd quarter of participants verbalizations	127	36	41	56
3rd quarter of participants verbalizations	152	35	28	49
4th quarter of participants verbalizations	172	23	26	42
<b>Totals</b>	<b>558</b>	<b>149</b>	<b>156</b>	<b>178</b>

The Intention segments were predicted to begin high then decrease as the participant progressed through the program. The intention verbalizations continued to increase through the progression of the participants' results (1<sup>st</sup> quarter 107 verbalizations to 4<sup>th</sup> quarter 172 verbalizations), therefore, disagreeing with what were the expected results.

Attention segments were predicted to begin high then decrease (1<sup>st</sup> quarter 55 verbalizations to 4<sup>th</sup> quarter 23 verbalizations) as the participant progressed through the program. This held true through the results as predicted.

Interrogation segments were predicted to be stronger in the latter stages as the participant progressed through the program. Interrogation verbalizations were stronger in the first quarter of the results and continued to decrease throughout the results (1<sup>st</sup> quarter 61 verbalizations to 4<sup>th</sup> quarter 26 verbalizations), therefore, disagreeing with the expectations.

Evaluative segments were predicted to be stronger in the latter stages as the participant progressed through the program. Evaluation verbalizations were slightly stronger in the latter stages (1<sup>st</sup> quarter 31 verbalizations to 4<sup>th</sup> quarter 42 verbalizations), but were not as prevalent as was expected. The conclusion will address some contributing factors that may have affected the outcome of the participants' results.

From post-test interviews, participants stated they used the sound prompts as a guide to focus on what to do next. Where a screen displaying a menu of choices was displayed the participants' preferred choice was to concentrate on one model through to the summary. The participant's choice took on a linear approach in the choice of what model to proceed with for example, they tended most often to begin from top to bottom. Figure 1 on page 32 shows a screen-print of one of the menus within the program "Rainforest of the World." The participants would most often begin with the adjectives button then proceed linearly through to the food button.

***Content Protocols.*** Thirty-four content segments comprised the content dimension: 22 Highlights and 12 Details. The participant's ages varied outside the range of grade five and six due to the student being held back one grade level. More girls than boys participated in the study due to choices the investigator and homeroom teacher made in who should participate. Regarding reading level, there were no above average readers due to the lack of available students at that academic level at that period of time.

Previously stated statistics from T-STAT (1996) support this notion, therefore average, below average and well below average readers was used for the study. Content segment data showed that of the thirty-four detail (22) and highlight (12) screens the participants averaged 21.5 of the detail screens and 11.17 of the highlight screens. Thus, most of the

participants were able to view the whole "Rainforests of the World" computer program in the time allotted. There was one participant that did not complete the program and two participants that proceeded through some sections of the "Rainforests of the World" computer program more than once.

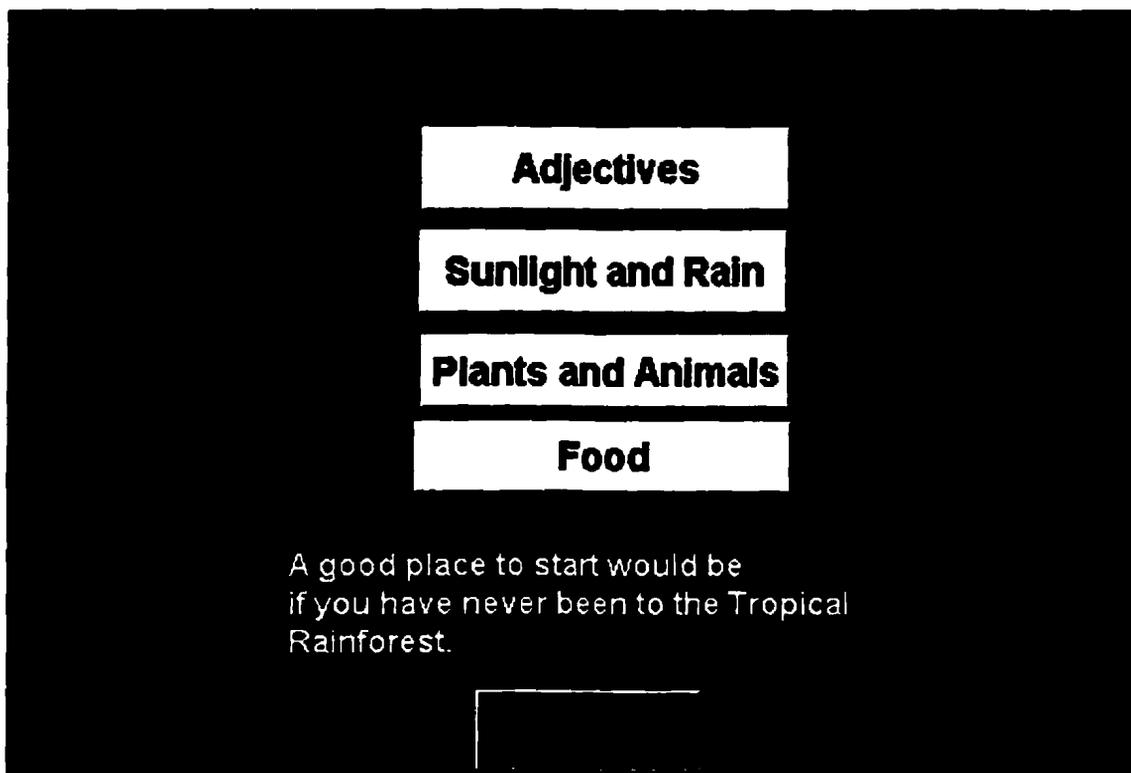


Figure 1. Facts menu screen print from "Rainforests of the World" prototype.

The conditions were compared within each category to reveal something about the task process. The most direct way to compare these different kinds of verbal segments was to discuss the categories, and then explain the results in summary form, as shown in the following sections. Participants also recounted their strategies in the interviews for making the learning experience and the content meaningful.

## **Summary**

This section reported on the methods used in the development and formative evaluation of the computer-based prototype called "Rainforests of the World", the Student workbook, and Instructor's Manual (Whenham, 1995). The next segment will discuss the validation of the learning process.

### **Validation of the Learning Process**

Results of the Validation stage showed that there were 1041 process protocols generated by the participants as they proceeded through the "Rainforests of the World" computer program. 53.6 percent of the results were Intention verbalizations, 14.3 percent of the results were Attention verbalizations, 15 percent of the results were Interrogation verbalizations, and 17.1 percent of the results were Evaluation verbalizations. However, the process verbalizations did not follow the expected flow of responses, beginning with Intention and Attention responses then Interrogation responses and finally Evaluation responses. Participant's characteristics matched the general statistical profile generated from the data collected from T-STAT (1996). Having looked at the process protocol (participants' responses starting with intention segments and proceeding to evaluation segments) we can proceed to look for relationships between the data and the participants' characteristics.

Relationships were examined between the participants' responses given while interacting with "Rainforests of the World." Correlations were calculated on the process segments to see if any significant relationships were present. Relationships were discovered between age and process segments, age and content segments, reading level and process segments,

special needs and process segments. Table 3 shows correlations between the raw summary data from the validation stage and the participants' characteristics.

**Table 3 Correlations between segment data and participant characteristics**

	<b>Intention</b>	<b>Attention</b>	<b>Interrogation</b>	<b>Evaluation</b>	<b>Highlight</b>	<b>Detail</b>
<b>Gender</b>	-0.2634	0.2044	0.3358	-0.0486	-0.2784	-0.4111
<b>Age</b>	0.5622*	0.6485**	0.0658	0.0733	0.6110**	0.5423*
<b>Reading Level</b>	0.3317	-0.3919	-0.6254**	-0.6724***	-0.2247	-0.2847
<b>Special Needs</b>	0.0552	-0.1879	-0.4974*	-0.5220*	-0.2624	-0.2683

n = 12

\*p<.10

\*\*p<.05

\*\*\*p<.02

### **Intention**

Data were correlated under the following relationships: Gender, Age, Reading level and Special Needs. Table 3 shows that age was the only characteristic to have a significant relationship with intention segments. Age and intention segments were moderately significantly related,  $r = +.5622$ ,  $n = 12$ ,  $p < .10$ , two tails. This positive correlation supports the results shown in process protocol. The moderate significance supports that as participant's age increases with the intentional segment responses. The following verbalizations qualified as intention segments:

The voice is telling me to look at the rainforests on the map (Intention).

There I go to next page (intention).

### **Attention**

Attention segments data were correlated under the same relationships used in intention segments. Age was the only characteristic to have a significant relationship with attention segments. Age and attention segments were significantly related,  $r = +.6485$ ,  $n =$

12,  $p < .05$ , two tails. Although attention responses decreased as the results progressed in the process protocol when combined with the intention segments the data shows a significant portion of responses. This positive correlation supports the significance of age on attention segments responses. The following verbalizations qualified as attention segments:

It looks like, its like... like there's lots of plants on the ground (attention).

I'm just looking at this picture...I'm looking for adjectives among the plants and animals (highlight / attention)

### **Questioning**

Interrogation segments data were correlated under the same relationships used in the previous two segments. Reading level and Special needs were the characteristics to have a significant effect on interrogation segments. Reading level and interrogation segments were significantly related,  $r = -.6254$ ,  $n = 12$ ,  $p < .05$ , two tails. Special needs and interrogation segments were significantly related,  $r = -.4974$ ,  $n = 12$ ,  $p < .10$ , two tails. Reading level and special needs have an inverse relationship to interrogation segments. With only one third of the study participants being average readers and one half the participants labelled as special needs, it makes sense that if the participant has a low reading level or is special needs or both they make less interrogation segment responses. The following verbalizations qualified as interrogation segments:

What am I going to do now? Pick one? (highlight / interrogation)

Adjectives what does it mean? (Interrogation)

What's that means...(Interrogation)

## **Evaluating**

Evaluation segments data were correlated under the same relationships used in the previous three segments. Reading level and special needs were characteristics that have a significant effect on evaluation segments. Reading level and evaluation segments were very significantly related,  $r = -.6724$ ,  $n = 12$ ,  $p < .02$ , two tails. Special needs and evaluation segments were moderately significantly related,  $r = -.5220$ ,  $n = 12$ ,  $p < .10$ , two tails. As stated previously in the interrogation segments, reading level and special needs again have an inverse relationship to evaluation segments. Again, given the low reading levels there was a very significant relationship to reading level and evaluation segments. This also makes sense with the previously stated results of process protocol where it was determined that interrogation and evaluation segments did not produce a sequence whereby process verbalizations tended to begin with Intention and Attention then Interrogation and finally to Evaluation. The following verbalizations qualified as evaluation segments:

I just did that. I just did that...mmm...It's the same picture (Evaluative).

Because, because up here (where we live) birds, some birds live on the ground (highlight / evaluative).

...animals...what's this...a penguin no-no a ptarmigan...bugs... (highlight / attention / interrogation / evaluation)

...a little bit of rain... the umbrella...(Evaluative)

Do I do the same thing...I did it on the other page (evaluative).

They're not the same like they're not...one is like a cool place and one is like hot like it's because like it's near the equator (evaluative).

### **Validation Interviews**

A semi-structured interview was administered immediately following the verbalization process in which the participants reconstructed the strategy they used in learning from the software prototype.

A consensus of the participants stated that they were able to navigate through the whole "Rainforests of the World" computer program in the time allotted. Most participants agreed that they preferred to be able to venture anywhere they liked in the rainforest. The graphics in the prototype are not redundant to the text, but effectively integrated with text to provide more information to enhance learning (Park & Hannafin, 1993). Were you able to make a connection with the graphics and questions? "Yes, the birds and their colours."

The use of sound through spoken instructions and directions for future screens and feedback about the past, created a relationship with the screen text (Mann, 1995a). Did the sound aid you with the next screen and what to look for? "Yes, very much" and "Yes, [provided] more information."

Effective prompting and feedback provides a method for emphasizing critical information and useful to ensure important information is learned and interpreted properly (Park & Hannafin, 1993). Almost all the participants commented that the sound feedback provided closure to the informational paths. "Yes, the animals [on the forest floor] are small and dark."

When new knowledge is integrated with existing knowledge learning will become more meaningful (Park & Hannafin, 1993; Wittrock, 1986; Seifert, 1994; Pressley &

McCormick, 1995). Did the prototype reveal certain aspects that were real-life to you? “Yes, [pointing to the bird] a Ptarmigan” and “Yes, the man standing on the ground [on the forest floor].”

In this evaluation, relationships produced very useful results. Even though gender does not have any correlation with “Rainforests of the World.” Age, Reading level and Special needs each have specific correlation with “Rainforests of the World.” Each of these relationships effects how well the participant is able to process and verbalize what they were experiencing while using “Rainforests of the World” software. The participants relied on the temporal sound prompts to help guide, facilitate and bring closure to their progress through the modules of the program. Participants were asked if the sound aided them with the next screen and what to look for, “the talking helped me a lot” and “I liked it, [it was] helpful”.

Most participants liked the “Rainforest” programs graphics when asked during the semi-structured interview. In combination with the sound prompt the graphic helped most participants focus their attention on where and what to look for on a particular screen print. For example, one participant listened tentatively to what the voice said on the computer and often hit the “go back” button to hear the voice again. For some participants the voice on the computer would initiate the participant to talk more openly or answer the question out loud without realizing they were talking to the computer.

Many of the participants commented they found the questions asked in the “Rainforests of the World” computer program hard, but although it was difficult all the participants commented that the program kept their interest and they did not get bored. When asked if the participant was challenged by the program’s questions many answered, “Yes

challenging, a little bit hard”, “[a] little bit hard” and “didn’t make me bored”. Some participants also expressed an interest in doing the program again, “[I] want to do it again”.

Four of the participants also commented on the colour scheme used in the “Rainforests of the World” computer program. Some noticed that darker colours were used on the forest floor and that the upper levels of the rainforest were brighter colours. The best example of this was when one of the participants commented on the screen print that had two birds (one from the forest floor and one from the canopy), “chicken [native word for a grouse] on the ground, parrot up high”. Participants also commented they liked the way the workbook colours were the same as the colours in the program.

83 percent of the participants expressed a positive interest toward the workbook.

Participants liked the pictures in the workbook and the fact that the picture in the workbook was the same as the graphic in the computer program, which made navigation between the two easier. The participants liked the construction of the workbook because there was a question, then for their answer the participant was prompted what to write. Figure 2 on page 40 details an example of the workbook construction. Notice the graphic of the forest floor and the question, “why do you think plants and animals on the bottom are dark and small?” The answer box is constructed to help the participant answer the question by stating, “I think they are dark and small because...” Many of the participants commented they liked the boxed area to write their answers in the workbook, “[I] like to write in the [workbook] boxes”.

The final positive comment participants made about the "Rainforests of the World" computer program was that they were learning about a place that was far away and that they had never visited and this they enjoyed very much.

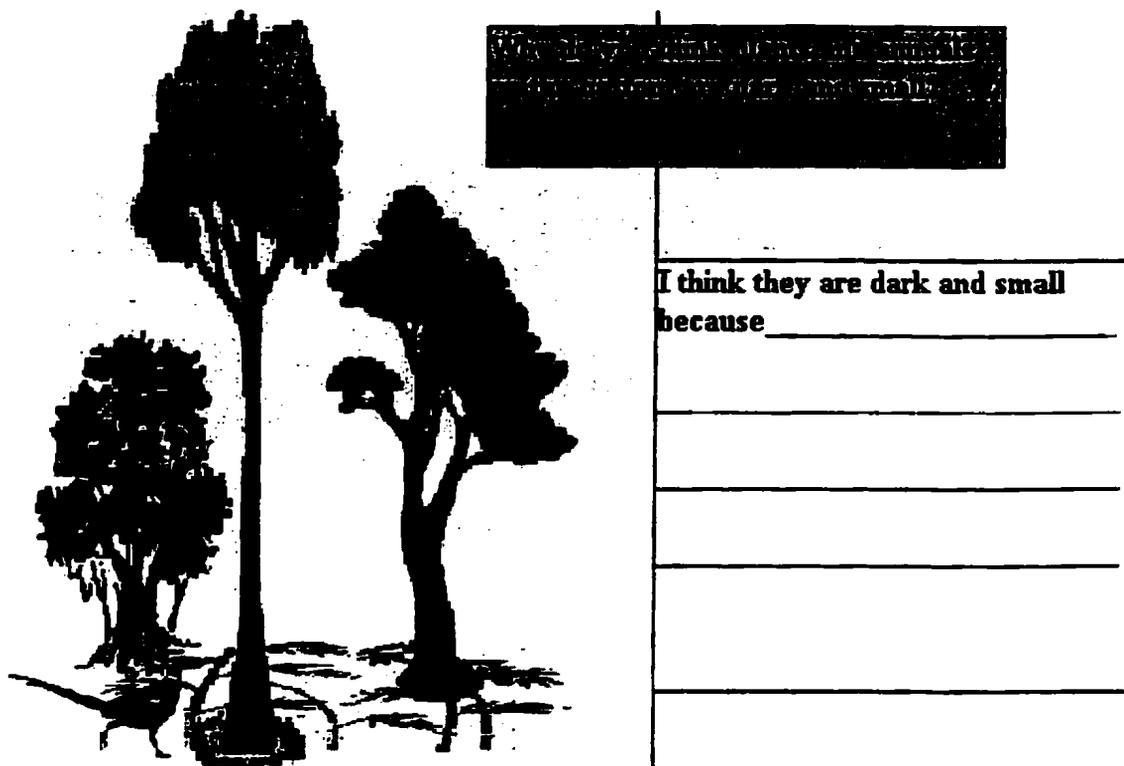


Figure 2. Sample workbook page from "Rainforest of the World" prototype.

### Validation of Rainforest Knowledge

Results from the Content Protocols showed that most of the participants were able to navigate through the whole "Rainforests of the World" computer program in the time allotted. One participant did not finish the program and two proceeded through some sections of the program more than once. Correlations were calculated on the content segments to see if any significant relationships were present. A correlation for the data revealed that age and highlight segments were significantly related,  $r = +.6110$ ,  $n = 12$ ,  $p < .05$ , two tails. It was also determined that age and detail segments were moderately

significantly related,  $r = +.5423$ ,  $n = 12$ ,  $p < .10$ , two tails. These two findings are interesting in determining the positive effect age has on being significantly better able to decipher information largely at the level of meaning (highlights) and less significantly at word level (details), which is consistent with research. The following verbalizations qualify as highlight and detail segments:

The rainforests are suppose to be around here (Highlight / Evaluative).

The rainforests are green... huh... green means trees...um...I think the blue means...ah...like water (Highlight / Evaluative).

I pictured myself at the bottom of the rainforest...it's big...the man is lost...can't find his way around...he's scared (highlight / evaluative).

All these are grass, tropical rainforest and mmm the blue is temperate rainforest (highlight / evaluative).

The ones on the forest floor don't have like no flowers and don't grow in the same layers (detail /attention / evaluative).

No... to low...and needs water to grow (detail / evaluative).

### Summary

Chapter three was a description of the formative evaluation of the computer-based prototype "Rainforests of the World" designed specifically for students attending grades five and six in the Northwest Territories and used the student data to improve the instructional materials. Chapter four reports on the recommendations for revisions to those computer-based materials.

## *Chapter 4*

### RECOMMENDATIONS

Several recommendations for improvement to the instructional materials can now be made here based on the quantitative and interview data in the Validation stage. The first recommendation suggested by the participants was navigational. These improvements would take a multi-faceted approach, and would all need to be looked at in unison to be able to solve the navigational difficulty. The three main factors that needed to be improved were, some screens had too many buttons on them and caused confusion in what to do next. Some participants had trouble with a graphic that was used in more than one module of the program, "I've already seen that [graphic]" and "haven't I done that?" The final area to address the navigation of the program concerned the names of some buttons, one participant suggested to replace the "go back" buttons with "replay" and "[I would] like to see some button[s] changed". One participant thought there were not enough options in the program. This participant would continually use the mouse to click on the coloured words because the participant thought something would happen, "highlighted word should give more information".

The second recommendation for improvement suggested by the participants was to improve the workbook. Some participants found it difficult to manage the workbook and the program together. One participant "find it [the workbook] a little hard to use". Some participants did not think enough space was given in the workbook answer box to write out their answer. Those participants commented, "need bigger boxes"; "need more room in boxes" and "bit bigger [box], please".

The third recommendation for improvement was to update and refresh the graphics of the program to eliminate duplicate graphics and the possible confusion that might result from the student seeing the same graphic in more than one module. This would improve the participants navigational ability within the "Rainforests of the World" computer program.

The fourth recommendation for improvement was to improve the structure of the buttons. Renaming some of the buttons would make a difference to the student's navigational ability to keep them from getting lost and ultimately frustrated with the program. One example of a button that needs to be improved is the button called "Tropical Menu" button at the end of each module in the study of the Rainforest by Facts menu (see figure 1 on page 32). The "Tropical Menu" button at the end of each module on the Rainforest by Facts menu takes one back to the Tropical menu, but the confusion arises when the student needs to proceed forward to the Rainforest by Facts menu in order to continue with the other modules of this menu. Renaming or linking the buttons to a different page would alleviate this navigational confusion.

The final recommendation for improvement to consider was to better integrate the workbook with the computer program. To make the workbook more functional and seamless with the program it needs to be incorporated into the program. By incorporating the workbook into the program the student would no longer need to shuffle between the computer screen and papers, thus lessening the chances for the student to become disoriented or lost while using the program. The student would be able to click a "Workbook" button then have the corresponding workbook page pop up, the student could then type in their answer and finally go back to continue on with the program.

Implementation of the improvements discussed in the previous paragraphs would enhance the program's ability to solve the improvements suggested by the participants. Improving some of the graphics, certain buttons and integrating the workbook would resolve the improvements that the participants felt needed to be addressed, thus strengthening the program's viability as an educational learning instrument for students.

### **Contributing Factors**

The findings of this evaluation appear to be predicated on several mitigating factors. The first factor was that the participants' characteristics (Gender, Age, Reading level and Special needs) affected the way in which they generated process protocols through verbalizations while deciphering the information, therefore, making the evaluation more reliable to both personal and situational traits (Knussen et al., 1993).

The second factor that seemed to affect the findings was the inability of some participants to focus on a task for any length of time. Some participants were observed squirming and fidgeting, unable to sit still for a period of time, easily distracted from the task at hand, had difficulty generalizing information, unable to complete task and exhibited a lack of organizational skills to manage the workbook and program. These are known symptoms to attention deficit disorders as suggested by (Glassman, 1999; McCarney, 1994) and fetal alcohol syndrome as suggested by (Doctor, 1996).

The third factor that imposed limitations in the findings was the effectiveness of the post-test interview. The post-test interview revealed the sequential training was beneficial to the participant to gain confidence and knowledge in how to navigate the "Rainforests of the World" prototype. The post-test interview conveyed the graphics effectively

integrated with the text to provide more information to enhance learning as suggested by (Park & Hannafin, 1993) by the participants' ability to visualize themselves in the situation detailed by the graphic as suggested by (More, 1999).

The fourth factor that seemed to affect the findings was that of the design of the program "Rainforests of the World" to take advantage of the learning strengths of the participants who tend to learn in a holistic (global) nature, as suggested in (More, 1999; Martin, 1990; Tamaoka, 1986). Presenting the overall concept at the beginning of the program then proceeding to its parts affected the participants strategic processing during learning the declarative information about the rainforest. Immediate feedback as suggested by (More, 1999) and effective prompting provides a method for emphasizing critical information and useful to ensure important information is learned and interpreted properly (Park & Hannafin, 1993).

### **Limitations**

The following limitations in the design of this evaluation should be noted. First, the size of the sample used in this evaluation was small ( $N = 12$ ) in order to make better predictions on the total population a larger sample was needed. Second, speech was used as opposed to attributional factors such as sound effects and or music thus informational cues were not addressed. Third, speech programmed was that of a Non-Dene person as opposed to a Dene person. Fourth, only Dene and Metis children were available to participate in the analysis; would the addition of non-native participants change the results? Fifth, the author was not provided with access to the participants' cumulative records, but was able to assess the participants through meetings with their classroom teacher and also being the previous teacher to some. Sixth, without access to participants'

cumulative records proper grade levels could not be used to categorize the reading level (broader categories were needed; average, below average, etc.). Seventh, no above average readers were available to participate in the evaluation; thus, what affect would there be on the results? Finally, regarding gender, would the results have varied if an equal number of male and female participants had been used?

### **Summary**

This discussion of the results of the formative evaluation of the "Rainforests of the World" computer prototype, the Student Workbook, and Instructor's Manual, as well as possible contributing factors concerning the results, and limitations of formative evaluation was intended to provide advice for improving the learning environments in the Northwest Territories.

Results of the Quality Review revealed that the wording of a few questions needed to be restructured and that the page-numbering scheme be revised. The size and colours of the Program's buttons were modified, as well as a new button was created. A graphical image was replaced due to poor quality and graphics were changed in the workbook. The modifications were made based on the subject matter experts and instructional design expert's comments; corrections were made in November-December 1995. Results of the Pilot Test showed that there were three suggestions for clarification to the "Rainforests of the World" computer program to be made before commencing to the validation stage. Some modifications regarding the sound, that is speaking less quickly so the participants could focus clearly on what information was required, were corrected within the program. A couple of changes with regards to the graphics were made to aid the participants understand and answer the questions the computer program was asking. The final result

that occurred from the pilot test was the addition of a title page for easier navigation of the workbook. Each result was modified and completed before proceeding to the validation stage. Results of the Validation stage revealed that a main advantage of this prototype was its availability to give the participant choices to learn the information about rainforests, as suggested in the literature (Park & Hannafin, 1993; Alessi & Trollip, 1991). Although unintended, this project also confirmed some predictions that may hopefully produce some insight into the application of instructional design and formative evaluative to the development of computer software for a specific target audience. Its strongest asset, however, must be its potential for future development of educational software for Dene students.

This Master of Education project then, aimed to report on the development and formative evaluation of computer-based instructional materials entitled "Rainforests of the World", a Student Workbook, and an Instructor's Manual (Whenham, 1995) designed for Dene and Non-Dene students attending grades five and six in the Northwest Territories. For all intents and purposes this aim has been achieved in this document.

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## APPENDIX A

The on-screen objectives for the software prototype "Rainforests of the World."

**Remember, your teacher's guide on your journey!!!**

**Remember, information you have gathered from a walk in the park, home, hobbies, talking with other people and other subjects in school will help you with the questions.**

important  
enjoy  
adventure

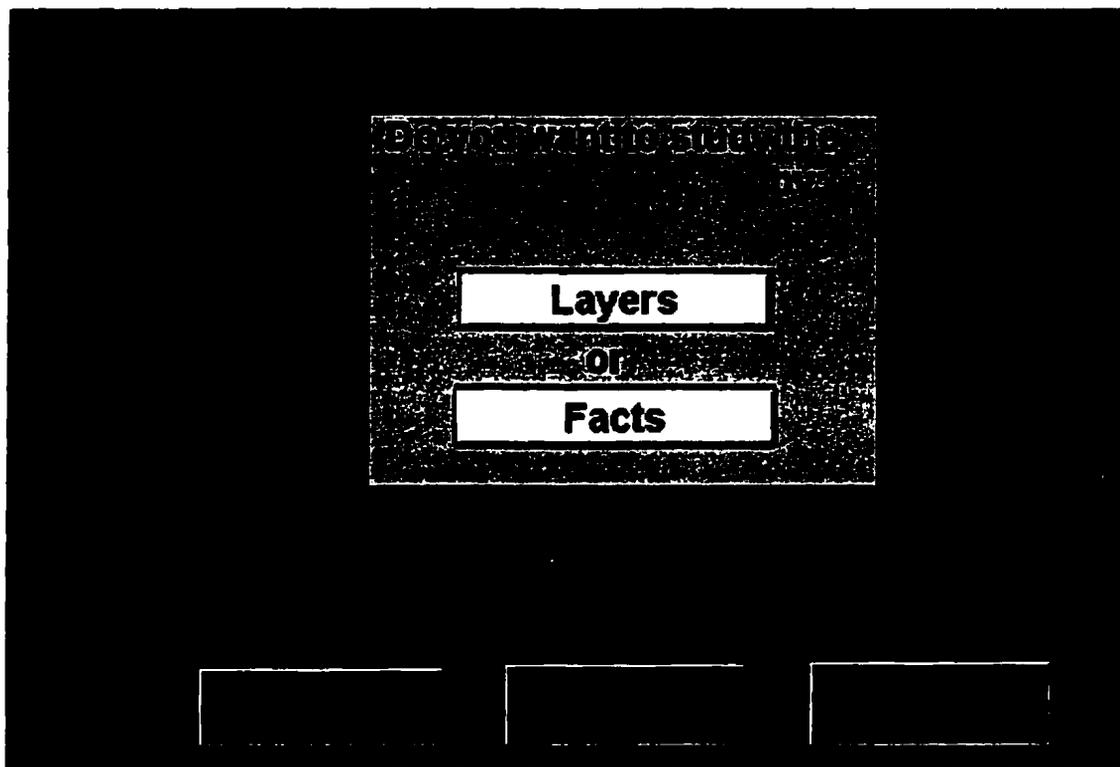
**You will need to use your imagination, be creative and rely on your instincts (a gut feeling) to learn about the questions.**

**Use your workbook to write down your thoughts and help you keep a record of your adventure**

Three empty rectangular boxes are located at the bottom of the interface.

### APPENDIX B

A menu demonstrating two choices on how students would like to learn about a tropical rainforest.



**APPENDIX C**

A menu indicating further options from a choice taken from the screen print illustrated in Appendix B. This menu will appear if the student clicked on the layer button.



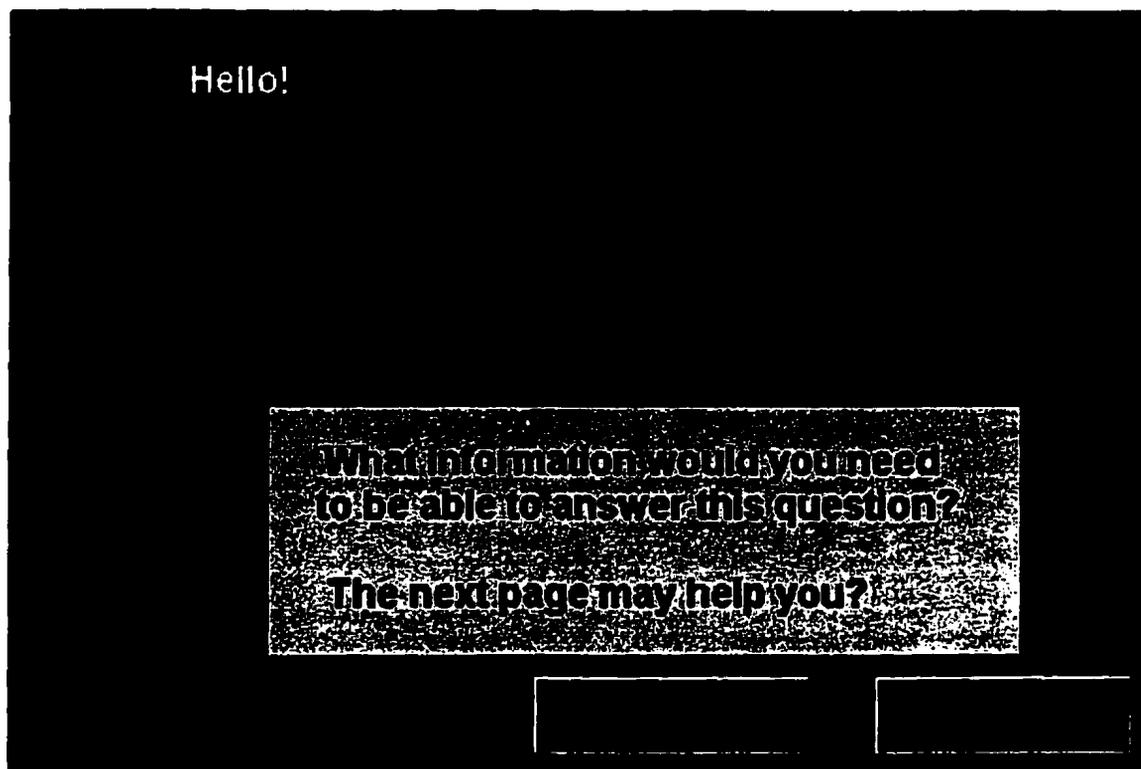
**APPENDIX D**

This screen print highlights the word adjective in red indicating an elaborative link.



**APPENDIX E**

An introduction to deep-level questioning and an example of a deep-level question found within the prototype.



**APPENDIX F****Semi-Structured Interview Questions**

1. Were the questions asked at a good level of understanding for you?
2. Were there enough options for you?
3. Did the prototype reveal certain aspects/issues that were real-life to you?
4. Did you realize/understand where you were within the program?
5. Did you find it clear where you were heading in the program?
6. Did you enjoy the program?
7. Were the categories interesting for you?
8. Were you challenged by the program's questions?
9. Do you believe this program helped you learn about the rainforests?
10. Did you find the hints helpful for responding to the question?
11. Were you able to make a connection with the graphics and question?
12. Would you return to the program again?
13. Did you like it that you were able to venture anywhere you like in the rainforest (free exploration)?
14. Were the questions clear to you?
15. Did you enjoy using the program as a group?
16. Did you ever use the program by yourself?
17. Is there anything you did not like?
18. What was it you found most fascinating?
19. Did you feel in control of the program?
20. How was the feedback? Was it enough?

21. Did the question "by sound" aid you with the next screen and what to look for?
22. Did you find that after you used the program you were able to respond to group discussion with the class?
23. Did the program assist with other group tasks?
24. Was using the mouse an acceptable way to move within the program?
25. Did you like using the mouse?
26. Were the help screens helpful to you?
27. Did the workbook help you organize your thoughts?
28. Did the program help you work together as a group?
29. Were you able to cooperate among each other?
30. Was the workbook easy to use?
31. Were you able to locate the questions in the workbook easily?
32. Did the colour of the pages make a difference to you?
33. Did you find the boxes where you state your response restrictive? Not enough space, etc.
34. Were the objectives at the beginning of the program beneficial to you?
35. Were you comfortable with the program?
36. Were you frustrated at any one time during the program?

### **Questions on the Tropical Rainforests**

- Have you heard or read anything about the rainforest?
- What do you think when you hear the term rainforest?
- What is the first word that comes to your mind when you hear rainforest?
- Have you heard about a tropical rainforest?
- Do you know where the tropical rainforests are in the world?
- Are you familiar with a temperate rainforest?
- Do you know where the temperate rainforests are in the world?

## Tropical Rainforests

- Do you know how many layers there are in a tropical rainforest?
- Are you able to recall the number of layers found in a tropical rainforest?
- Do you know the names of each layer?
- Are you able to recall each layer's name?
- What should you think of when you start to describe a layer of the rainforest?
- What information do you need when you are asked to describe a layer of the rainforest?

## Forest Floor

- Now that you have gone through the prototype, are you able to give two words that may describe the forest floor?
- Why do you think plants and animals living on the forest floor are smaller and darker?
- Will such foods as bananas and nuts grow on the forest floor?
- Why won't agricultural foods grow on the forest floor?

## Understory

- What adjectives best describe the understory of a tropical rainforest?

## Canopy

- How would you describe the canopy layer?
- Why do you think the canopy layer is the busiest layer of a tropical rainforest?
- What factors come into play to make the canopy layer so busy?
- Why do you think most of the wildlife, plants and food make a home for themselves at the canopy layer?

## Emergent

- What makes the emergent layer so different from the other layers of the rainforest?
- Why do you suppose the rainforests are so important to the world?

## Adequacy of Ancillary Learning Support Tools

- What did you like about the workbook?
- How did the workbook help to organize your thoughts as you were learning about the rainforest?
- Was the workbook helpful to you?
- How was the workbook helpful to you?
- Was the workbook easy to use or was it confusing?
- Explain how the workbook, program and you worked together while learning about the rainforest?
- Describe your overall opinion of the workbook?
- What was the writing space like in your workbook?
- Comment on the writing space in your workbook?

**Outstanding Strengths and Features**

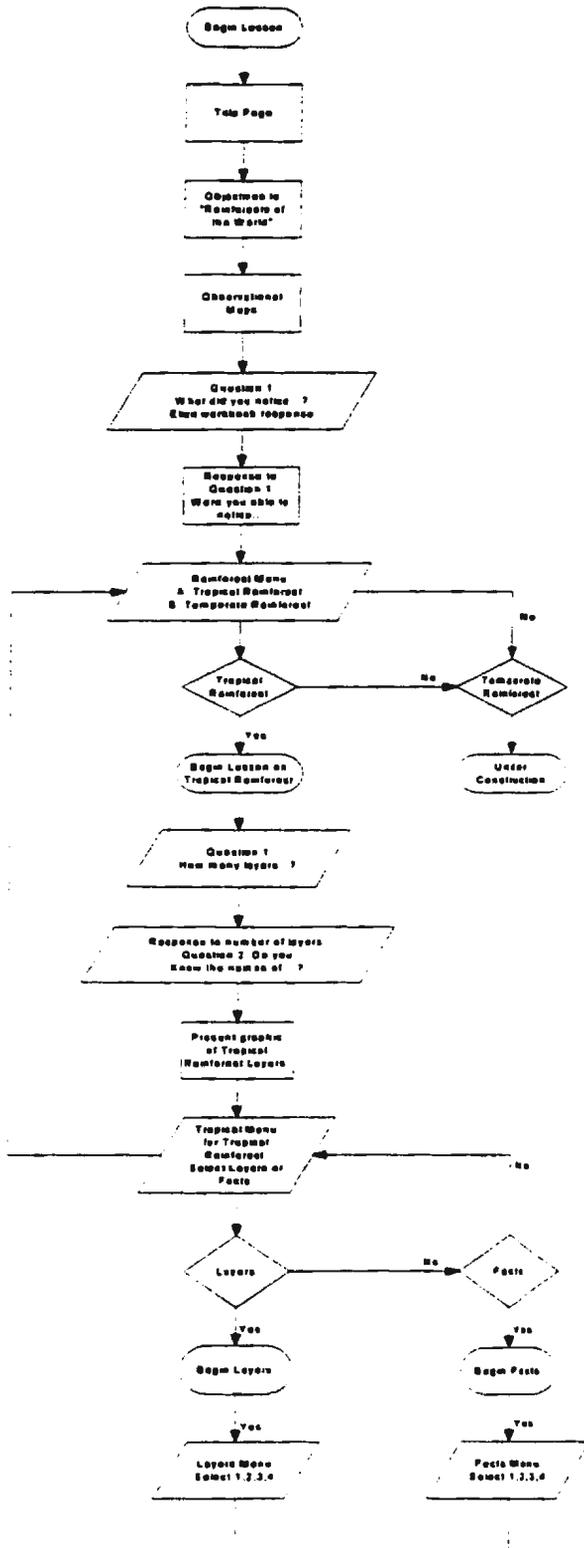
- Is there one thing that stands out to you as being really good about the program?
- What one thing appealed to you as being really good about the program?

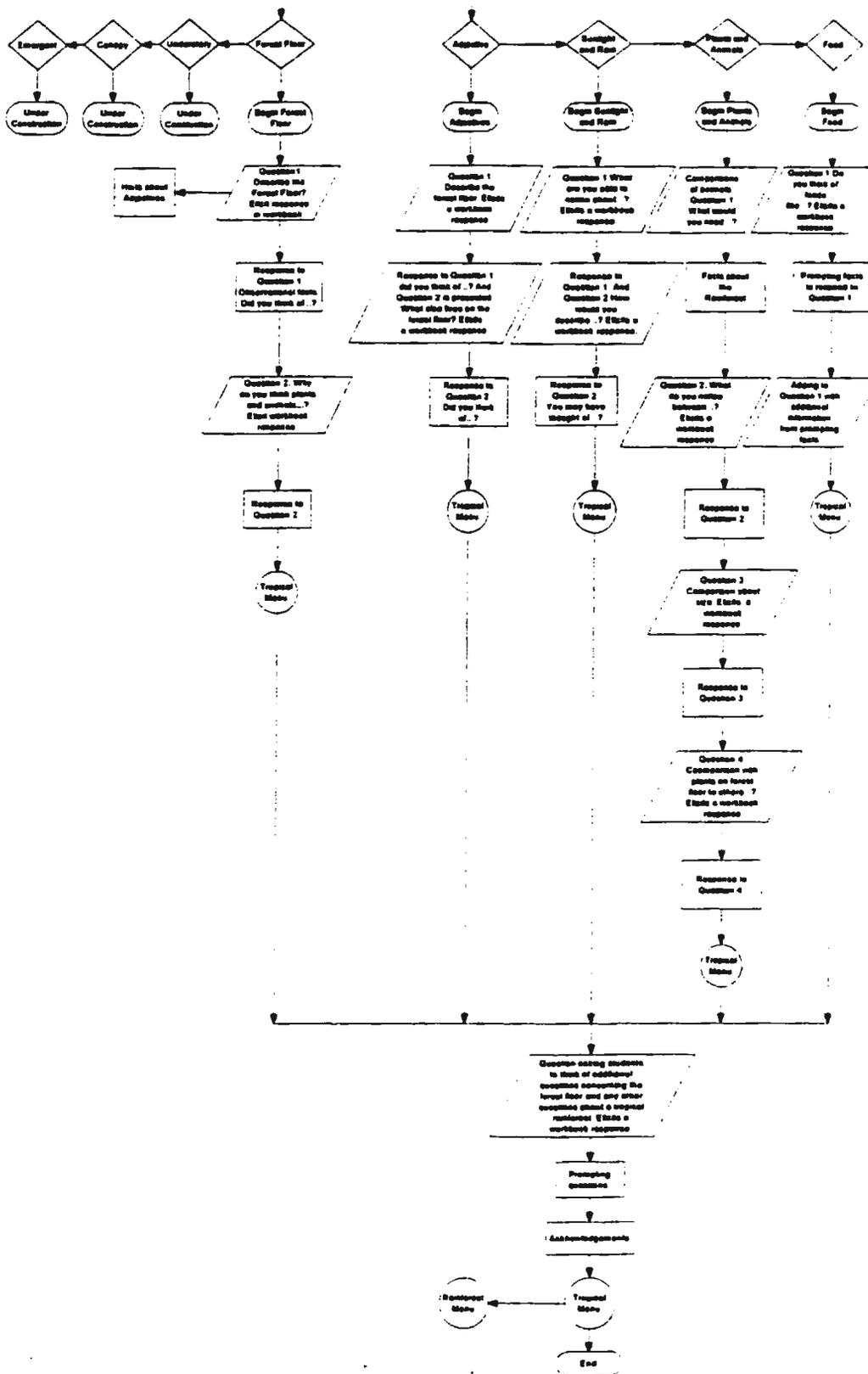
**Outstanding Limitations and Weaknesses**

- Is there one thing that stands out that you really did not like in this program?
- What was one thing that stood out that you really did not care for in this program?

### APPENDIX G

A flowchart illustrating the flow of the software prototype "Rainforests of the World."





## APPENDIX H

**Feedback from the experts while evaluating the prototype at the Quality Review Stage.**

### Instructional Design Expert:

- Nice piece of work, impressive.
- Much effort has gone into this prototype.
- Delays during installation depend on computers speed.
- Add button for listing objectives.
- Page numbering sequence can be simplified.
- Size and colour of buttons could be changed to make them easier for user to locate.
- Sound should be added.

### Subject Expert:

- Removal of one graphic – too dark.
- Restructure two questions.
- Sound would be beneficial to program – implemented later.
- Enjoyed the choice menus.
- Liked the colour scheme.
- Information was appropriate for the grade level.
- Program was easy to use.
- Good two-tiered questions.
- Thought provoking questions.

## APPENDIX I

### Consent Letter Director of the Dogrib Divisional Board of Education

April 19, 1998

Dear Gerri-Anne:

While teaching at Elizabeth MacKenzie Elementary School I would also like to continue with my graduate studies program from the Faculty of Education at Memorial University of Newfoundland. I have developed a software prototype titled "Rainforests of the World" and now require students from grades five and six to assist me in the final evaluation of my prototype. That is, to gather information as each student interacts with my prototype. This research is Project work towards fulfilling my Master of Education.

I am requesting access to students' cumulative student records as well as obtaining teachers' opinions on the academic abilities of students to be involved in my study. To ensure the prototype meets the needs of all students, participants will be selected the best potential students, average students and students who are having academic problems.

Individual students will sit with me, the investigator, at the rainforest computer program. Students will think aloud as they use the prototype to learn about rainforests of the world. Their verbal reports and computer mouse activities will be recorded on videotape. When each student has completed interacting with "Rainforests of the World," I will be asking him/her some questions about the prototype and the subject matter of rainforests. This will take approximately one hour. Since I am teaching full-time my intention is to proceed with the evaluation of my prototype after school hours, although the process of participant selection could take place during school hours, such as teacher discussions regarding students.

All information gathered in this study is strictly confidential and at no time will the school or individuals be identified. I am interested in learning how students in grades five and six learn and interact with computer instruction. One way to assist me is to videotape record students as they think aloud while interacting with my prototype. Participation is voluntary and participants may withdraw at any time without prejudice and may refrain from answering whatever questions he/she prefers to omit. The results of my research will be made available to you upon request. Upon completion of my research it is my intention to discard all evidence, data and videotapes.

The evaluation process has received approval from the Faculty of Education's Ethics Review Committee. If permission is granted to me to conduct my final evaluation of the software prototype please sign below and keep one copy for yourself and forward the other in the enclosed self addressed envelope. If at any time you wish to speak with a resource person regarding the evaluation please contact Dr. Patricia Canning, Associate Dean of Graduate Studies for the Faculty of Education or my supervisor, Dr. Bruce Mann at Memorial University of Newfoundland.

It would be greatly appreciated if you would return this permission form to me by \_\_\_\_\_.  
Thank you so much for your consideration.

Sincerely,

Carolyne Whenham

I, \_\_\_\_\_ (Director of the Dogrib Divisional Board of Education) hereby give permission to Carolyne Whenham to proceed with her evaluation of the software prototype "Rainforest of the World" at Elizabeth MacKenzie Elementary School in Rae, NT.

## APPENDIX J

### Consent Letter Principal Elizabeth MacKenzie Elementary School

April 19, 1998

Dear Lucy:

While teaching at Elizabeth MacKenzie Elementary School I would also like to continue with my graduate studies program from the Faculty of Education at Memorial University of Newfoundland. I have developed a software prototype titled "Rainforests of the World" and now require students from grades five and six to assist me in the final evaluation of my prototype. That is, to gather information as each student interacts with my prototype. This research is Project work towards fulfilling my Master of Education.

I am requesting teachers' opinions on the academic abilities of students to be involved in my study. To ensure the prototype meets the needs of all students, participants will be selected the best potential students, average students and students who are having academic problems.

Individual students will sit with me, the investigator, at the rainforest computer program. Students will think aloud as they use the prototype to learn about rainforests of the world. Their verbal reports and computer mouse activities will be recorded on videotape. When each student has completed interacting with "Rainforests of the World," I will be asking him/her some questions about the prototype and the subject matter of rainforests. This will take approximately one hour. Since I am teaching full-time my intention is to proceed with the evaluation of my prototype after school hours, although the process of participant selection could take place during school hours, such as teacher discussions regarding students.

All information gathered in this study is strictly confidential and at no time will the school or individuals be identified. I am interested in learning how students in grades five and six learn and interact with computer instruction. One way to assist me is to videotape record students as they think aloud while interacting with my prototype. Participation is voluntary and participants may withdraw at any time without prejudice and may refrain from answering whatever questions he/she prefers to omit. The results of my research will be made available to you upon request. Upon completion of my research it is my intention to discard all evidence, data and videotapes.

The evaluation process has received approval from the Faculty of Education's Ethics Review Committee. If permission is granted to me to conduct my final evaluation of the software prototype please sign below and keep one copy for yourself and forward the other in the enclosed self addressed envelope. If at any time you wish to speak with a resource person regarding the evaluation please contact Gerri-Anne at the board office, Dr. Patricia Canning, Associate Dean of Graduate Studies for the Faculty of Education or my supervisor, Dr. Bruce Mann at Memorial University of Newfoundland.

It would be greatly appreciated if you would return this permission form to me by \_\_\_\_\_.  
Thank you so much for your consideration.

Sincerely,

Carolyne Whenham

I, \_\_\_\_\_ (Principal of Elizabeth MacKenzie Elementary School) hereby give permission to Carolyne Whenham to proceed with her evaluation of the software prototype "Rainforests of the World" at Elizabeth MacKenzie Elementary School in Rae, NT.

## APPENDIX K

## Consent Letter Parent or Guardian

April 19, 1998

Dear Parent or Guardian:

I am a university student in the Faculty of Education at Memorial University of Newfoundland and a teacher at Elizabeth MacKenzie Elementary School. I will be interviewing grades five and six students to assist me in the final evaluation of my software prototype, titled "Rainforests of the World." I am requesting your permission for your child to become actively involved with my study.

Your child's participation will consist of interacting with the computer while being tape recorded and videotaped. Your child will be asked to think aloud as he or she journeys through the rainforest prototype, as well as writing brief responses in a provided workbook to the questions in the prototype. When your child has completed interacting with "Rainforests of the World," I will be asking him or her some questions about the prototype and the rainforests. This will take approximately one hour.

All information gathered in this study is strictly confidential and at no time will individuals be identified. I am interested in learning how students in grades five and six learn and interact with computer instruction. One way to assist me is to videotape record your child while he or she is using my prototype. This evaluation process has received approval from the Faculty of Education's Ethics Review Committee. The results of my research will be made available to you upon request.

If you are in agreement with having your child participate in this evaluation of my prototype, please sign below and return one copy to the classroom teacher. The other is for you. If you have any questions or concerns, please do not hesitate to contact me at home. If at any time you wish to speak with a resource person not associated with the evaluation, please contact Lucy Lafferty, Principal E.M.E.S., Gerri-Anne Donahue at the board office, Dr. Patricia Canning, Associate Dean of Graduate Studies for the Faculty of Education or my supervisor, Dr. Bruce Mann at Memorial University of Newfoundland.

It would be greatly appreciated if you could please return this consent form as soon as possible.

Masi Cho,

Carolyne Whenham

I, \_\_\_\_\_ (parent, guardian), hereby give permission for my son or daughter to take part in the evaluation of the software prototype "Rainforest of the World" undertaken by Carolyne Whenham. I understand that participation is entirely voluntary and that my son or daughter or I can withdraw permission at any time. All information is strictly confidential and no individual will be identified.

---

 Date

---

 Parent or Guardian Signature

## APPENDIX L

### Verbal Instructions and Notes

#### Instructions

- Tell me everything you are going to do.
- Even why you point the arrow where you are pointing it.
- Looking at the picture what are you trying to find in the picture?
- Tell me what you are thinking.
- Read everything on the computer screen aloud.
- Tell me what you are going to do and why you are doing it.
- All your computer movements will be videotape recorded.
- I want you to try your best with the new information.
- Try to block out all distractions and have fun while using the program. Try to put yourself in that place even though you have not been there.
- Try to picture what it would be like and remember your own experience in the bush.
- Do not be scared to ask questions. If you get stuck let me know. I cannot give you the answers, but I will try to help you the best way I can.
- You are helping me to make the program better (reassurance).

#### Notes

- Showed the participant how to use the practice program and demonstrated the videotape capture.
- Describe aloud what you are thinking, doing, attending to, or planning in the course of solving a problem.
- During the practice program the instructor can interact freely with the participant offering suggestions and encouragement.

- **The instructor will model the task to the participant with the practice program.**
- **The instructor will initiate the validation stage by telling the participant, “as you go through ‘Rainforests of the World’ software prototype, just tell me how you are getting your answers.”**
- **If the participant “freezes”, the investigator will ask one of the following questions.**
  - (a) What are you trying to do now?**
  - (b) What makes you think so?**
  - (c) How did you know that?**
  - (d) Why did you do that?**





