THE IMPERIAL OIL STEM OUTREACH PROGRAM FOR CHILDREN AT THE UNIVERSITY OF NEW BRUNSWICK: DEVELOPMENT OF OUTCOME MEASURES

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ABSTRACT

The purpose of this paper was to describe the system upon which a package of outcome measures for the Imperial Oil Science, Technology, Engineering, and Math (STEM) Outreach Program for children at the University of New Brunswick (UNB) could be developed. Given that the STEM program is comprised of a quite a diverse set of activities, a variety of outcome measures are required to determine the activities' success in meeting program objectives. Therefore, a hierarchical model was created and applied to selected STEM activities and initiatives.

INTRODUCTION

The Imperial Oil Science, Technology, Engineering, and Mathematics (STEM) Outreach Program for Children at the University of New Brunswick (UNB) is comprised of a collection of outreach activities and initiatives for girls and boys from kindergarten through to grade 12. The primary goal of this five year program is to create a model science outreach community in the province of New Brunswick which will strongly support children as they increase their interest(s) and abilities in science, technology, engineering and mathematics while minimizing the duplication of efforts or costs. A second goal of this program is to create a package of intellectual property which other groups can duplicate in part or in whole in their development of STEM outreach programs. For the annual report provided by the STEM Outreach Coordinator to the University of New Brunswick and the Imperial Oil Charitable Foundation, each STEM outreach activity is evaluated on the basis of whether the activity has met the objectives outlined in Figure 1 (McGinn-Giberson, 1999). It is hoped that through the fulfillment of these objectives, the program goals will be reached. As the program progresses, objectives which emerge will be added to the list delineated in Figure 1. As can be seen in Table 1, the Imperial Oil STEM program involves many different outreach activities because we want to reach many children of quite diverse backgrounds and ages. The third column of Table 1 relates to the objectives outlined in Figure 1 by providing symbols which indicate the 'assumed' objectives met for each individual outreach activity. However, while we may assume that individual objectives are being met, certainty of whether they are being fulfilled require the development and implementation of appropriate outcome measures so that the effectiveness of these activities can be known. Therefore, the purpose of this paper is to describe the development of outcome measures for the Imperial Oil STEM program at UNB.

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Figure 1 - Objectives for the Imperial Oil STEM Outreach Program at the University of New Brunswick

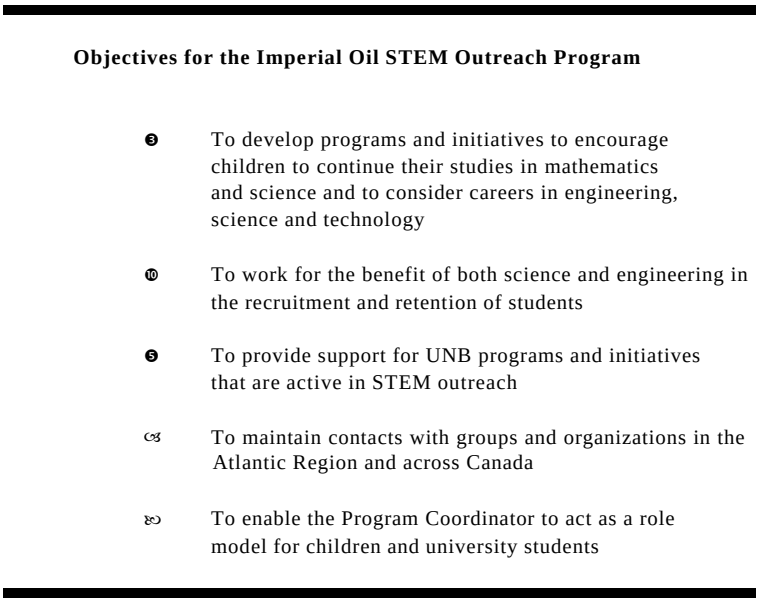

Table 1 - Selected Imperial Oil STEM Outreach Activities at the University of New Brunswick

Activity or Initiative	***Target Population***	***Assumed Objectives Met***
The NEST Website and Informal Working Group	The students, teachers and parents of Kindergarten through to Grade 12 as well as STEM outreach providers in New Brunswick	▲▼◆■●
Robots EAST	High School/Middle School Students	▲▼◆■●
Mini Robots EAST (Canadian Association of Girls in Science)	Elementary/Middle School Students	▲◆■●
Worlds UNBound	Elementary/Middle School Students	▼■●
New Brunswick Middle School Math Competition	Gifted Middle School Students	◆■●
Middle School Enrichment	Gifted Middle School Students	▲▼●■
Province Wide Online Science Experiment (Pilot)	Middle School Science and Physical Education Classes	▼●▲■
Recruitment of Grade 12 Students to UNB Engineering	Grade 12 Students	▲◆■●

THE NEED FOR EVALUATION

There are a number of reasons why it must be determined if these STEM outreach approaches are effective in meeting their stated objectives. One of the primary reasons is that in order to attract or maintain corporate sponsorship, sponsors want to know generally that their money is being spent wisely, and that the programs that they are contributing to actually have some measurable effect. Moreover, outreach providers want

to know if their programs are effective so that they can make alterations (Women in Engineering Program Advocates Network, 1996).

However, a set of outreach activities such as those encompassed by the UNB program cannot be evaluated utilizing a single methodology. Even a single activity within the program will require generally a variety of methods depending on things such as the length of time the activity has been in operation, and whether one wants to measure attitudinal or behavioural changes. The primary factor, however, in the selection of outcome determination methodologies should be that the method is appropriate for the question that one wants to answer. As a facetious example, if one wanted to know if the Worlds UNBound summer camp[1] experience affected the career choices of young girls aged 8 to 12 years, clearly a questionnaire administered immediately after their participation in the camp would provide no indication of this.

From the perspective of the UNB program, since it is comprised of many different activities which are intended to target a diverse set of children's ages and backgrounds, we have embarked upon a process to identify a series of outcome measures which will allow us to evaluate our package of outreach activities. Through the development of an overall framework of outcome measures, we will have a better sense of whether we will meet our goal of developing effective activities that will create a model science outreach community by the end of the five year period.

As illustrated in Figure 1, the first (and primary) objective is to encourage children to continue their studies in STEM areas. We interpret this to mean all children regardless of gender, socioeconomic level, or ability status. Therefore, aiding the development of what is hoped to be an 'inclusive' model science outreach community, it is expected that an added benefit of this self-reflection process is that it will point out to us which groups of children we are not currently providing programs for.

EVALUATION MODEL

An evaluation can obviously be as basic or as in depth as need, wish, time and funding will allow. We have developed an evaluation model that will clearly and immediately articulate to the funding body as well as other interested parties if an evaluation of a project or initiative has taken place and, if so, was that evaluation basic or more in depth. This evaluation model also incorporates the symbols used for the objectives of the STEM Program so that it may be immediately understood which of these objectives is being evaluated. It will also indicate planned evaluations thereby inviting input in advance from interested parties such as corporate sponsors. This framework provides a degree of flexibility as it does not preclude the measurement of objectives that were not part of the original program (Figure 1).

Evaluation Model Framework

As can be seen in the evaluation model shown in Figure 2, there are three levels of evaluation. Shown in the shape of a triangle the model indicates that the intensity of the evaluations increase generally as the levels increase. Intensity refers to the increasing resources required in terms of time, money, and effort. At the lower levels of evaluation the information that is being gathered is very simple, and the mechanism used to gather that information is usually straight forward. Generally speaking, the funding and time commitments increase as the level of evaluation increases. There are usually a number of very simple descriptive evaluations that can be carried out at Level 1 in order to measure the most basic of objectives. For example, as can be seen in the second column of Table 2, more than 300 children participated in each of two years at Robots EAST. This indicates that at a very basic level, as per objective one of Figure 1, a program was developed which encourages children to continue their STEM studies and to consider STEM careers (●). Evaluation at this level does not attempt to measure attitudinal or behavioural change.

At Level 2, the types of evaluations become more specific as shown visually by the increasing narrowness of the physical model and the increasing level of the intensity of the colour in Figure 2. Level 2 evaluations are intended to provide a measure of attitudinal change. As can be seen in column three of Table 2, the questionnaire administered by Frize (1997) indicated that Worlds UNBound had a positive effect on children's attitudes toward science and engineering (● ▲).

At Level 3 the evaluations are the most specific as indicated by the shape and intensity of the colour in the physical model. The goals or changes that are being measured are behavioural changes and are specific objectives

[1] Worlds UNBound is a gender-balanced summer engineering and science week-long day camp for children aged 8 through 12 at the University of New Brunswick in Fredericton.

that require generally in-depth evaluations. Column four of Table 2 provides an example in the middle school enrichment category. By following these enrichment students through their high school years, one way of monitoring behaviour change would be to determine the number of top level STEM courses that these individuals take in high school. Obviously at this stage, a more sophisticated experiment design might need to be employed. To provide more clout to the findings, the enrichment subjects should be matched with control subjects (who did not participate in a STEM enrichment program) on things such as intellect and socioeconomic status. Comparisons could then be made between the two groups. A study such as this would answer the questions associated with objectives 1 and 2 (●▲) in Figure 1 from a behavioural change perspective.

As can be seen in the preceding descriptions and examples of the three evaluation levels, generally speaking, the cost in terms of money and time of conducting an evaluation goes up as one goes through the levels. Clearly, though it is the most costly, both sponsors and STEM providers are most interested in results emanating from Level 3 investigations which determine if the STEM activity has actually effected a positive behavioural change.

Figure 2 - Evaluation Levels

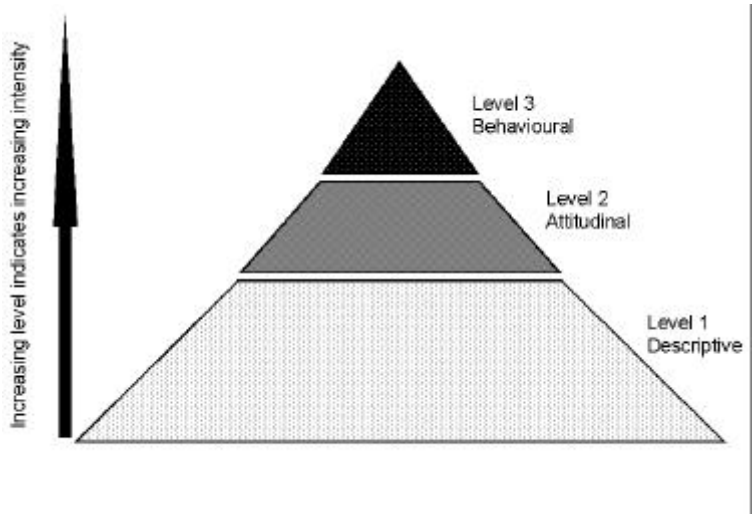

Table 2 - Application of the Evaluation Model to Selected Imperial Oil STEM Outreach Activities

Activity or Initiative	***Level 1 Evaluation***	***Level 2 Evaluation***	***Level 3 Evaluation***
The NEST Website and Working Group	▲▼ ●◆NEST group comprised of provincial, Atlantic and National STEM outreach providers, and provincial Education officials meets every 2 months ■ The website is located on the UNB server and the STEM		

Activity or Initiative	*Level 1 Evaluation*	*Level 2 Evaluation*	*Level 3 Evaluation*
	coordinator maintains it		
Robots EAST	●▲■▼◆Program has been positively delivered by the UNB STEM Coordinator for 2 years (more than 300 high and middle school students participated each year)($11,000 contributed directly over 2 years) ▼Coordinator will continue to assist with Robots EAST in a reduced capacity now that it moves on to the Moncton area	●▲ Pre- and Post-Robots EAST questionnaire given to participants to assess attitude changes toward STEM subjects	●▲ Tracking of former Robots EAST participants to see what university and career choices they made
Mini Robots EAST (Canadian Association of Girls in Science) (pilot project)	●▲■◆ Approximately 60 elementary and middle school girls were matched with 6 women undergraduate mechanical engineering students who guided their learning of LEGO Mindstorms™		●▲Track the number of CAGIS girls who go onto participate in Robots EAST
Worlds UNBound	●▲Program is in its eighth year and remains very popular (Fredericton camps are always sold out serving 60 campers in each of 4 weeks) ■ $6000 provided in 2000 ▼Two Worlds UNBound Instructors attended National YESVACC/ACTUA Conferences in July 1999 and January 2000	●▲Questionnaire was administered to former Worlds UNBound campers and parents to determine if campers' science and engineering understanding was improved and if parents felt that the camp had a positive impact on the child's math and science marks (Frize, 1997) (results indicate that Worlds UNBound had a positive impact on things such as: attitudes toward high school math and science courses and	●▲Questionnaire/ Focus groups administered to former Worlds UNBound campers to determine if camp attendance had an influence on their selection of high school and university courses in math and science ●Questionnaire/ Focus groups administered to former Worlds UNBound counselors to determine if camp participation had an influence on their career selections

Activity or Initiative	*Level 1 Evaluation*	*Level 2 Evaluation*	*Level 3 Evaluation*
		future career choices	
New Brunswick Middle School Math Competition	■ $2000 provided in May 1999 ◆ ●STEM Coordinator coordinated all tours of Engineering laboratories (1999 and 2000)		
Middle School Enrichment	▲ ◆■ ●Eight middle school children from two local schools spent Wednesday afternoons working with the Worlds UNBound staff developing camp teaching modules	▲■ ●Questionnaire administered pre- and post- enrichment activity to assess pre- and post-participation attitudes	▲ ●Follow participants to see the number of level 1 STEM courses that the children take in high school
Province Wide Online Science Experiment (Healthy Pulse Project) (Pilot)	▲■ ●▼Website and teacher's packages were developed	▲ ●Pre- and Post-participation questionnaire to see if knowledge and awareness regarding the physiological effects of diet and exercise are improved	
Recruitment of Grade 12 Students to UNB Engineering	▲ ● ◆Development of a CD and website, and school visits	▲ ● Questionnaire administered pre- and post- school visit to see if visit, CD and/or website was effective in changing attitudes towards university engineering	▲ ● Number of students recruited

CONCLUSIONS

Our approach to the development of outcome measures for the Imperial Oil STEM program was to create an evaluation system that would enable the funding body, the university, and interested STEM programs to gauge our success in meeting our program objectives (Figure 1) for each of our outreach activities (Table 1). By breaking our evaluation procedures down into levels, we will be able to provide these interested parties with very specific (i.e. descriptive, attitudinal, and behavioural) information regarding the success of our various activities. The other thing that this framework will allow us to do is to incorporate emerging objectives which will let us to grow as an outreach provider without getting too far off track from our goal of creating a model outreach community.

Our funding agency (Imperial Oil Limited) has told us quite clearly that they wish to know if the activities contained within our STEM outreach program have any effect on the first two objectives detailed in Figure 1. This points out the need to sit down with funding bodies to discuss the structure of things such as the annual report (McGinn-Giberson, 1999) as well as the evaluation model so that there is clear understanding on both sides.

Through this type of communication, the flow of information and advice between funding agency and recipient is enhanced which may increase the possibility of continued funding in both the short and long term.

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