PROCEDURES AND PROCESSES FOR IMPLEMENTATION OF AGRICULTURAL SCIENCE PROBLEM BASED LEARNING CURRICULUM IN SASKATCHEWAN SECONDARY SCHOOLS

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ABSTRACT

Increasing enrolments in the study of agriculture and related programs is an essential component of the overall sustainability of the industry and human well-being on the planet. Despite the abundant opportunities available in the agriculture sector, high school students are largely unaware of the education and careers opportunities in agriculture. Fueling this problem is the fact that secondary science curricula in Canada contain virtually no agriculture related content. As a solution, the College of Agriculture and Bioresources (AgBio) in Saskatoon, SK proposed that if high school science curriculum resources with an agricultural emphasis and related science teacher training programs could be created, perhaps more students would be exposed to this discipline through classroom teachings and choose to participate in agriculture. This study offers a reflective analysis concerning the process and procedures needed for an organization to implement a Problem Based Learning (PBL) curriculum in high school science classes. Qualitative data collected is summarized to include relevant information on integral partnerships with teachers, school divisions and funding agencies. Timelines, program marketing and teacher perceived barriers to implementation are reviewed. An overview of the Problem Based Learning curriculum resources that have been created is shared, and an examination of the high school science teacher workshop explored. Through this outreach endeavour, hundreds of high school science teachers have attended workshops and implemented the PBL curriculum in many classrooms, greatly exposing the careers and education potential of agriculture.

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1.0 OVERVIEW

The importance of agriculture in society cannot be understated. In fact, a major factor in the stability of a country's economy is the resiliency of its production of resources from plants (Clark, 1952; Diamond, 2005). It has been stated that the planet will be challenged to produce food, feed, fibre, and biofuel feedstock for a global population that is set to reach nine billion people by the year 2050 (UN DESA, 2009). Over the next 40 years, it is expected that we must produce more food than has been produced over the past 10,000 years combined (Testa and St. Pierre, 2007). In an effort to meet these lofty goals, the industry must have the ability to attract and retain a highly skilled workforce.

In my work as the Community Liaison Coordinator at the College of Agriculture and Bioresources (AgBio) in Saskatoon, I am directly involved in attracting an increased number of students towards careers and education in agricultural sciences. Since I was a Student Ambassador at the University of British Columbia in 2001, I have directly spoken to thousands of high school students and hundreds of high school educators about careers and education in this dynamic sector. Time and time again, the response I have seen from them is that of surprise, having little or no idea of the diversity and opportunities in this sector. Despite the importance of the industry, the vast majority of students and educators are largely un-aware of the opportunities and thus not choosing to pursue careers and education in this sector. In an effort to be successful in my position at the College, methods of reaching large numbers of youth and educators with proper information on agriculture were devised in hopes of successfully attracting an increased number of students towards careers and education in this sector.

As I travelled from school to school and to various recruitment events promoting agriculture, it became clear that agriculture was not a popular choice of career or education path as the opportunities were perceived to be limited to "farming" type jobs. I began to wrestle with the question of why this is so. Despite a world of agricultural opportunities in high tech, lucrative scientific jobs, students, teachers, and career counsellors were not familiar with the industry opportunities. It became clear that disconnect between the perception of the industry opportunities and reality of was perpetuated by the lack of agricultural content in the high school science curriculum of Saskatchewan. If little or no agricultural science was being taught, students would not understand the industry opportunities and not choose to pursue education and careers in this sector. The solution then, in part, lay in increasing the amount of agricultural content within the high school science curriculum. *If science curriculum materials that use agriculture concepts to meet provincial learning objectives can be created and implemented, then more students will become engaged in the agricultural sciences and more will likely choose to pursue education and careers in this sector.*

In an effort to address this challenge, an external funding application was sent to Natural Science and Engineering Research Council (NSERC) PromoScience Program in August of 2005. The major component of the funding application was to develop curriculum resources for high school science classes and provide training for science educators. Included in this application were letters of support from faculty in the College of Agriculture and Bioresources, Ministry of Education officials, and the Dean of the College of Agriculture and Bioresources. This application was successful and drew the attention of a large agriculture company who was also concerned with the lack of students enrolling in post-secondary agriculture programs. This company offered to put forth significant funding for the project. With funding and support from private industry, government, and the College in place, the curriculum resource development and teacher workshop project was poised to move forward.

After the initial excitement of securing the funding dissipated, the looming task of creating a successful program set in. I had many questions and much anxiety about implementing such a large program. Having not been in a similar position before, and starting everything from the ground up with no other model to follow, I wondered if I could indeed be successful. I questioned the program: Would anyone use the curriculum resources? Would teachers attend the workshops? How would I promote the curriculum resources? Would this program be taken seriously? How does one go about developing curriculum resources? Would my granting agencies be pleased with the type of resources being created? How would the curriculum resources affect students and educators? Armed with these questions, fears, and anxieties, I set forth on creating the program.

Fast forwarding to 2011 and looking back at these initial fears, I could never have of the success and impact this program would grow to enjoy. To date, over 180 teachers have attended workshops at the College of AgBio, received training in Problem Based Learning (PBL) , been exposed to AgBio research programs, and provided with AgBio curriculum resources. Curriculum resources have been developed that use PBL to teach Biology 20, Biology 30, Science 10, and that have a fit in various other courses. These resources have impacted hundreds of science students across the province and beyond. Many educators have commented that the workshop is amongst the best and most meaningful professional development events they have attended, and students have commented that the curriculum resources have changed the way they view science and the natural world. Many teachers have attended the workshop in subsequent years to further PBL skills and link with other teachers. The project, in my opinion, has been successful.

Through this project, I have seen evidence of curriculum implementation success. Increasingly, teachers are being attracted to and attending 2-day problem-based learning workshops being held at the College of Agriculture and Bioresources. To date, over 180 educators have participated. Feedback from the workshop includes statements such as "*the best PD event I have attended", "I will definitely be using the resources provided by the workshops.", "I would recommend this workshop to anyone interested in learning about PBL."* The College of Education at the University of Saskatchewan asked me to host a one-day workshop for high school science teacher candidates, 40 candidates attended. The demand for this PBL outreach program is not restricted to on-campus workshops. In the 2010-2011 school year, I was asked to host an off-campus workshop for science educators within the Meadow Lake Tribal Council school division. This two-day workshop was attended by 12 educators and was followed up with a one-day session to discuss implementation and collaboration amongst schools. School divisions are also asking for problem based learning workshops. This year, Saskatoon Public School Division had me speak to all of the science teachers in the division and followed up with a small working group of educators interested in the PBL process. The Prairie Valley School Division asked me to lead a one-day PBL workshop for science educators in the division. It has become clear that the PBL outreach program has become widely known and is viewed as a quality professional development opportunity for educators.

The resources developed in the program use PBL and AgBio sciences to meet the learning outcomes and indicators (objectives) for senior sciences. Initially, Bioresource Management courses were developed for the 20 and 30 (grades 11 & 12) level. These courses were approved by the Saskatchewan Ministry of Education as locally developed courses, which could be offered as an elective at schools. These courses consisted of four case studies each. The Bioresource Management courses have since been modified and now meet the objectives for the Bio 20 and Bio 30 curricula and therefore do not need to be offered as an elective in schools. As more teachers became familiar with the resources and the PBL process, more students became exposed to the science of agriculture and bioresources through the implementation of these curricula.

Teachers have embraced this new problem based learning curricula and have implemented it within schools around Saskatchewan. In 2010, Evan Hardy Collegiate, a Saskatoon high school, won a United Nations recognition award for Education in Sustainable Development for the delivery of Bioresource Management Biology 20. Other schools that have adopted the resource include, but are not limited to, Kinistino School, Canoe Lake First Nation School, Central Collegiate (Moose Jaw), Asquith School, Aden Bowman Collegiate (Saskatoon), Walter Murray Collegiate (Saskatoon), Oskayak High School (Saskatoon), Montgomery School (Saskatoon), Outlook High School, Landis School, and Kenestan High School). The implantation at these schools has impacted hundreds of students.

Feedback from students indicated they enjoy Problem Based Learning and are engaged in science at a high level. Students have commented, "*This is the BEST class I ever took." "I have become motivated to study Agriculture at University because of this class", "This class has influenced me to be more aware of my actions and how they affect the environment. I hope to be a better example to other people and the environment*", *"BRM (Bioresource Management) opens your eyes to things you never noticed. It's a new perspective on everything we do. It's taught me to be more aware of what I'm doing to the world in a way that's different and more effective than just sitting in a desk.".* Through student feedback, it became clear that this curriculum has had a meaningful impact on the students who experienced this learning.

I began to be interested in better understanding the evolution of this outreach program. It became important to me to understand what aided and what hindered the development. I wished to understand what this may mean for others who wish to implement a similar program. Having started at ground zero, with basically just an idea, and taking it to the level of a widely recognized outreach program, I wanted to explicate the key steps along the journey that enabled success. If such an outline could be created, it would be of use for other outreach organizations and groups to see how to reach large numbers of educators and penetrate into high school classes with meaningful curriculum resources. Outlining and defining these processes would become the basis for my research question: *what were the procedures and processes needed to implement agricultural science problem based learning curriculum in Saskatchewan Secondary Schools?*

I was also interested in making sense of these processes and procedures that led to the success of the program. Sub-questions I was interested in exploring include: *What were the processes for contacting educators and creating an interest in the College of AgBio outreach efforts? What key partnerships enabled success? What key events, conferences, and meetings allowed our program to reach educators? What were my perceptions of barriers to implementing these curriculum resources in schools? What were educators' perceptions of barriers to implementing AgBio curriculum resources in schools? Were these barriers actual or perceived?* By piecing the answers to these questions together, a better understanding of the implementation process was determined and shared in this publication.

As with any good research, there is a need for it to be helpful, accessible, and have efficacy. Upon completion, this research project has impact in many arenas. The research serves to partially fill a gap in current academic literature surrounding the implementation of agriculture based PBL curriculum in high schools, as done so by an external agency. By outlining the steps taken to achieve success, this information is valuable to other outreach professionals wishing to create similar programs and gain access into high school classes and teachings. These professionals may be part of academic units, such as the author, or of industry and affiliated groups also wishing to further connect with students and teachers. Lastly, this research is important to my own personal development and day-to-day practices. The completion and publication of this research serves to benefit a diversity of groups and organizations.

In beginning this research project, it was noted that very little has been published in the area of implementing an agricultural PBL curriculum into high school science classes. Indeed, very little information exists on the experience of an external agency, such as a university outreach organization, implementing any type of curriculum into the high school science environment. In Canada, there is sadly a large gap in agriculture education in the high school system, resulting in no recent academic publications on this topic. By researching and publishing works in this discipline, an attempt to fill this academic void is undertaken by the author.

In an increasingly competitive college recruitment environment, many academic departments are looking to engage high school students in relevant subject matter in hopes that it may inspire students to pursue post-secondary education in their departments. There is currently little information on best practices that an external academic unit or agency may undertake to implement curricula into schools. The information in this thesis acts to serve as a template that outlines the steps already taken by an outreach program that has enjoyed success in reaching large numbers of high school science students and teachers. Increasing the efficiency of competing academic units in reaching potential students may be detrimental to the author's academic department, but in the long run, if students become more engaged in general academia, it is a benefit to everyone.

Similar to the above situation, many agencies representing industry are keen to engage students in relevant academic activities as to draw them towards careers in the industry. This information allows these external agencies to see an example of how to potentially reach large numbers of students.

Through analyzing data collected in this research project, the consolidated information also served as a personal benefit. As an outreach specialist passionate about reaching high school students with agriculture knowledge, this information has allowed me to become better at doing what I love doing. Pitfalls, redundancies, and mistakes can be avoided through a focussed examination of what has contributed to success so far. A detailed examination of the evolution of this project becomes an interesting and necessary exercise in increasing personal effectiveness.

2.0 LITERATURE REVIEW

2.1 Nature of Problem Based Learning

"Learning should give students something to do…and the doing is of such a nature as to demand thinking or intentional connections"

John Dewey. Taken from *Democracy and Education (1916).*

Problem Based Learning (PBL) roots trace back to McMaster University's Medical College and the development by Barrows and Tamblin (1984). This approach, new at the time, was designed to promote a more student-centred education. It was hoped that this approach would not only develop student's content knowledge, but also their ability to apply that knowledge (Barrows, 1985). Since its development, PBL has become widespread in post-secondary education and is now increasingly becoming adopted in secondary school education.

Problem-based learning is an approach to education that places students in a situation where, in small groups, they have to solve realistic, ill-structured problems. Through this process, students develop their knowledge content and increase higher level thinking skills and problem solving abilities (Barrows, 2000; Hmelo-Silver, 2000). Problem Based Learning is student-centred by design. The role of the teacher becomes that of a facilitator or guide for the small working group, and no longer is the teacher viewed as "the one with knowledge at the front of the class".

In its conceptualization, problem based learning does not present a uniform approach to teaching and learning (Barrows, 1986). While the PBL environment takes on different looks in each environment in which it is implemented, there are critical aspects of the PBL process that remain adhered to; students collaborate in small groups and work independently at times, the teacher acts as a facilitator of student learning, students publicly share solutions to problems, and learner assessment is completed by individual and group assessment processes as well as an assessment of content knowledge.

One of the distinguishing features of PBL is the small groups (3-12 students) that students work within. In these small groups, ground rules are set by the group on how the group is to perform and what the expectations for performance may be. The ill-structured problem information is presented to the group through a series of disclosures. In a group, students brainstorm what is known, what needs to be known, methods of finding information, reporting new information, evaluating possible solutions, and generally working through a case study to completion. Students are required to provide feedback on members' performance and group function as part of the process. Interpersonal communication skills become of paramount importance to group success.

Students also have to conduct independent work throughout a case. This independent work comes in the form of reading and researching resources, recording notes, contacting experts, and preparing information for the group. Students are encouraged to seek information from a wide variety of sources and in diverse formats. Students may gather information through phone contact, emails, web searches, library information, and other relevant sources. Independent tasks may be required for each group member to successfully provide a solution to the given problem.

Another key aspect of the successful PBL environment is a truly student-centered approach to learning, which requires the teacher to vacate the role of the disseminator of knowledge, and shift into a facilitating role. Ideally, each small group would have its own trained facilitator to oversee the smooth functioning of the PBL process. This facilitator becomes removed from the problem solving process and does not provide content knowledge in the group setting. Proper facilitation ensures everyone participates and ground rules set by the group are respected. The facilitator is aware of the overall learning outcomes of the case being worked on and gently guides the group in the proper direction through probing questions, although the group will ultimately determine its own directions. The role of the facilitator is comparable to that of navigation equipment on a large ship. The facilitator subtlety lays out a course for the group and provides warnings of going off course, but the group steers itself on whatever path it sees fit. Additionally, the facilitator provides feedback on group and individual performance as part of the PBL process. The facilitator does not need to be a content expert in the given area of the case, but does need to have some level of expertise in the role of the PBL facilitation process.

In an ideal PBL setting, students have the opportunity to share their “solution” to the problem in a more public setting than simply presenting to peers in the classroom. This presentation could possibly include school administrators, relevant industry representatives, parents, post-secondary educators, and other professionals where appropriate. This interaction with the members of the community works to increase student confidence in presentations, as well as allow the community to see the type of innovative, engaging education the students are involved in. Presenting in a more public forum acts as a motivating factor for the students to produce a high quality final product.

There are many forms of assessing performance in PBL that utilizes both individual and group assessment of the learning process, skills, and knowledge content. Traditional examinations of content knowledge have been administered and required in some instances (departmental exams). Marks are given based on individual performance in the group presentation or a group mark based on group presentation merit. Individual work handed in has been graded independent of other group members, or again as a group mark for a larger final product. Students evaluated themselves based on their own performance in the group setting, were evaluated by others in the group based on their performance, or were given a mark by the group facilitator. There is a tremendous diversity of assessment methods to be employed in the PBL process and it is essential the PBL educator is prepared.

Barrows and Kelson (1995) have identified five goals of PBL and how it related to the learning process. The first goal, constructing flexible knowledge speaks to the interdisciplinary aspect of the problem solving process. The student must be able to integrate knowledge from a diversity of fields and sources and apply that knowledge in varying contexts. The second goal involves developing effective problem solving skills. This is accomplished through planning, problem solving, monitoring progress, and selecting and applying appropriate meta-cognitive and reasoning skills. The third goal speaks to the PBL process striving to create self-directed learners with lifelong learning skills. Students must be able to set goals, develop a plan to reach goals, reflect upon success of achieving goals, and demonstrate an awareness of what they have come to know. The fourth identified goal stresses the development of effective collaboration skills. Due to the small group work nature of PBL, students build skills in conflict resolution, consensus-building, negotiation, and effective interpersonal communication. Intrinsic motivation is the fifth goal of the PBL learning environment. This is achieved when groups working towards a common goal, overcome challenges together, and develop a shared interest in a particular subject matter (Hmelo-Silver, 2004). This motivation may be deepened with a sense of competition between multiple groups working on the same problem and motivating the student to produce the best possible solution to a given problem. If the PBL process is correctly carried out, the five above goals are reachable.

The Saskatchewan Ministry of Education has recently put a large emphasis on inquiry learning throughout the science curriculum. Problem based learning is an excellent teaching strategy that falls under the inquiry-learning umbrella. Inquiry and PBL are grounded in the constructivist framework of education. It is important to understand the constructivist framework and its importance within PBL and science curriculum.

2.2 The Constructivist Framework

Constructivism can be described as a theory on how one comes to understand or how one comes to know. Savery and Duffy (1996) characterise the philosophical framework of constructivism in terms of three primary propositions:

1. *Understanding is in our interactions with the environment.* What we come to know is a function of the content, the context, the activity of the learner, and the goals of the learner. Understanding cannot be shared between individuals, rather a comparison of individual understandings can be made to see if there is compatibility and congruencies amongst understandings. What is learned cannot be separated from how it is learned, and a variety of experiences cannot lead to the same understandings.

2. *Cognitive conflict or puzzlement is the stimulus for learning and determines the organization and nature of what is learned.* This proposition implies there must be some stimulus, goal, or puzzlement that will drive learning; the learner has a reason for being there. The goal(s) of the learner is a central consideration in what is learned. This goal is the stimulus for learning and determines what the learner emphasises and what prior knowledge and experiences the learner weighs when creating and understanding.

3. *Knowledge evolves through social negotiation and through the evaluation of the viability of individual understandings.* The social environment becomes critical in influencing and shaping what the individual considers to be knowledge or fact. At the individual level, others play a primary role in testing our knowledge. In a group or collaborative environment, our own understanding becomes tested against others understandings of similar phenomenon as well as enriching, interweaving and expanding what the individual views as knowledge. In this sense, other people become the greatest source of challenges to our current knowledge and create a sense of puzzlement that stimulates new learning (von Glasersfeld, 1989). In this sense, facts are facts not because they adhere to a universal truth, but rather because there is widespread agreement amongst individuals. What we call truth is actually the most viable interpretation of our experiential world (Resnick, 1987). However, the constructivist framework requires that the constructed knowledge be viable and understandings must be tested. The social environment can provide alternative views and additional information against which we can test what is considered knowledge.

These constructivist propositions provide a framework for a learning environment to be created that is guided by a set of instructional principles. Savery and Duffy (1996) provide instructional principles derived from constructivism:

1. *Anchor all learning activities to a larger task or problem.* The learning must have purpose and meaning and be clear to the learner. It becomes important that the learner accepts the relevance of the learning activity in relation to a larger task or complex problem.

2. *Support the learner in developing ownership for the overall problem or task.* Preparing students to pass a test or simply "put in their time" cannot be the focus of a constructivist-based curriculum. The goals of the learner should be consistent with the instructional goals. It is critical the learner be engaged in dialog that brings the relevance of the problem to the forefront for the learner.

3. *Design an authentic task.* The learner should be prepared in such a way that the cognitive demands are consistent with the cognitive demands in the environment for which the learner is being prepared (Honebein et al, 1993). The learner should be immersed in activities which presents the same type of realistic challenges.

4. *Design the task and learning environment to reflect the complexity of the environment they should be able to function in at the end of the learning.* Create a complex learning environment that will serve to challenge the learner. This is reflected in the importance of context in coming to understand any given principle or concept.

5. *Give the learner ownership of the process used to develop a solution.* Pre-specification of activities, readings, and outcomes of learning greatly limits the ability of the learner to become engaged in authentic thinking and problem solving. The learner must generate their own sense of 'coming to know' and not have the educator attempt to proceduralize that thinking.

6. *Design the learning environment to support and challenge the learner's thinking.* Here the educator takes on the role of the consultant or coach in order to be able to challenge the learners' knowledge. The educator then probes the learner for understanding and facilitates the scaffolding of concepts. No longer does the educator have the "right" answer as seen in the Socratic Method.

7. *Encourage testing of ideas against alternative views and alternative contexts.* An effective learning environment has a setting in which ideas can be discussed and understood and enriched by social dialog and interactions. Thus, knowledge becomes socially negotiated.

8. *Provide opportunity for and support reflection on both the content learned and the learning process.* Reflective thinking throughout the learning process should incorporate both a reflection on the learning process and the content of what was learned as this helps learners self-regulate and ultimately become independent.

Given that curriculum standards are increasingly being framed within a constructivist learning paradigm (Richardson, 2003); the implementation of problem based learning fits well within this reform of science education. Through reformed educational practices, such as adopting PBL, a desired outcome could be the development a more globally competitive national work force.

2.3 Changing Science Education & Teacher Professional Development

Improving global competitiveness through developing a workforce that has a greater understanding of, and is motivated to pursue careers and education in science, technology and mathematics can be seen in countries around the planet; United States (Augustine, 2005), European Union (European Commission, 2004), England (Roberts, 2002), Finland (Ahtee et al, 2007), and Australia (Jones, 2008). In Canada, the *Mobilizing Science and Technology to Canada's Advantage (*2007) addresses the need to enhance scientific talent within the country in the "People Advantage-Growing Canada's Base of Knowledge Workers" section of the report. Canadian agriculture recognized the need to invest in science innovation; within the $1.3 billion dollar Growing Forward Agriculture Policy Framework (2009-2013), the Growing Canadian Agri-Innovations Program recognized the need for science innovation to keep Canada competitive in an increasingly global marketplace (Agriculture and Agri-Food Canada, 2008).

High school science teachers are in a prime position to develop a positive attitude and interest towards science for today's youth. To this end, nations have invested greater amounts of funding toward the improvement of science curricula and classroom instruction (Lustick, 2011).

In order to improve science education, the ongoing support of teachers through professional development is critical (Goodnough and Cashion, 2006). In the United States, the National Research Council (1996) has stated that current reform initiatives require "a substantial change in how science is taught" (pg 56.). It has been shown that teacher professional development activities need to be "embedded in daily classroom practice, to be systematic, and to foster active engagement with new ideas" (Goodnough, 2008). Research has shown that improvements in teaching practices depends on the quality of professional development the individual educator experiences (Corcoran et al, 1998, Loucks-Horsley and Matsumoto, 1999; Zhang 2010). To this end, Desimone et al. (2007) have conducted an extensive review of recent research on professional development and concluded that in order to best provide effective learning opportunities for science and math teachers, PD events should:

1. Focus on subject matter content and how students learn that content;
2. Be ongoing throughout the year;
3. Be consistent with other activities;
4. Provide opportunities for teachers to actively interact around issues of curriculum and instruction.

For those interested in working with teachers to implement new science curriculum, it becomes essential to know what types of professional development opportunities are of most benefit to the educator, and ultimately effect change in the science education environment.

2.4 Problem Based Learning Implementation

Problem based learning has been shown to be an effective teaching and learning strategy (Norman and Schmidt, 1992) and that through constructivist lenses it may enhance science achievement in students. Despite PBL's potential, barriers (perceived and real) to implementing the process in schools exist.

Achilles and Hoover (1996) identified several concerns of high school and middle year educators who had implemented a PBL project:

- Students lacked adequate social skills needed to progress group work effectively and efficiently
- Students were distrustful of each other and wouldn't share or willingly cooperate
- Students new to PBL needed schooling in social skills related to group processing
- Teachers felt bound by the constraints of the school-day schedule
- Teachers needed to work on group processing and team skills just as students do
- Students thinking and processing skills were unrefined, resulting in frustration
- Students and parents didn't understand a need to change "old" way of teaching, the "old" was comfortable

- Students were often overwhelmed
- Extensive time was needed to implement PBL
- The need to start with small PBL cases

Clouston and Whitcombe (2005) have encapsulated PBL implementation challenges that impact the tutor, student, working group, and organization in five categories: the nature of the learning environment within the organization, the role that group dynamics play in realizing a collaboration, the nature of communication, cognitive dissonance and congruence, and the readiness and preparedness of the student to engage in PBL activities.

2.5 Reflective-self Inquiry

Reflective-active learning, also called action learning, allows one to critically reflect on professional processes, make changes, test new ideas, and continue the cycle of gaining experience and reflecting upon it in order to increase efficiency of a given task or process (Kolb, 1984; Zubert-Skerritt, 2002).

As a professional, it becomes important to understand one's actions through a self-evaluative process and make changes where necessary to improve performance. The use of self-study and reflective inquiry as used in the field of education can be seen as a model to improve profession performance and practice in a variety of disciplines. Self-study research encourages the author to initiate focussed and systematic inquiry into their actions (Devendahl et al. 2002). Reflective inquiry helps to view experiences in broader social, political, and economic contexts (Glen et al., 1995). Used together, the term reflective self-study (Devendahl et al. 2002) encapsulates both inquiry realms. Through this self-reflective research project, the results have allowed me to personally improve my practice, and allow others to gain valuable insight into the processes already undertaken.

The process of reflection has been characterized by academics over the last century, starting with Dewey (1910), who saw the importance of learning from practice and experience as well as from conceptual knowledge (Freire, 1970; Schon, 1983). The obstacles that impede success can be re-constructed through reflection. From here, appropriate action can be taken to resolve these barriers to success and realise desirable results (Johns, 1999). Reflection then becomes a predecessor of implementing procedures that create change (Glen et al., 1995).

Within the realm of education research, self-study is used to create knowledge that helps understand and answer pedagogical questions and is built on the premise that teachers are able to manifest change within schools (Cochrane et al., 1999). A self-study examines the act of teaching while simultaneously researching the convictions and behaviours of the researcher within an educational context (Whitehead, 1993). To help reduce self-serving biases, collaboration in self-study research may be employed. This collaboration also helps to foster dialog and critique, which ultimately results in improved professional practice.

Through the combining of self-study with the process of reflection, one can improve professional practice. By analysing process, barriers to success, and collaborating with others, powerful research results are yielded that can aid others in considering their professional work and programs.

3.0 QUESTIONS AND METHODOLOGY

The overall goal of this thesis research was to investigate what processes and procedures were needed to successfully implement agricultural science problem-based learning curricula in Saskatchewan secondary schools. This was completed through a reflective self-inquiry process. Specific questions addressed include:

Main Research Question: What processes and procedures were needed to successfully implement agricultural science problem based learning curricula in Saskatchewan secondary schools?

Sub-Questions: *How did I reach educators and create an interest in the College of AgBio outreach efforts? What key partnerships were formed that enabled success? What events, conferences, and meeting allowed our program to reach educators? What were my perceptions of barriers to implementing these curriculum resources in schools? What were educators' perceptions of barriers to implementing AgBio curriculum resources in schools? Were these barriers actual or perceived?*

3.1 Research Methods

I examined the processes and procedures that led to the implementation of the PBL curriculum in Saskatchewan high schools. Through this inquiry, barriers that hindered success were identified. In future curriculum implementation endeavours, processes can be streamlined through examination of the results of this project. This phase of the qualitative research project includes a reflective self-study and offers a data-collection-analysis-interpretation approach.

The data analysis examines several issues. As a starting point, the process of AgBio PBL implementation is described through references to qualitative data drawn from personal experiences and documents relevant to the outreach efforts. This is complemented by a narrative description of these events. Next, an examination of perceived teacher barriers to implementing PBL curriculum was undertaken.

My interest in creating a self-reflective study lay in the desire to improve personal practice and communicate the results with other professionals. Borrowing from the work of LaBoskey (2004), the most important characteristics of the self-reflective inquiry methodology is to ensure the work is "self-initiated and focussed; … improvement aimed; interactive in such a way that it uses multiple, mainly qualitative, methods; … and has a validation process based in trustworthiness" (LaBoskey, 2004a, p.817). Data was collected using written communications, calendars, emails, and oral conversations and thus ensured the voice heard in the research portrays an accurate record of the events rather than a simple reflection constructed from memory after the completion of the project (Pinnegar and Hamilton, 2009).

In the work done creating and implementing PBL curriculum, I consider myself an educator. For this outreach project, PBL curriculum was developed under my directive, implemented through education of the teachers and through the support of classroom activities for the teachers who implemented the PBL approach in the classroom. As such, I consider myself an educator on a variety of levels. The results of this research improved personal pedagogical approaches taken and the general approach taken to outreach and extension of Agricultural Sciences.

The research in this project allowed for a process of systematic data collection and analysis. Data collection methods included, but were not limited to, an examination of personal calendars to outline a sequence of events, examining relevant meeting minutes, and highlights from correspondence with key stakeholders.

Where possible, an inclusion of information collected from communications with participants, collaborators, and voices from the field was utilized as a method of challenging and verifying the personal interpretation constructed. This use of other voices, stories and information sources contributed the trustworthiness and validity of the overall findings. Through data collection, analysis, and interpretation, the reader is clearly able to see how conclusions were drawn.

The data analysis of this research strived to provide an in-depth picture of what was needed to implement an agricultural oriented science based PBL curriculum in high schools of Saskatchewan. I undertook the responsibility of analyzing the data that was collected. Marhsall and Rossman (1999) consider "data analysis the process of bringing order, structure, and interpretation to the mass of data collected" (p. 150). In essence, I became the interpretive instrument in this self-reflective inquiry.

My expertise in the area of PBL implementation and competency with the subject matter in the PBL areas under study by students, as well as my familiarity with the research literature on PBL provided the necessary level of trustworthiness. To analyze data collected, various techniques were used such as: reading and re-reading the data, writing analytic memos, categorizing, linking categories, interpreting and offering explanations, plus drawing conclusions, which ultimately helped make sense of the information. This qualitative data analysis involved the organization, classification and categorization of information and a search for patterns amongst data.

3.2 Sub-Questions addressing the overall goal

In order to answer the main research question several sub-questions were explored.

How did I reach educators and create an interest in the College of AgBio outreach efforts?

A detailed examination of communication to educators, administrators, curriculum specialists and other key stakeholders is shared. Data was collected through an examination of the various communication channels used in outreach efforts. Data collected and summarized includes advertisements to teachers, emails to educators, personal correspondence, newspaper/newsletter articles, key conferences attended with a summary of session topics, and highlights of meetings with education specialists. Methods of collecting this data included an examination of emails, recounts of conversations, conference proceedings, highlights of relevant meeting minutes, and a summary of the key advertising efforts to educators. The description and analysis of this qualitative data was drawn from the experiences of the author and likewise interpreted for key findings. A summary of data is presented in chronological order, paraphrasing emails, conversations and meeting minutes. Where possible, advertisements were included. A description of the author's thoughts on each finding accompany this data set to paint a picture of effectiveness of each key communication step taken. Through this collection and analysis, a clear picture of the key methods of how I communicated with educators is presented.

What key partnerships were formed that enabled success?

In order to successfully implement the PBL curriculum in high schools throughout Saskatchewan, key partnerships were formed with schools, teachers, administrators, community partners and more. Data collected that explicate these relationships was collected through a recollection of the authors experiences throughout the outreach efforts taken which is consistent with a self-study. A description of the key partnerships was shared, with notes on why, or why not in some cases, these relationships contributed to the success of the outreach efforts. By understanding these key partnerships, readers gain an understanding of which relationships enabled success and if similar efforts are to be undertaken, the process may be streamlined.

What activities allowed the outreach efforts to connect with educators?

Efforts undertaken in this curriculum implementation project included a number of outreach activities. Data relevant to understanding these efforts was collected through an examination of my personal calendar. A summary of these outreach activities is provided. An analysis of this data included a personal recount of the event, and a reflective provided on the effectiveness of this effort.

What were my perceptions of barriers/challenges to implementing these curriculum resources in schools?

As the curriculum implementation project was a brand new endeavour to the author and the College of Agriculture and Bioresources, a number of barriers (real and perceived) were experienced that had to be overcome in order for the outreach efforts to be successful. Data on these barriers is provided through a reflective summary of personal feelings I had throughout the outreach efforts. By understanding and expressing these barriers, others undertaking similar efforts can come to understand what are real and what are perceived barriers to implementing curriculum. Methods/pathways of overcoming these barriers are also explored.

What were educators' perceptions of barriers to implementing AgBio curriculum resources in schools?

To implement AgBio PBL curriculum, educators play a key role. It is natural that educators have anxiety or concerns surrounding the implementation process. Understanding educators' perceptions of barriers to implementing a PBL curriculum aided my efforts in implementing the agriculture curriculum resources in more secondary schools. Data was collected from questionnaires already filled out by teachers who have attended College of AgBio high school science teacher workshops (see attached). The main question to analyze from the questionnaire is: *"What do you see as the biggest challenges to implementing PBL in your classroom?"* Information collected from this question is presented to the reader as expressed by the answers on the survey. Common answers were grouped together an emerging themes summarized. As themes emerge, possible solutions to barriers were explored.

By creating relevant sub questions, collecting data, reflecting and summarizing information, a picture begins to emerge that assisted in addressing the main research question.

There are limitations of this case study. As this is simply one author's experience in implementing an AgBio PBL curriculum, cautions must be made when generalizing this to other outreach efforts. This case focussed on implementation in Saskatchewan, other geographical regions may offer different experiences.

3.3 Ethical Guidelines

Before research was carried out, the University of Saskatchewan Ethics Office was contacted and provided information regarding this research proposal as it involves human subjects at the U of S campus and the external community. After submitting the necessary information to the ethics office, an exemption for this research project was provided as it fell under 'program evaluation' status. The questionnaire that was completed was anonymous and had no identifying characteristics in the reported answers. There was no position of power or influence over anyone participating and there was no perceived risk in participating in the study. The results of the study are made available to anyone who seeks this information. Through careful planning and approval processes, there are no ethical issues that arise from this research project.

3.4 Summary

This study outlines the processes and procedures that were needed to implement a PBL AgBio Science curriculum in several high schools of Saskatchewan. This research contains a self-reflective inquiry and interpretation of collected data. Through the discoveries of this research, a stream-lined process of curriculum implementation is realized and utilized by academic divisions wishing to enhance secondary education as well as industry groups wishing to gain greater exposure to high school groups. The research also serves to enhance personal effectiveness of agriculture education outreach into schools.

4.0 DATA COLLECTION

4.1 Genesis

The creation of a *Community Liaison Coordinator* position within College of Agriculture and Bioresources was the first step in connecting teachers and students with the science of agriculture. In 2004, the College dedicated a full-time, permanent position that would have a focus on student recruitment and agricultural outreach. This was a new position, created as a partial solution to drastically declining enrolments in Agriculture programs at the U of S.

As stated in the Job Profile, the primary purpose of the position is to: "*To provide leadership and support to the College of Agriculture & Bioresources in the areas of student recruitment and community initiatives. This will include the coordination and evaluation of the College student recruitment plan; identification of marketing opportunities; relationship-building through the development and application of appropriate communication strategies.*" (College of Agriculture and Bioresources, 2005). Amongst accountabilities were: development and implementation of effective recruitment strategies to increase enrolment in undergraduate programs, facilitate communication with prospective students, educators, producer and industry stakeholders, plus facilitate communications with the public to raise the profile of College of Agriculture & Bioresources education and research programs. Key tasks include: develop and deliver presentations on College programs and career opportunities for College graduates, coordinate departmental participation in recruitment and promotional events, and coordinate the revision and development of brochures, newsletters and other publications regarding student recruitment as required (College of Agriculture and Bioresources, 2005).

4.2 An Idea Born

Shortly after beginning work in July, 2005, a hallway conversation between myself and the closely situated Research Development officer hatched the idea of working closely with high school science teachers and the Ministry of Education, plus creating high school curriculum and hosting teacher workshops. If the College of Agriculture and Bioresources could produce high school science curriculum, then more teachers and students in Saskatchewan could become engaged in agricultural education. To support this idea, I was made aware of and successfully applied for the National Science and Engineering Research Council's (NSERC) PromoScience program. (R. Mantyka, personal communication, July 28th, 2005).

NSERC's PromoScience program "*offers financial support for organizations working with young Canadians to promote an understanding of science and engineering (including mathematics and technology).*" This program "supports hands-on learning experiences for young students and their science educators." PromoScience grants support to organizations that; work with young Canadians to inspire an interest in science and engineering, motivate young people to study science and engineering and to pursue careers in these fields, bring interactive, hands-on science experiences to young people, focus on groups that are traditionally under-represented in scientific and engineering careers, and train the teachers who teach science, math, and technology to our young people. (Natural Sciences and Engineering Research Council of Canada, 2005).

4.3 Funding the Idea

An extensive funding proposal was developed to support the outreach efforts. The program was named *Experience Science in Agriculture and Bioresources* (ESAB) and was centred around developing high school science curriculum resources and a series of three-day teacher workshops to train the educator in their use (Treloar, 2005). An outreach component of the proposal included visiting high school classes, career fairs and trade shows to bring information on careers and education in agriculture to high school students. The proposal aimed to develop and deliver a three-year program. Clear benchmarks for the workshop program were set with goals of twelve teachers attending in year one, thirty in year two, and thirty-six in year three. Year one of the program included time needed to forge relationships with high school science teachers and develop high quality materials. A three-year program budget was developed within the proposal. Program costs relevant the curriculum development included a half time position and laboratory materials. The total cost of the program over three years was estimated to be $447,988.00 with the College of Agriculture funding 50% of those costs. The proposal requested $221,088 from NSERC PromoScience. The proposal was extensive, well rounded, and ready to be endorsed.

To strengthen the proposal, letters of references were procured from key individuals. First, the Dean of Agriculture offered his support for this program, "The College of Agriculture enthusiastically offers its research laboratories and expertise in applied sciences to the curriculum augmentation component of the Experience Agriculture program. Opportunities for leading edge researchers to partner with teachers and curriculum developers will allow innovative science created at the College of Agriculture to take the forefront of classroom learning." (Barber, 2005) Second, several faculty members in the College of Agriculture offered their support. In a written endorsement of the outreach program, Professor Gordon Gray states, "The "teaching of those who teach" aspect of Experience Agriculture is particularly intriguing and I feel we have excellent facilities in the College to accomplish this goal." (Gray, 2005). Third, a letter from the Saskatchewan Ministry of Learning's Executive Director, Curriculum and Instruction Branch offers support, "Very often, science teachers have not had the opportunity to be involved in authentic scientific research or to experience authentic science in a work environment. Your proposal would provide that opportunity." (Sagal, 2005).

The completed proposal was sent to NSERC in September of 2005. On December 21st, 2005, notice was received from NSERC that the Experience Science in Agriculture and Bioresources program was successful in receiving a three-year funding commitment (NSERC; Barbara Conway, 2005). The funding covered $14,700 for year one, $21,800 for year two, and $23,700 for the third year, for a total of $60,200. While not enough to cover complete program costs, this initial funding and NSERC endorsement was an essential catalyst in program development and success.

In early 2006, the Dean of the College of Agriculture and the Development Officer were in meetings with Monsanto Canada, discussing opportunities for Monsanto to possibly fund College activities. Of concern to Monsanto Canada was the lack of graduates from College of Agriculture programs. While not on the official agenda of discussions, the conversation turned to the ESAB program and Monsanto Canada viewed the program as extremely favourable. The Public Relations Coordinator for Monsanto Canada requested a complete proposal for the ESAB program that she would endorse and send on to The Monsanto Fund International, based out of St. Louis, Missouri. Serendipitously, the program had caught the attention of industry.

In August of 2006, the ESAB program received news that would shape the program for years to come. The Monsanto Fund Program would be funding the ESAB program $50,000

(USD) each year for three years (Monsanto Fund; Deborah Patterson, 2006). The terms required that twice a year, activity and budget reports be submitted to the Monsanto Fund organization. Importantly, the funding agreement did not outline the nature of the science educational material to be developed. Backed by industry, the program was now extremely well-funded and ready to be set in motion.

4.4 Putting Things into Motion

While it was very exciting to receive large amounts of funding, at the time, I had no expertise in curriculum development and teacher training. Fears and apprehensions aside, it was time to move forward with program development. The first step in the process was to hire a curriculum writer to help create relevant science resources. A job was posted on campus, targeting students in the College of Education who had a background in sciences. A connection was made with the College of Education Curriculum Studies department, and they recommended a recent graduate. After interviewing, a suitable candidate was found.

Under my direction, in autumn of 2006, work began within the College of Agriculture on developing curriculum materials suitable for senior sciences within Saskatchewan. Outreach and collaboration with community partners was critical to program success. Throughout the next months, meetings were held with faculty, teachers, and curriculum writers from the Ministry of Learning to see what materials would be best suited for the high school science classrooms. Initial curriculum resource ideas were centralized around soil, plant, animal, and food sciences, as these were established disciplines within agriculture and would be designed to help meet curricular outcomes for senior science courses. As progress was made, it seemed a natural fit for materials to fit into the Biology 20 curriculum (grade 11). It was deemed important to work firstly with senior sciences (Biology, Chemistry) as these were required courses for students to enter the College of Agriculture from high school. Slowly, the process of curriculum development had started, but it was still largely an internal process within the College.

4.5 Promoting the New Program

To reach out to educators around the province, promoting the new program was deemed important. In November of 2006, the Sciematics Conference in Regina, SK I attended and presented a plenary session on the ESAB program. This annual conference attracts hundreds of science and mathematics teachers. In the session I described the goals of the curriculum development project and sought support, input, and partnerships from science educators. Attending this conference would profoundly alter, and ultimately enhance the direction of the outreach program.

Disappointment quickly ensued when only six teachers, out of hundreds present, attended the session. Information on ESAB program objectives was shared, and partnerships, input, and feedback was requested. Although attendance in the session was dismal, a key partnership was initiated with one of the science teachers in attendance. Disappointment turned to excitement upon conversation with a science educator from a Saskatoon high school.

E.D. Feehan Catholic High School in Saskatoon, in response to a shifting student population, was in the process of restructuring and establishing itself as a career academy. Within the academy was to be three “strands”: Construction, Computer Science, and Science. While the other two strands had structures in place, the science strand was lacking focus. It was immediately recognized that a symbiotic relationship could be formed. The curriculum design program I was leading could clearly benefit from a school that was willing to help create, pilot and teach the material, while the science strand would benefit from associating with a science-based college and related thriving industry. It was agreed further meetings with administration were needed.

4.6 A Partnership Formed

In the ensuing months, meetings with school administrators, teachers, Deans of AgBio, and district superintendents took place. A partnership was formalized with the signing of a Memorandum of Understanding between the College of AgBio and E.D. Feehan High School. The school wanted specialized education that would provide students with a meaningful science education that had significant ties to industry, and post-secondary. An education that would provide students with practical skills to prepare them for employability in the science community and for post-secondary science education was needed. The Bioresource Management Stream of the Career Academy at E.D. Feehan Catholic High School was born. Within this stream, it was decided that a specialized science course was to be developed in partnership. As it was a partnership, the Saskatoon Catholic School Division invested $10,000 in the creation of the course to help fund the curriculum development. This course was to be named Bioresource Management 20L, a locally developed course, and taught to students in the senior years of high school at the newly formed career academy.

Initial work was done to outline the content of the Bioresource Management curriculum and a meeting was planned with the Ministry of Learning to share the ideas for the course. Present at the meeting was the vice principal from E.D. Feehan, myself, the curriculum writer, a district Superintendent, and members of the Curriculum branch of Sask. Learning. Upon seeing the soils, plants, animal, and food units and associated curricular objectives, the Ministry provided valuable feedback. It was felt that the content of the curriculum really matched what was already (supposed) to be happening in senior biology classes. What the Ministry was most interested in was an alternative delivery style of the course, something that was experienced by the teacher and learner in a different format than what was already present. Since the College was the content expert in this area of science, trust would be laid in the fact we could get the knowledge content right, it was the how the curriculum is experienced that would have to change.

4.7 An Agricultural Science Problem-Based Curriculum was Born

Upon walking into work one of the following winter days, an idea for a new delivery method struck me from almost out of no-where. My undergraduate education at the University of British Columbia was delivered almost entirely in PBL format. As a student, this format was an entirely new method of learning to me, but one that I quickly became a firm believer in as it provided me with an engaging learning style that promoted critical thinking, problem solving and enhanced communication skills. The Bioresource Management course could be developed in PBL format. This winter’s day revelation was to prove to be the key in winning approval from the school, the ministry, and ultimately the students who experience the curriculum.

Upon returning to the office, I consulted with my employee, and the administrators at E.D Feehan. The process of PBL was unheard of to everyone, although upon brief consultation it was decided that this approach was just what was needed to advance the course. We would move ahead with the course in PBL format, integrating concepts of soils, plants, water, animals, economics, and science into an engaging and meaningful integrated curriculum.

Designing the knowledge content of the units in the course built, upon strengths of the university, a desire to create and enrich science experiences for students, my personal beliefs, and faculty & industry consultations. The group decided that the course would be named Bioresource Management 20L. The "L" designation at the end of the title would indicate that the course was a Locally Developed Course, approved for use by the Ministry of Learning, and open for use in any school in the province. The course was credited as an elective course, but not a designated science credit. The name reflected the proposed content and subject matter of the course, and highlighted the College of AgBio' role in the creation and development of the course.

A blank-slate was presented to me, allowing me the freedom, and responsibility, to design a curriculum that would have impact and meaning to those who experienced it. Industry was consulted for skills they wanted to see in their new employees, and the university was scanned for relevant areas of expertise that could influence science curriculum. Areas of interest meaningful to me were articulated into the curriculum. Because the course was new, I was completely free to develop the learning outcomes and indicators (learning objectives) for the Bioresource Management 20L class.

Ultimately, four units were developed in the course, spanning an entire semester. The units included; sustainability of ecosystems, wild cougar sightings in the city, a landscape design unit, and a First Nation and Métis health and nutrition unit looking at the functionality of traditionally used berries and how they promote health. Each of the units concentrated on a connection to "real-world" science happening in Saskatchewan and showcased potential careers and technology within the science community. These four units were designed with purpose, care and attention.

Sustainable agriculture and responsible use of the land is a strong personal belief that I hold and something I am interested in promoting. Based on this fundamental belief, I wanted students who experienced the Bioresource 20 curriculum to develop a strong understanding of the concept of sustainability, and in particular, how it applies to agricultural production. It was felt that in the very first unit, students should form a solid understanding of sustainability, and this understanding would permeate throughout all other units and forms of learning the course provides to the learner. By providing students with the ability to critically analyze the sustainability of the use of an ecosystem, I felt I was doing something right for ecology and the environment. The first PBL case explores processes with natural ecosystems and contrasts that to processes within a mono-crop agricultural ecosystem. Students are challenged to develop methods of incorporating and applying principals seen in nature to agriculture production systems in order to improve sustainability while maintaining productivity. Having a degree in Agroecology myself, I was able to articulate what I thought were key concepts within this unit. Known concepts of ecology such as niches, energy flows, adaptations, and resiliencies were drawn upon that could be applied to agriculture. Having the freedom to create curriculum that would reach large numbers of students and provide them with a solid understanding of sustainability was incredibly rewarding.

Having been to many industry meetings and networking events with agricultural college and university administrators as well as industry leaders from across the country, I have had the beneficial insight into where there is a shortage of employees. One area in particular, the landscape and nursery industry, indicated a lack of available labour and professionals. As horticulture is an area within my educational and teaching background, I believed it would be practical to create a unit that would introduce students to nursery plant production and landscape design. Elements of plant sciences would be embedded with the curriculum, such as plant growth regulators, conditions and resources needed to grow plants, greenhouse technology and sustainable pest management techniques. Consultation with faculty members within horticulture helped me develop a sense of what, ideally they would like to see first year students entering the college know about horticulture and landscape design. The results of these consultations were embedded within the curriculum.

Cougars in the City is a unit within Bioresource Management 20L that challenges students to develop a humane solution to the problem of increased cougar sightings within Saskatoon city limits. Wildlife ecology is highlighted within this case. It was felt that students would be engaged in problem solving within an everyday context, as cougars were recently making news in the city of Saskatoon with a recent police shooting. Wildlife studies were thought to be a popular theme with students and within the context of this case, many ecological concepts and frameworks were illustrated.

Studying health within a First Nations and Métis context is explored in the unit First Nation Health and Nutrition, health benefits of berries case. This case connects students to health issues faced by many First Nations and Métis people and challenges students to create a nutritional awareness program. Again, students pursue solutions to real life, complex problems challenging society.

Upon completion of course development, the curriculum with appropriate paper work, was submitted to the Ministry of Learning for approval as a locally developed course. This course was submitted on behalf of the Saskatoon Catholic School division through E.D. Feehan as a sponsoring school. This process was observed as the course could only be approved if submitted by a school, opposed to an outside agency such as the University of Saskatchewan. The process of an institute outside of the Ministry of Learning developing a curriculum was an entirely novel approach to curriculum design, but the partnership between the College of AgBio, E.D. Feehan and the Saskatoon Catholic School Division proved to be fruitful as the course was quickly approved for usage within the division and school as a locally developed course. The course was ready to be piloted in February of 2007.

The Bioresource Management 20L course was offered in the second semester, beginning February 2007 and ending in June. Twenty-six students participated in two sections of the course, with two science instructors leading the course. At the end of the year, feedback from students was solicited in the form of an anonymous questionnaire. In one question, when asked to comment on the following statement, *"This was a positive experience and I would participate in a PBL case again"* 22 out of 25 (88%) students indicated it was a positive experience, with one not commenting (Treloar, Community Liaison Coordinator, 2007).

With the science curriculum developed, approved and implemented at a local school, the ESAB program had a tremendous platform in which to launch into subsequent years. While the local partnership was fruitful, true success could not be had without reaching many more educators in the province. The process of promoting the curriculum resources to other science teachers through the workshop series was initiated.

4.8 Developing the Workshops

Central to implementing the curriculum in as many schools as possible, the workshop program was the next key component to be developed. As the workshops were critical to overall program success, the workshops had to be meaningful and relevant to the science educator. It was quickly decided that the workshop would be scaled back to a two-day event. Educators have a limited professional development allowance and cannot be out of the teaching environment for extended periods of time. Importantly, it was also decided that the workshops would be free of charge to the educator. Out of convenience, the workshops would be held on a Thursday and Friday, feeling that educators would not attend a weekend event.

The workshops would have three main objectives:

1. Provide exposure for the science educator to the realm of agriculture and bioresources, allowing them to understand the nature of scientific research conducted and a more solid understanding of the relevant education and careers available in this field.
2. Offer an introduction and training in PBL to the science educator.
3. Provide innovative, new, PBL curriculum resources to the science educator.

An agenda was established for the workshop. This agenda included a tour of agriculture facilities at the U of S, a general overview of problem based learning, hands-on sessions with the teachers acting as PBL students solving a case, a lunch speaker, experiential learning opportunities related to the case, facilitator training, PBL assessment, general discussion, actually observing high school students working on a PBL case, and an overview of the curriculum resources. Meals are provided. With an agenda established, curriculum developed, and funding in place, all that was needed was science teachers to attend the workshop. The first two-day workshop was set to take place Nov. 22nd & 23rd, 2007, with the second workshop following on Dec. 1st and 2nd, 2007.

4.9 Promoting the Workshops

As an agency external to the school system, promoting the College of Agriculture and Bioresources science teacher workshops was a new endeavour. We were an outside agency looking in, trying something new. As program lead, my largest fear was that no-one would attend the workshop, because teachers would not be interested in attending this type of professional development event. In the months leading up to the workshop, a large effort was needed to encourage teachers to attend the workshop. Promoting the workshop too early would mean educators might see the event as being too far off, promoting too late risked educators would not have sufficient time to get necessary permissions to attend. Promoting the workshop was largely completed via email. Workshop information and registration forms (see appendix A) were sent out to science teachers who become connected to the College through other outreach events such as on campus visits, and school career talks. Teachers within the Saskatoon Public School and Catholic Division were advised of the opportunity through division notifications. School division superintendents were advised of the program and asked to forward to science teachers. High schools were faxed information and the fax was addressed to the science department head. Considerable time was spent promoting the workshop through email.

Teachers wishing to attend the workshop could either reply by email or fax in the registration form. There was no website with information on the workshops. Questions about the workshop were fielded by myself, typically asked via email. Within a week, registrations began to show up in my inbox.

In total, thirteen educators attended the first workshop held Nov 22nd&23rd workshop, and fifteen attended the December workshop.

4.10 Experiencing the Initial Workshops

It was essential that the participants found the event worthwhile and that they experienced an excellent professional develop workshop. To meet the objectives of the workshop, teachers listened to a short overview of the College of AgBio, they then toured the AgBio labs and facilities. In this initial series of workshops, PBL was something that educators had heard of, but had not implemented in their classrooms. Largely, educators were curious about the PBL process, but had little knowledge of it. They were interested because it was an alternative teaching method that promised a student centred learning environment, engaged students, and was a real-life context for science teaching.

Because teachers were there to learn the PBL process, and the implementation of the agriculture curriculum resources depended on them understanding PBL, teachers were placed in the role of the student so they could experience the PBL process firsthand. On the first day of the workshop, two groups were formed and provided the same case to work on, a horticulture case from the curriculum resources package. Groups were facilitated by myself and my employee. Included in the case were guest speakers and hands-on lab experiences in the greenhouse and landscape design area. The groups were provided the opportunity to present their landscape designs to the larger audience of workshop attendees. Over the course of the day, teachers had experienced the PBL process.

Day two saw a dissection of the PBL process. The role of the facilitator was discussed and teachers had an opportunity to practice facilitation skills. Students from E.D. Feehan came in and worked on PBL in a “fishbowl” activity. In this activity, students worked through a PBL session with workshop attendees observing the PBL process from a non-participatory vantage. Attendees were permitted to question the students about the PBL process and experiences.

Resource packages containing the PBL cases were given to the educators. The cases were packaged as the Bioresource Management 20L course. As per Ministry of Learning requests, a thorough explanation was provided about process needed to implement the locally developed course as an elective within their schools. It was generally felt to be a worthwhile experience for educators. Feedback from high school science teachers attending a November workshop allowed insight into what educators thought was worthwhile. The following are quotes from teachers attending the workshop, each response from an individual teacher:

Did the workshops meet your objectives?:

- Yes-opened a whole new corridor to implement in the classroom
- I was intrigued with the notion of making science/biology more connected to “real-life” The workshops definitely gave me a new perspective on this idea.
- The curriculum developed requires students to be actively learning and accountable to peers. Students become more skilled at problem solving and communication skills.
- Yes, it was very good. Learned a lot about Bioresource management and Problem Based Learning.
- Yes, Presented information in a new, exciting way
- Yes…actually exceeded them. I took away much more than I expected in terms of resources, ideas and process.

With the first two workshops completed the ESAB program was beginning to accomplish the goals it set out to do.

Clearly the workshops had the ability to draw in science educators. A major goal of the overall project was to implement curriculum into the high school science classes. In order to find out the most effective method of implementing this new curriculum, it became clear that knowing teacher perceptions of barriers to implementing PBL in the classroom would be useful. If these barriers were known, more education around how to remove these barriers would be of benefit to implementation.

Data was collected from two workshops in November of 2008. In an anonymous questionnaire at the end of the workshops, participants were asked a series of questions that included, "What do you see as the biggest challenges? to implementing PBL in your classroom?" Replies from all the educators were recorded and the results examined and placed into themes: (SA) Student attitudes, (TC) Time constraints (AM) Assessment methods, (FI) Facilitating Issues, (TP) Teacher preparedness, (CO) curriculum objectives met. See Table 1.

Table 1.0. Teacher responses to the question *"What do you see as the biggest challenge to implementing PBL in your classroom?"* Data was collected at November and December 2008 workshops.

Student Attitudes (SA)	**Time Constraints (TC)**	**Assessment Methods (AM)**	**Facilitating Issues (FI)**	**Teacher Preparedness (TP)**	**Curriculum Objectives Met (CO)**
Students unwilling to try something new Students who prefer getting high marks on tests Helping groups distribute the workload equally Changing the mentality of my students may be the biggest challenge Learning curve and adjustments for students	Time constraints Time constraints- time to plan the integration of regular information and activities Timelines, expenses (busses to different experiential learning sites) Time is always the limiting factor, this definitely lends itself to a locally developed course.	Determining a numerical grade appropriately Assessment- transition from current methods to more self/peer/group	finding someone to help facilitate Finding the help to facilitate Being the facilitator and not the teacher	Working with large class sizes which would require 3-4 groups and working with four different Bio 20 classes per year Obtaining resources as always can be a challenge, but we work with what we have One of me, twenty of them I just think I have to take small steps vs. jumping in with two feet	Student enrolment. We need it to be recognized as a science credit Meeting curricular objectives through the problems To ensure content is covered to a reasonable detail and to make it obvious what are the expected outcomes

Getting the students/parents on board Getting all the students motivated to participate I think the most difficult aspects are the responsibility required by each student Attendance by students Motivation to be part of a strong group effort. Attitudes towards active learning “Why do I need to know this, what’s the point, can’t you just tell us the answer?” Engaging all students Getting students to think and				Learning curve and adjustments for teachers I would need more information/findings for some of the research the students need to carry out so I have an idea of which questions to ask to lead the students in the right direction or know they have come up with an answer. Perhaps in the form of fact sheets. I don’t see having enough time to do the leg work on my own Access to experts (other than internet)	Getting a good result at the end of the PBL module-did the students achieve the desired learning outcomes (CO); did everyone fully participate

work independently (without teacher as a resource and "security guard" Having all students engaged and working as a group Buy in by students to engage in alternative style of learning.					

In attendance at the November 2008 workshop was a biology teacher from a local high school who was returning to the workshop for a second time. She brought with her another science teacher from her school. Together they were very interested in implementing this learning strategy in the science classroom of their school. A meeting was set for the spring of 2009 to examine methods of implementing these PBL resources into their school.

Upon meeting, a closer examination of all the cases developed to date led us to the conclusion that if re-organized, the cases would satisfy the objectives for the Biology 20 (grade 11) curriculum. Four cases would draw from the Bioresource Management 20L & 30L curricula. One new case had to be developed to ensure the curricular objectives for Biology 20 would be satisfied. Re-packaging the cases and creating some new resources to meet the Biology 20 curriculum outcomes, meant a school would no longer need to apply to offer a locally developed course. Schools would not have to offer an additional elective course, because students could use this elective instead of Biology 20 for a science credit required for graduation. It was decided that Evan Hardy Collegiate, in Saskatoon, Saskatchewan would offer a Biology 20 course named Biology 20 Bioresource Management. The course would be a dual credit course, combined with Work Experience 30, and it would be team-taught. The teachers were responsible for communication with the principal regarding the shift in scheduling and relevant school-based administrative changes required for implementation. The course had another home.

In the years following, the AgBio science curriculum outreach program grew into a formidable enterprise. Numerous additional teacher workshops were held, attendance at education conference sessions climbed, funding was increased, partnerships were developed, and more schools implemented the curriculum. The following offers a list of significant events that helped to shape, grow, and expand the AgBio science curriculum outreach program.

4.11 Other Significant Events

- July-Aug 2008: Development of Bioresource Management 30L: $10,000 from Saskatoon Catholic
- September 26th 2008: “Problem Based Learning in Your Class” hosted by ESAB at Peacock Collegiate High School. Over 70 teachers attend
- September 2008: Connection with Federation of Saskatchewan Indian Nations (FSIN): Program Manager, Science Education and Training Secretariat

- January 15th, 2009: "Problem Based Learning in Your Class" at Central Butte School. 15 teachers in attendance
- April 8th & 9th, 2009: Treaty 4 Educators Conference presentation:, 8 attendees
- April 23rd & 24th 2009: High School Science Teacher Workshop: FSIN partnership 22 attendees
- September 2009: Evan Hardy Wins U.N. Recognition Award for BioResource Management Class delivery
- Nov 19th & 20th, 2009: FSIN/AgBio Teacher workshop 20 attendees
- March 22nd & 23rd, 2010: FSIN/AgBio Teacher workshop 18 attendees
- April 22nd & 23rd, 2010: Treaty 4 Educators Conference presentation 25 attendees
- April 30th, 2010: Awasis Conference presentation 25 attendees
- Sept 2010: Saskatchewan Teacher's Federation Bulletin Article about outreach program
- Sept 2010: Ministry of Learning Curriculum Bulletin highlighting outreach program
- September 26th, 2010: Presentation to Common Department Meeting (Saskatoon Public Science Teachers)
- September 2010: Info and Registration form available on-line
- Oct 2010: Accelerator Publication Article about outreach program
- Oct 21 & 22, 2010: FSIN/AgBio Teacher workshop. Introduced to Erin Jones, science teacher at Oskayak High School in Saskatoon 36 attendees
- Nov 5th, 2010: Sciematics Regina presentation 30 attendees
- Nov 18th& 19th, 2010: Science Teacher workshop 17 attendees
- Dec 6th & 7th, 2010: Meadow Lake Tribal Council Science teacher workshop 8 attendees
- Dec 2010: Crop-Life Canada, $30,000 donation to program

4.12 Workshop Promotion

High school science teacher workshops continued to be held at the College of AgBio. The most important aspect of the workshops was getting science teachers to attend. Teacher feedback from the workshops continued to be outstanding. As it is crucial workshop information reach science teachers, ensuring the teachers had a high quality experience meant teachers would recommend the workshop to their colleagues. As more educators moved through the workshop program and implemented this learning at their schools, promoting the workshops became easier and numbers of attendees began to grow. The PBL workshop held at the College of AgBio shifted from an oddity to a well-recognized program.

To promote workshops, a number of channels were used. Past attendees were contacted via email and provided information regarding upcoming workshops and registration forms. These teachers were asked to relay this information to science teacher colleagues. Key administrative contacts within school divisions were also informed of the workshop dates. Marketing information stated that these workshops were a high quality, transformative professional development event; therefore administrators were keen to send workshop information to science departments within the schools they were responsible for. Information quickly moved into the hands of the science teachers and workshop enrolment remained high.

To help facilitate the communication of workshops, information was posted on the College of AgBio website. This web-presence provided information on the workshop agenda and a downloadable registration form. Potential attendees had another point of access for information.

Publications relevant to provincial science educators were contacted to see if there was an interest in publishing information on the overall curriculum program and upcoming workshops. As the curriculum had already been successfully implemented in a number of schools and had received accolades, these publications were eager to assist in promoting the workshops at no cost to our program. These free publications included the Accelerator magazine - a quarterly publication coordinated by the Saskatchewan Science Teachers Society, information in the Ministry of Learning Curriculum Newsletter, and an article in the Bulletin (Saskatchewan Teachers Federation newsletter, 2010). This enhanced marketing meant more teachers were hearing about the workshop program, thus increasing the likelihood of them attending a workshop.

A key partnership was realized in the late summer of 2008. A connection was made to the Federation of Saskatchewan Indian Nations (FSIN) Science Education and Training Secretariat. At a small career fair, I was introduced to the Program Manager. We immediately recognized similarities in our mandate to enhance science education. An important relationship had begun.

Over the next two and a half years, the ESAB program would partner with FSIN to offer high school science teacher workshops at the College of AgBio. As it was FSIN's mandate to work with the seventy-four First Nation Reserve Schools in Saskatchewan, a communication channel was opened up to the science educators teaching at reserve schools. FSIN had funding in place to support teacher workshops and provided financial support for meals, supplies, and resource printing. Additionally, FSIN had funds to pay for teachers' transportation, accommodation, and meal costs. Through partnering with FSIN, an increased number of workshops were held, bringing even more teachers in contact with the ESAB program.

Through the partnership forged with FSIN, a new communication channel into First Nation Reserve Schools in Saskatchewan was recognized. As these schools do not fall under the jurisdiction of the Saskatchewan Ministry of Learning, there is an increased possibility science teachers at these schools may miss some of the information put forth about ESAB workshops and PBL curriculum. The science and education secretariat within FSIN has regular communication to science teachers on reserve schools and successfully promoted the workshops to all seventy-four First Nation Reserve Schools in Saskatchewan. Through this promotion, dozens of teachers from First Nation Schools attended workshops held at the College of AgBio.

Another key element of this partnership was the enhancement of First Nations and Metis content within the PBL science curriculum resources. Ensuring that content was appropriate and relevant to First Nation students increased the likelihood of the curriculum becoming implemented at First Nations Schools. In partnership with FSIN, curriculum content was enhanced and revised to increase the First Nation and Metis content.

In March of 2010, an educational administrator from the Meadow Lake Tribal Council (MLTC) attended a PBL workshop at the College. Seeing the potential benefits of PBL to be implemented with the schools in MLTC, in July of 2010, I was invited to Meadow Lake, Saskatchewan to host a two-day PBL workshop for the science teachers within MLTC (Dean Loberg, 2010). This was the first full, two-day PBL workshop held at a remote site. Science teachers representing eight schools within MLTC attended the December workshop, furthering the reach and impact of the ESAB outreach program.

An opportunity to present to First Nation and Metis science educators was realized with the acceptance of a presentation proposal for the Awasis conference in April of 2010. This conference, held in Saskatoon, SK., "aims to improve Aboriginal knowledge and spirituality for all people," and includes education as a holistic theme (Awasis Education Council, 2010). The proposal for this conference included information on PBL curriculum resources, First Nation and

Metis content in science, and information on workshops held at the College (Treloar J. , Community Liaison Coordinator, 2010). This conference created a connection to twenty-five educators who later in the year participated in the AgBio science curriculum program.

The Treaty Four Educators conference was held in Regina, SK, in April of 2009 & 2010. A presentation proposal similar to the Awasis conference was submitted and accepted. This conference allowed eight attendees to hear the presentation in 2009, and an additional twenty-five in 2010. This increase in attendees could be attributed to the increase in popularity of the program.

4.13 Packaging the PBL Curriculum Resources

A new willingness to implement the curriculum began to occur in 2009. With the curriculum implemented at Evan Hardy Collegiate, a local high school and being taught as Biology 20, a new format to package the PBL resources was realized. The curriculum resources were re-organized with a selection of cases packaged to meet the objectives for Biology 20, the provincially mandated grade 11 biology curriculum. This newly repackaged curriculum resource was now distributed to teachers attending the two-day workshops. A shift in teacher willingness to implement this curriculum occurred with this re-packaging. Units could now be implemented in ongoing Biology 20 classes which are offered in every high school in the province. PBL units had distinct congruence with the curriculum and course objectives could clearly be met through the PBL resources. Because of this fit into Biology, teachers became more willing to implement the curriculum.

4.14 Observing the PBL Process

Observing students participating in the PBL process became one of the most powerful tools in convincing teachers to implement PBL in their classrooms. Teachers attending the workshops experienced the PBL process themselves and further dissected and discussed components of the process. Students from local Biology classes using the PBL resources were then brought into the workshop to participate in a “fishbowl” activity. Students worked through a case and teachers were allowed to observe how the students collaborated. After the students worked through the case, teachers were allowed to ask questions of the students about the PBL experience. This powerful exercise gave insight into student attitudes and experiences.

Often teachers new to the PBL process have many questions, fears, and misconceptions about how students experience and regulate the PBL environment. Observing the students participating in a PBL exercise allowed some of these apprehensions educators had to be dispelled as students successfully followed the PBL process. Blunt questions from educators directly to the students were answered in a very forthright manner. Questions about student attendance, participation, evaluation, engagement and group process were answered directly from the student's perspective. This exercise truly painted a positive picture of the PBL process and became a valuable tool in promoting PBL to educators.

Again, in the next series of workshops, educators were asked, "What do you see as the biggest challenges to implementing PBL in your classroom?" The results are summarized in the table below with answers grouped according to emerging themes: Student Attitudes (SA), Time Constraints (TC), Assessment Methods (AM), Facilitating Issues (FI), Teacher Preparedness (TP), and Curriculum Objectives Met (CI).

In total, combined with the earlier survey, 88 responses were solicited from the teacher surveys. The results of this questionnaire show that 26 (37.6%) of the responses indicated that student attitudes would be the biggest challenge to implementing PBL in the classroom. Seven (10.1%) indicated that time constraints would be the biggest challenge. Only three (4.3%) replied that assessment methods would be the biggest challenge. Facilitating Issues was indicated in ten replies (14.4%), teacher preparedness accounted for 16 (23.1%) responses and meeting curricular objectives was indicated by seven (10.1%) responses.

Table 2.0. Teacher responses to the question *"What do you see as the biggest challenge to implementing PBL in your classroom?"* Data was collected at 2009-2010 workshops.

Student Attitudes (SA)	**Time Constraints (TC)**	**Assessment Methods (AM)**	**Facilitating Issues (FI)**	**Teacher Preparedness (TP)**	**Curriculum Objectives Met (CO)**
Attendance issues Work ethic of students Introducing students to the process Student resistance Challenge is attendance Different student achievement levels, motivation, and work ethic Convincing the students that this is worthwhile Getting the students on board to a different learning style	Time would be the biggest challenge only having 1 hr/day Time Time. I teach 10 other courses	The evaluation process I am busying with the assessment piece	I think the classroom management associated with the initial implementation of the learning/teaching methods of PBL facilitating in a large class with no support (EA's Etc) Staying on top of the process as a facilitator Facilitators We have 32 student & it is hard to ensure that everyone does their work adequately	Convincing teachers to try PBL in their classrooms Getting past the awkward first case study getting enough resources (speakers, computers, etc) Teaching a split grade 8/9 together. The grade 9 class only has 6 and the 8's are 20. Getting started Class size, initial input of time Easy access to resources	w Bio 30 because cases are so content heavy Being sure I feel comfortable that I have covered content in Bio 20 & 30

Teaching the kids the process Teaching the kids the format & teaching them how to research The students being used to it How students will initially react – 11 years of info dumping…having to think on their own = shut down Diversity of students (special needs) Attendance Student resistance/frustration at the beginning of the first case Students buying into it & attendance by students Students first time Group Organization Getting students accustomed to that particular learning strategy			As a teacher being an effective facilitator lack of space and anyone available to help facilitate Teachers giving up “control” of the information Large class sizes Class size It will take some time and some trial and error for me to develop as a facilitator	Other colleagues buying in, getting speakers, having field trips. my own insecurities getting other teachers/admin on board not having relevant cases for my sciences Working specific PBL cases into my classes Convincing my coworkers to do it Resources No support Small school ‘isolated’, funding for trips The biggest challenge will be the lack of technology in our classroom	

Students with many absents Resistance to change				Being fully prepared myself to know the material inside and out to properly guide the students	

5.0 DISCUSSION

5.1 Introduction

The result of implementing the Problem Based Learning agriculture science curriculum has been rewarding. The journey, from an idea hatched in the D-wing hallway of the Agriculture building, to the growing list of schools teaching the PBL curriculum, can be mapped out through the research conducted in this project. This section of the research project dissects and discusses key events that led to the widespread implementation of the PBL curriculum. A reflective narrative is provided, allowing insight into the author’s feelings, apprehensions, reasons and rationale behind steps taken in the implementation process. An examination and discussion of the barriers, both personal and external to success is provided and information on methods to overcoming barriers is examined. Based on the results of the findings, recommendations to streamline the implementation process are provided. Through the examination and reflection of this journey, a clear picture of the key processes and procedures needed to implement agricultural science Problem Based Learning Curriculum in Saskatchewan secondary schools becomes clear.

5.2 Reflections on Genesis

The College of AgBio dedicated resources to reaching out to high school students. The establishment of the Community Liaison Coordinator position was central to the outreach activities leading to the implementation of the agricultural curriculum resources. For an institution to have success in the implementation of a curriculum in the school system, considerable time must be invested in creating resources, forging relationships, stewarding the program, evaluating, re-creating, adapting, and general program leadership. This leadership took considerable time, focus, passion and dedication. As a critical component of successfully implementing the PBL curriculum, having a position dedicated to this type of outreach activity was essential.

While the College of AgBio established the Community Liaison Coordinator position as the central leadership role in the curriculum outreach project, the position was not created to include these activities. In looking at the primary purpose of the position within the College, as well as the accountabilities, there was no mention of creating high school science curriculum or hosting teacher workshops. While these activities, related to curriculum implementation are aimed at long-term student recruitment, it is worthwhile to have them implicitly written into the job description and accountabilities. Another benefit to this inclusion in the job profile is having the right individual be attracted to, and fill the position. Creating and implementing PBL science curriculum in schools requires a diversity of skills and abilities, it is essential these are laid out in the job profile of the position.

For me at the time of applying in early 2005, the position focus was ideal. I have a passion for agriculture outreach and recruiting and had years of experience in British Columbia doing similar activities. I was comfortable with the accountabilities and my experiences proved to be a good fit for the position. I was excited upon being hired and ready to bring forth passion and experience into the position for years to come.

Key Step: The creation of a position that includes a dedication to the curriculum outreach project.

Key Step: Identifying an individual, passionate about Agriculture Education, with key traits; creativity, well networked, personal drive towards achieving goals, strong personality and the ability to relate well to a cross section of population, good public speaker, and openness to change. In addition this person must have solid support from superiors.

Barrier: Not having the information in job description to support curriculum resource development and implementation.

5.3 An Idea Born

Luck played a role in the creation of the PBL outreach project. The College was lucky to have an individual with the foresight and creativity to casually propose a project of this magnitude. The Research Development Officer also had relevant connections to individuals who were key in supporting this idea. He also provided the source of potential funding. A chance hallway conversation truly got the ball rolling on a significant project.

At the time, it was felt this project was exciting, but nebulous, and I had no experience in something of this magnitude. I could see the long-term benefits of this project, but did not clearly see the short-term work that would be needed. In short, the steps needed to implement the curriculum in schools of Saskatchewan were not known. This lack of knowledge was a cause of anxiety, but a challenge I knew I could step up to and meet head on.

Writing the grants was essential to program success. The creation of the grant application was a time consuming process. It was essential that outreach program activities clearly articulated how all funding program requirements would be met. Having created a program idea from the ground up, it was not always immediately clear how the program would meet these requirements and often I would have to assume program success in order to accomplish the goals of the funding agency. Considerable time was spent describing the program to College administration and faculty to ensure that I would have the full support of the College behind the project. Time was also spent connecting with the Ministry of Learning and procuring a letter of support from an administrator in the Curriculum and Instruction Branch. While laborious, time invested on writing a comprehensive grant application ultimately paid off and laid the foundation for a successful outreach project that allowed the development and implementation of PBL within science classrooms of Saskatchewan.

The initial NSERC grant application had several components that led to overall program success. The letters of support were from influential offices with a significant amount of authority associated with the positions. The letter from the Dean indicated College support, the letter from faculty indicated that relevant expertise would help shape the curriculum, and the letter from the Ministry of Learning indicated that this type of project was supported from the government office associated with curriculum and instruction. The grant application contained a monetary request that was significant enough to cover expenses for the program. A timeframe of three years was set for the initial program, allowing enough time for the creation, implementation and evaluation of the outreach effort. Because the grant application was well thought out, supported by faculty, staff, & the education community, and was creative, funding was received.

Private industry funding from Monsanto International was a welcome surprise. It was not my intent to ask industry for funding and it was somewhat serendipitous that funding was received from this source. Through my connection to industry, significant money from Monsanto was obtained for this program. While excited to receive this significant funding, I was concerned over the implications funding from this company may have on the program. There is considerable controversy surrounding Monsanto, particularly around the use of biotechnology. I did not want to be perceived as running a program for Monsanto or in any way be perceived as trying to influence educators and students as to the merits of this company, be it scientifically or through their business model. To the credit of Monsanto, no-where in the grant agreement was there mention of the type of scientific content they would like to educators to access. The content was to be determined by the College of AgBio, completely free of outside influence from Monsanto. Monsanto was interested in the numbers of teachers attending workshops and where the curriculum was implemented. While personal judgement on Monsanto is reserved, the risks of receiving funding from them versus not accepting this money was weighed. Upon careful consideration, this money was gratefully accepted as considerable benefits could be realized for the program. Despite the negative sentiments some carry towards Monsanto, funding from this source would allow the science of agriculture to reach many educators and students who may have otherwise not had a connection to this area of science.

Key Steps: Locating appropriate granting programs to provide funding to support outreach activities, and obtaining strong letters of support from diverse parties to strengthen grant applications. Obtaining funding that allows for program establishment over a reasonable timeframe, plus creating an accurate budget are needed for program success.

Barriers: No experience leading this type of program. Unsure if funding source would detract educators.

5.4 Project Initiation

The project now had the both the financial resources and technical backing needed to bring it to fruition. Setting the project in motion was difficult as I lacked the expertise to implement the project. Never before had I undertaken such an effort, and there was no information or literature present on how to lead such an endeavour. It would be completely up to me to implement and lead this project. While I had connections with educators and financial support, I lacked the pedagogical knowledge that is required to create curriculum and train educators. I needed to move forward, but my apprehensions held me back.

Barriers: Unsure if I possessed the skills needed to implement a program. Not having the educational skills required to implement and maintain a program.

A significant component of the federal grant funding was dedicated towards the creation and hiring of a new position. This position was the curriculum writer position, which was equal to approximately a half-time employee at the university. The connection made to the College of Education was important in procuring a suitable candidate as faculty in the Department of Curriculum studies made a solid recommendation. In hiring an individual with an education background, the curriculum materials developed were put into a format that would be easy to use and understood by science educators in the province. As I did not at the time, possess these skills, this became a valuable contribution to the overall project.

Key Step: Ensuring outreach efforts include an individual or individuals with a solid understanding of the provincial curriculum in the school systems.

Initial meetings with faculty within the College of Agriculture and Bioresources were both useful and frustrating. The utility of this series of consultations lay in the types of knowledge content they would like to see a first year student have upon entering university. While this material is useful, the frustration lay in the fact that each scientist thought that their discipline was the most essential for students to learn about. Regardless, consultations with most faculty who were sought for project input were more than willing to assist and contribute expertise to curriculum development. Having the backing and support of faculty with their vast amount of expertise in a diversity of disciplines was an essential component of program success.

Key Step: Seeking expertise in content area for curriculum to be developed.

Barrier: Biases' of experts when developing content for curriculum resources.

In the weeks leading up to the Sciematics conference in November, 2006 in Regina, I was enthusiastic because I would be talking about my program which was new, had industry support, had experts backing it, and the program had a structure in place that would allow for years of outreach continuation. I was disappointed to see my presentation time slot in the last session of Friday afternoon as I feared many educators would not stay around the conference and attendance would be miserable. These apprehensions were well founded as only six teachers attended my session. I was hoping for at least twenty in order to make an impact. As it turned out, one out of the six was all that was needed to have a significant impact on the outreach efforts. Excitement returned as a key connection with the science teacher at E.D. Feehan High School. This was a key partnership that helped shape the program for years to come. I had science teachers to work with to develop curricula, classes to pilot PBL cases, administrators to support locally developed course development, and support from a school division. The Sciematics conference in 2006 was an essential step in building the program into something successful.

Key Step: In order to promote outreach efforts, seek out and attend conferences that host large numbers of teachers in relevant subject areas.

Barrier: Apparent lack of general interest in outreach efforts by educators.

The partnership that was forged between the College of AgBio and E.D. Feehan School was of tremendous importance to the outreach efforts. This partnership allowed the science curriculum resources to be developed with experts from both institutions. The materials would benefit from having an increased influence from science teachers in the classroom as they were created. Materials were also piloted at the school to ensure relevance and decency, an important aspect to consider when promoting the resources to other schools and teachers. Feedback from students provided an essential insight into the experienced curriculum. This partnership verified the relevance and importance to the overall Experience Science in Agriculture and Bioresources program from a high school science point of view. If a school was willing to form a partnership, the program must be on the right track.

Key Step: Establishing a partnership with a local school in which materials can be developed together, piloted, and revised accordingly.

Meeting with the Ministry of Learning early in the curriculum resource development process was another key step in the overall project. Through this meeting, feedback on our project direction was provided. What I thought to be relevant curriculum resources, were not met enthusiastically by this group. While frustrating at first, this feedback proved to be a blessing in the long-term. The Ministry was looking for curriculum delivery methods that were learner centred and offered enhanced methods of student engagement. Again, I did not know what this might look like and there was an element of frustration and anxiety. This dose of tough love helped shape the curriculum resources into the innovative and desirable PBL format. This meeting really shaped the future success of the outreach project.

Key Step: Meeting with provincial Ministry of Learning curriculum specialists. Understanding what curriculum resources are the most attractive to the Ministry of Learning.

Barrier: The need to create innovative curriculum resources that provide a student centred approach to learning.

Problem Based Learning was a key element of the entire curriculum outreach and teacher training program. When the idea came to me from out of no-where, I was incredibly enthusiastic about creating resources in this format. As a student of PBL, I enjoyed virtually every aspect of this method of learning because cases connected science to real life scenarios, they provided an opportunity to collaborate with colleagues, it was an interdisciplinary approach used to develop solutions, flexibility was encouraged, brainstorming of ideas was commonplace and most importantly, I retained the knowledge I gained. To me, the curriculum materials developed *had* to be in this format. It made the most sense and I was disappointed in not thinking of this sooner.

While excited about the inclusion of PBL into the curriculum resource project, I quickly discovered I was alone in this excitement because the people I was involved with in the project had no knowledge or experience with PBL. The curriculum developer was not familiar with PBL, and the educators at E.D. Feehan had heard of the method but were not intimately familiar with it. Upon describing it to my partners, curiosity and enthusiasm surrounding PBL grew.

To familiarize my partners with these curriculum resources, I quickly provided resource materials, web-sites, and examples of Problem Based Learning curricula. A workshop was sought for the curriculum writer to attend in order to become better familiarized with the PBL process, The writer was sent to a 3-day workshop in Chicago. Between my enthusiasm for PBL and the resources provided, all partners agreed to develop resources in the PBL format.

Key Step: Inclusion of an innovative, engaging curriculum delivery (PBL) as an educational strategy to be used in the curriculum resource development.

Barrier: Lack of familiarity of PBL amongst educators, and curriculum writer.

Perhaps one of the most exciting elements of the curriculum development project was having the ability to create brand-new curricula. The blank slate this project provided afforded me the opportunity to develop curriculum that could include areas of personal interest and importance. Having a personal interest in issues around agricultural sustainability meant I could weave this into curriculum resources that had the potential to reach large numbers of students. This freedom also meant I could look at all the renowned research facilities at the university and decide from where to draw upon expertise I needed. At this stage of the curriculum development project, the learning objectives were still wide open as we were creating a new locally developed (elective) course. There was no need to create resources which had to meet existing objectives. There was a sense of responsibility to ensure the curriculum that was being developed was going to be important to both those delivering it and those experiencing it. The curriculum also needed to create an interest in pursuing further education and careers in agriculture for those students enrolled in the program.

The creation of BioResource Management 20L allowed agricultural science to be placed at the forefront of high school learning. As discussed, the units created were of both personal interest and scientifically relevant to areas of expertise on campus. Through this creative process, an entire course was available to the science educator, not just some stand-alone units or resource materials. The curriculum was approved by the provincial Ministry of Learning, was listed as a locally developed course, and was readily available to any educator/school that wished to apply to teach the course as an elective. There were enough cases to span an entire semester and were targeted towards senior high school students. The Bioresource Management 20L was ready to be introduced to students.

Key Step: Completing resource package with ample, diverse materials for educators.

Students at E.D. Feehan were introduced to the Bioresource Management 20L curriculum as part of the science strand offered by the school within the Career Academy model. The curriculum implementation project had now gone from an idea in a hallway to a recognized course within the province that was being taught at a local school. Indicators of success were beginning to materialize.

Key Step: Implementation of curriculum in high school science strand.

A critical component of the curriculum outreach problem centred around having science educators attend two-day workshops held at the College of Agriculture and Bioresources. At the onset of the workshop program, I had no idea how well attended the workshops would or would not be. A fear of mine was that very few teachers would attend the workshop. If no one attended the workshop, the curriculum resources would not be able to be distributed. It was essential that educators receive information on the workshops, although at this time the best way to reach high school science teachers was not known.

Key Step: Reaching educators with information on science teacher workshops.

Barrier: Lack of knowledge on how to reach science educators with workshop information.

A total of 28 educators attended the first two workshops held in the College of AgBio in the autumn of 2007. Clearly, the efforts put forth to reach educators had worked. Using as many channels to reach science educators as possible contributed to successfully attracting workshop attendees. This initial workshop promotion was very time consuming as many different channels were used to connect with the science educators.

Key Step: Connecting the science educator to workshop information through email notification, poster advertisements, calling pre-existing contacts, speaking with Science Department Heads, connecting with division superintendents,

Barrier: Reaching educators with outreach information can be time consuming.

5.5 Experiencing the PBL workshop

With 13 educators set to attend the first workshop in November of 2007, both excitement and apprehension was experienced in the days leading up to the workshop. While it was exciting to have the opportunity to promote the curriculum resources to educators, I had never hosted a two-day professional development event and was apprehensive that the event would not be perceived as worthwhile.

Barrier: Lack of personal confidence in the ability to deliver a PBL workshop.

In reflecting on the content of the initial workshop, teaching the educators PBL methods was an essential component of the curriculum implementation project. Teaching content of the curriculum resources was not as important as teaching the PBL process. By placing the educators in the role of the PBL student, the educator experienced the curriculum and gained first hand-knowledge of its workings. Workshop attendees experienced the complete PBL cycle, from group introductions in the morning, to presenting a final product in the afternoon. Teachers attending the workshops became fully engaged in the horticulture PBL case they were working on throughout the day. Teachers experienced hands-on labs and listened to guest speakers related to the case, much as a student would experience in a classroom setting. The idea was to create an authentic PBL experience for the workshop attendee. This experience was then further dissected in workshop activities.

Key Step: Creating an authentic PBL experience for the workshop attendee.

Day two of the workshop dissected the PBL process into smaller, essential components. One key aspect was a role-playing activity where attendees volunteered to take on the role of the PBL group facilitator. Various mock situations such as dominant students, quiet groups, and off-topic discussions were provided as the facilitators tried to manoeuvre the group through these situations. This activity was followed by a discussion of best methods of dealing with the situations. This activity allowed the educators to get a view of and experience what effective PBL group facilitation was all about.

Key Step: Outlining the role of the PBL facilitator to workshop attendees.

One of the most powerful tools used in teaching Problem Based Learning at the workshop was bringing in high school students to work on a PBL case while the teachers observed. This “fishbowl” activity allowed educators to view how the high school students experienced the PBL curriculum. As the students went right to work on the case, educators attending the workshop were amazed at the level of engagement, maturity and dialog the students conducted throughout the workings of the group. After the students were done working, a question period allowed teachers to query the students on their PBL experiences. Students gave frank and open answers to the questions, most of which were about the PBL process itself, rather than the content of the cases. High school student participation in the workshop was a key step in the overall success of the workshop.

Key Step: Having high school students attend the workshop to be observed participating in the PBL experience and providing an opportunity for educators to question the high school students on their PBL experiences.

Feedback from the first teacher workshops confirmed that it was a worthwhile experience for the science educator.

Key Step: Creating a PBL workshop that allows educators to experience, dissect, discuss, and observe the PBL process.

In order implement the PBL curriculum materials in as many high schools as possible, it was useful to know what the teacher perceived as barriers to implementing the PBL curriculum. A survey provided 36 replies which were grouped into themes. Multiple replies to the same question were separated. In looking at the results of the survey, the largest barrier to implementing PBL curriculum was Student Attitude concerns (SA) with 15 of the 36 (41%) replies falling into this category. The next largest barrier to PBL implementation was teacher preparedness (TP) with seven of the 36 (19%) replies indicating this. Time constraints (TC) and curriculum objectives met (CO) had four responses each (11%). Assessment methods (AM) were indicated by two people (5%) and Facilitating Issues (FI) by three (8%). In knowing the perceived barriers to implementation, more time was spent on addressing these areas in future workshops.

Key Step: Understanding educators perceived barriers to PBL implementation through interpretation of survey results.

Working with local teachers in 2008 and re-grouping the PBL units into a package that met the objectives for Biology 20 was a key step in the overall success of the outreach program. I am not sure why this was not done from the beginning of the program. Because the program was revised meant that no longer would schools have to apply to teach the locally developed Bioresource Management 20L course. Most high schools in Saskatchewan offer a Biology 20 course, a potential home for the resources could thus be found throughout the province. The PBL curriculum materials were re-organized and published in the Biology 20 format. The units had information on how they met the provincially mandated curriculum objectives.

Key Step: Creating PBL curriculum resources to meet the provincially mandated learning objectives for Biology 20.

Between 2009-2010, numerous educator conferences and teacher PD events were attended as a means to promote the PBL curriculum materials and teacher workshop series. These included PBL training events at schools, First Nation Educators conferences, science teacher conferences, and school division meetings. These events were an excellent contact point with science educators, principals and school division administrators. With a presence at numerous events, a face was put to the AgBio outreach program and questions answered directly. These events allowed people who had heard of the PBL endeavour to find out more. Attending these events was a cost & time effective method of promoting the program. No single event could be pinpointed as the quintessential event to attend. The power of these events lay in attending many of the single events and getting the word out to as many people as possible. By attending many events, a familiarity with the program spread throughout the teaching community.

Key Step: Attending as many education related events as possible to promote the PBL curriculum development outreach efforts.

Barrier: Time constraints, budget constraints needed to promote workshops and curriculum materials.

Establishing a presence on the College of Agriculture and Bioresources website continues to be important to the outreach efforts of the curriculum development program. A dedicated webpage allows educators to seek out and find information on curriculum resources and upcoming science teacher workshops. Registration forms can be downloaded and contact information if people have questions is provided. With this being said, the curriculum development and outreach efforts within the College of AgBio are poorly represented on the website, largely due to lack of time and expertise to make the webpage(s).

Key Step: Establishing a web-presence where outreach efforts can be described.

Barrier: Lack of time and expertise to establish a quality on-line presence.

6.0 CONCLUSIONS

The creation and implementation of an Agriculture based PBL curriculum into science classrooms in Saskatchewan has been a long, convoluted, arduous journey that has yielded strong results and tremendous personal satisfaction. By examining and understanding the processes and procedures of this journey, one can gain insight into the most effective methods of delivering a similar project while hopefully avoiding pitfalls. The following section offers a summary of some of the key steps of the journey, potential barriers to success, and a timeline of events.

The first section in the conclusion is a summary of the barriers experienced by the author along the PBL creation and implementation journey. By articulating and understanding the barriers that existed throughout this project, others wishing to initiate a similar project can avoid mistakes, hasten the process, and streamline their efforts. Additionally, the summary is of benefit to me as I am able to reflect on the implementation efforts that have been achieved thus far and sharpen my own individual efforts. Through the listing and understanding of the barriers, the key steps listed in the next section offer insight into potential methods overcome these barriers.

A key step summary section follows the listed barriers. This section summarizes the key steps identified in the self-study that contributed to the success of the PBL creation and implementation efforts. These key steps contributed to overcoming many of the barriers experienced along the program journey. The key-steps can be read as recommendations to facilitate/enhance the PBL creation and implementation process. By reading and understanding these key steps, others wishing to pursue similar curriculum development and implementation programs will benefit.

As there is an increased pressure to attract youth into various disciplines, other groups, academic departments, and extension specialists may wish to create a similar outreach program with curriculum development and implementation in schools. This research offers insight into one program’s success. Barriers to success have been identified, through the understanding of these barriers, one has an increased knowledge of the challenges that may lie ahead when trying something similar. The key-steps that contributed to program success allow people and organizations wishing to achieve similar results in curriculum development and implementation a series of recommendations. These key-step recommendations may act as a template for other groups to follow and achieve similar success.

6.1 Barriers (Perceived and real), experienced by program lead, to developing and implementing agriculture based PBL in high school science classes of Saskatchewan.

Barrier: Not having the information in job description to support curriculum resource development and implementation.

Barriers: No experience leading this type of program. Unsure if funding source would detract educators.

Barriers: Unsure if I possessed the skills needed to implement a program. Not having the educational skills required to implement and maintain a program.

Barrier: Biases' of experts when developing content for curriculum resources.

Barrier: lack of general interest in outreach efforts.

Barrier: The need to create innovative curriculum resources that provide a student centred approach to learning.

Barrier: Lack of familiarity of PBL amongst educators, and curriculum writer.

Barrier: Lack of knowledge on how to reach science educators with workshop information.

Barriers: Reaching educators with outreach information can be time consuming.

Barrier: Lack of personal confidence in the ability to deliver a PBL workshop.

Barrier: Time constraints, budget constraints needed to promote workshops and curriculum materials.

Barrier: Lack of time and expertise to establish a quality on-line presence.

6.2 Key Step Summary

Key Step: The creation of a position that includes a dedication to the curriculum outreach project.

Key Step: Identifying an individual passionate about Agriculture Education.

Key Step: Locating appropriate granting programs to provide funding to support outreach activities.

Key Step: Obtaining influential letters of support from diverse parties to strengthen grant applications. Obtaining funding that allows for program establishment over a reasonable time-frame.

Key Step: Setting an accurate budget that allows for program success.

Key Step: Ensuring outreach efforts include an individual or individuals with a solid understanding of the provincial curriculum in the school systems.

Key Step: Seeking expertise in content area for curriculum to be developed.

Key Step: In order to promote outreach efforts, seek out and attend conferences that host large numbers of teachers in relevant subject areas.

Key Step: Establishing a partnership with a local school in which materials can be developed together, piloted, and revised accordingly.

Key Step: Meeting with provincial Ministry of Learning curriculum specialists. Understanding what curriculum resources are the most attractive to the Ministry of Learning.

Key Step: Inclusion of an innovative, engaging curriculum delivery (PBL) as an educational strategy to be used in the curriculum resource development.

Key Step: Completing resource package with ample, diverse materials for educators.

Key Step: Implementation of curriculum in high school science strand/class.

Key Step: Reaching educators with information on science teacher workshops.

Key Step: Connecting the science educator to workshop information through email notification, poster advertisements, calling pre-existing contacts, speaking with Science Department Heads, connecting with division superintendents.

Key Step: Creating an authentic PBL experience for the workshop attendee.

Key Step: Outlining the role of the PBL facilitator to workshop attendees.

Key Step: Having high school students attend the workshop to be observed participating in the PBL experience and providing an opportunity for educators to question the high school students on their PBL experiences.

Key Step: Creating a PBL workshop that allows educators to experience, dissect, discuss, and observe the PBL process.

Key Step: Understanding educators perceived barriers to PBL implementation through interpretation of survey results.

Key Step: Creating PBL curriculum resources to meet the provincially mandated learning objectives for Biology 20.

Key Step: Attending as many education related events as possible to promote the PBL curriculum development outreach efforts.

Key Step: Establishing a web-presence where outreach efforts can be described.

These key-steps were established through the experience and research whilst implementing an agricultural based PBL program science program in high school classrooms of Saskatchewan. While this overall list of key steps may differ for different organizations and different individuals attempting similar endeavours, it is important for this research to identify what is felt to be the absolute crucial steps for PBL curriculum implementation.

The key step of *ensuring outreach efforts includes an individual or individuals with a solid understanding of the provincial curriculum in the school system* are recognized as essential. When the outreach efforts of the College of AgBio modified the PBL curriculum resources to match the provincially mandated Biology 20 curriculum, the uptake and implementation by teachers rose quickly. Including an individual(s) with a solid understanding of provincial curricula contributes to the applicability of the resources to be created and thus increases the likelihood the resources will be used within the classroom.

The *inclusion of an innovative engaging curriculum delivery (PBL) as an educational strategy to be used in the curriculum resource development* is critical to the success of an outreach program. In our meeting with the Ministry of Learning near the beginning of the project, they indicated they were looking for us to develop a student centred, engaging, inquiry based curriculum. The Ministry was not as concerned about content as it was about delivery. The use of PBL matched what they were looking for in terms of curriculum resources. With the endorsement of the Ministry of Learning, our curriculum resources had a higher likelihoods of being used.

One of the most important steps in the College of AgBio outreach efforts was identified in the key step: *Establishing a partnership with a local school in which materials can be developed together, piloted, and revised accordingly.* This partnership allowed for curriculum resources to be created together and increased the usefulness of the resources. PBL cases could be piloted and feedback solicited from students, teachers, and administrators. A partnership with a local school means that travel time is not an issue and personal relationships are easier to form as in-person contact is easier to achieve. Without the formation of a local partnership, the outreach efforts would have been greatly dampened. Groups trying to mimic the outreach program within this research project would be advised to form a partnership with a local high school early on in the program.

Attending as many education related events as possible to promote the PBL curriculum development outreach efforts ensured that the outreach program was well marketed and should be seen as an essential step within this program. Communication with educators about such a program is a difficult task and every communication effort is valuable if it connects with an educator. Education events such as conferences and professional development seminars offer a method of reaching potentially large numbers of educators at one place. Every opportunity to promote the outreach efforts should be undertaken for any type of similar project.

Lastly, *identifying an individual passionate about (agriculture) education* is perhaps the most critical of all steps. Any program that wishes to mimic the success of this program should strive to identify an impassioned leader who is committed to the success of the program and willing to stick with the efforts for many years. Success is not guaranteed, and as we have seen, numerous barriers are a reality. A passionate, talented individual is more likely to provide the leadership needed to achieve success.

The widespread implementation of curricula by an entity external to the school system is complex and can be difficult to navigate. It is hoped the key-step findings of this research, alongside the essential steps listed above will help organizations wishing to attempt similar feats find success.

6.3 Timeline

- 2004: Creation of Community Liaison Coordinator position within the College of Agriculture and Bioresources
- July 2005: Idea of curriculum resource development and teacher workshops hatched
- August 2005: Potential funding agent identified, letters of support procured, grant writing completed
- December 2005: Grant money awarded (NSERC)
- August 2006: Grant money awarded (Monsanto)
- Autumn 2006: Curriculum resource development
- November 2006: Sciematics conference attended (E.D. Feehan partnership initiated)
- Jan 2007: MOU with Greater Saskatoon Catholic Schools signed
- February-June 2007: Bioresource Management 20L PBL cases piloted at E.D. Feehan Catholic High School
- June-September 2007: PBL cases revised and packaged as Bioresource Management 20L
- September-November 2007: Workshop promotion
- November-December 2007: First series of two-day workshops held at the College of Agriculture and Bioresources
- March-May, 2008: Promoting spring workshops
- May 2008: Second series of workshops
- July-Aug 2008: Development of BRM 30L. $10,000 from Saskatoon Catholic School System
- September 2008: Connection with FSIN: Program Manager, Science Education and Training Secretariat

- September 26th 2008: "Problem Based Learning in Your Class" hosted by ESAB at Peacock Collegiate High School. Over 70 attendees
- January 15th, 2009: "Problem Based Learning in Your Class" at Central Butte School. 15 attendees
- April 8th & 9th, 2009: Treaty 4 Educators Conference,, 8 attendees
- April 23rd & 24th 2009: HS Science Teacher Workshop: FSIN partnership, 22 attendees
- September 2009: Evan Hardy Wins U.N. Recognition Award for BRM
- Nov 19th & 20th, 2009: FSIN/AgBio Teacher workshop. 20 attendees
- March 22nd & 23rd, 2010: FSIN/AgBio Teacher workshop. 18 attendees
- April 22nd & 23rd, 2010: Treaty 4 Educators Conference. 25 attendees
- April 30th, 2010: Awasis Conference. 25 attendees
- Sept 2010: Saskatchewan Teacher's Federation Bulletin Article
- Sept 2010: Ministry of Learning Curriculum Bulletin
- September 2010: Information and Registration forms available on-line
- September 26th, 2010: Common Department Meeting (Saskatoon Public Science Teachers)
- Oct 2010: Accelerator Publication
- Oct 21 & 22, 2010: FSIN/AgBio Teacher workshop, introduced to Erin Jones. 36 attendees
- Nov 5th, 2010: Sciematics Regina. 30 attendees
- Nov 18th& 19th, 2010: Science Teacher workshop. 17 attendees
- Dec 6th&7th, 2010: MLTC Science teacher workshop. 8 attendees
- Dec 2010: Crop-Life Canada, $30K

While this timeline has unfolded over the course of approximately 5 years, this is by no means indicative of what may be experienced by other organizations. A hastened curriculum development and implementation timeline could be experienced by individuals/organizations who have had experience in this arena. Through an examination of this research project, one is able to pick out the key-steps this program undertook to achieve success in curriculum development and implementation and streamline events.

6.4 Addressing Sub-Questions

In order to fully understand the best practices and procedures to implement the science curriculum in schools, the sub-questions in this thesis were explored.

In thinking about how best to communicate information about the PBL curriculum to educators, the question was asked: *What were the processes for contacting educators and creating an interest in the College of AgBio outreach efforts?* In looking at the results of the research, key communication processes were outlined. Clear, effective, multi-facetted communication with educators was of paramount importance to the overall success of the project and took on many forms. This research summarized the communication channels that contributed to the implementation of a PBL curriculum in science classrooms of Saskatchewan.

Through various outreach activities with the College of AgBio, a network of science educators had been established before the onset of the curriculum development and implementation project. Having pre-established communication channels with these educators contributed to the ease of communications. Utilizing connections to this network was a key step in marketing the outreach program.

To reach educators with information about workshops and PBL curriculum, email channels proved to be the most effective method of reaching large numbers of educators. Information about the initial workshops along with registration forms was sent to my contact list approximately two months before the initial workshop. Additionally, I had connections with curriculum specialists within both Saskatoon Public and Saskatoon Catholic School divisions. These connections were given information about the upcoming workshops and asked to forward the information to science departments within their school divisions. Questions about the workshops were answered via email. Emails proved to be highly effective as registration replies were quickly returned.

Faxing was another method used to reach science educators. Specific Saskatchewan school science departments were sent faxes notifying them of the upcoming workshops. The fax was sent to the school and addressed to the science department head. This was a time consuming process as school fax numbers needed to be found and time was taken to fax the information out to schools.

Personal communication with educators also helped get the word out about the program. This included having information available for science educators at various career fairs and trade show events as well as any on-campus recruitment events.

Providing workshop and PBL curriculum information to publications targeting science teachers of Saskatchewan was yet another effective channel for reaching educators. These channels included the Science Teachers Society publication, the “Accelerator”, as well as the Saskatoon Public School Division newsletter, and the Saskatchewan Teachers Federation newsletter, the “Bulletin”.

Another key communication channel was offering sessions at educator conferences. Offering sessions meant that large numbers of educators would hear detailed information about the curriculum outreach project and have the ability to ask questions and provide feedback.

Communicating with large numbers of science educators was of critical importance to the success of the program. Through email, faxes, personal communication, and conferences, I was able to effectively contact educators and create an interest in the College of AgBio outreach efforts. While no single communication channel could be identified as the most effective method of reaching educators, a sustained, multi-faceted approach to communication led to successful communication with large numbers of science educators.

An examination of the overall outreach efforts allowed for the identification of key partnerships that enabled overall program success. These partnerships, made up of local high schools, community groups, and school divisions allowed the program to blossom.

The initial partnership with E.D. Feehan Catholic High School allowed the curriculum development and implementation program to flourish. In subsequent years, the partnership with another Saskatoon high school, Evan Hardy Collegiate, further contributed to program success. Having partnerships with these schools opened communication channels into both school divisions in an urban setting and provided further support and legitimacy to the program. Having local schools to partner with and collaborate with was central to the success of the program.

The partnership with the Federation of Saskatchewan Indian Nations (FSIN) was also central to program success. This partnership allowed for important First Nations content to be added to curriculum resources, funding for workshops, and enhanced communication channels to science Educators at First Nation schools in Saskatchewan. In the case of AgBio outreach efforts, this community partnership was highly effective and rewarding.

Curriculum development and implementation is a large task for an entity outside of the school system. Finding key partners to assist in this endeavour greatly enhanced efforts. Local schools, community groups, and school divisions were key partners that helped to develop and implement an AgBio based PBL curriculum in science classrooms of Saskatchewan.

Interesting results were generated from a second sub question: *What key events, conferences, and meetings allowed our program to reach educators?*. Without these events, conferences, and meetings, overall program success may not have been achieved.

Educator conferences were a highly effective method of reaching educators with curriculum and workshop information. Offering mini-workshop sessions at provincial science teacher conferences such as Sciematics allowed the program to take information outside of the college and provide direct communication with potentially large numbers of educators. Offering information sessions and workshops at school and school division events was also of great benefit. This was experienced at the Saskatoon Public School Division common department meetings, Central Bute School, and the Prairie Spirit School Division to name a few. First Nation educator events such as the Awasis Education Conference and The Treaty 4 Educators conference diversified and increased the number of teachers attending the workshops. Educator conferences were highly effective and critical to overall program success and should be a major component of curriculum development and outreach efforts.

Meetings also contributed to the overall success of the program. One meeting in particular that was of utmost importance and helped to shape the program, was the meeting with the Saskatchewan Ministry of Education specialists. This meeting enabled me to gain insight into the type of curriculum resources that would be of most benefit to the education system and thus most likely used by science educators. Meeting with local school administrators, principals, and science teachers also played an essential role in shaping the program. Additionally, the meeting with agriculture industry specialists allowed the curriculum resources to best help shape future agriculture industry employees. While at times somewhat time consuming, these series of meetings were absolutely essential.

This research project asked: *What were my (the program coordinator) perceptions of barriers to implementing these curriculum resources in schools?* Perhaps the largest barrier to success occurred at the beginning of the program, which was my lack of experience in curriculum development and workshop delivery. I had funding in place, but absolutely no idea how to create curriculum or train teachers in its use. This caused anxiety and some delay in creating the actual resources. Once the project was underway, and teachers attended the workshops and started using the resources, this barrier disappeared.

Another perceived barrier I had was that educators would not be interested in my workshop and curriculum resources. Because this was a fear of mine, I worked hard to ensure this barrier did not become a reality. Clearly, with time, this barrier was not to be realized as many educators have attended workshops and have used the curriculum resources with positive results.

More importantly, this research project strived to understand: *What were educators' perceptions of barriers to implementing AgBio curriculum resources in schools?* After creating a workshop survey and directly asking educators what they perceived to be the biggest challenges to implementing PBL in their classrooms, responses were analyzed. These responses were then summarized, examined and placed into themes. These themed barriers were quantified based on total number of responses: student attitudes (37.6%), time constraints (10.1%), assessment methods (4.3%), facilitating issues (14.4%), teacher preparedness (23.1%), and curriculum objectives met (10.1%). These were indeed real barriers to implementing PBL in schools of Saskatchewan as they were teacher perceived and thus could block a teacher from implementing PBL in their classrooms.

Through the identification and examination of the sub-questions in this research project, useful information was generated. The answers to the sub-questions helped to shape the overall answers to the main research question within this project.

Through this examination, it is hoped that the information generated through research and discussion can be of benefit. Others wishing to undertake a similar endeavour have the ability to look at the key steps and barriers to success that were identified and possibly streamline their efforts. Personally, this research project has been of great benefit as I have had the opportunity to reflect on my work and revise details of my profession.

7.0 THE PATH FORWARD

The College of AgBio continues to show leadership in the creation and implementation of agriculture-based PBL curriculum materials for high school science classes in Saskatchewan. Recently (2012), PBL curriculum materials for grade 9 science, grade 10 science and Biology 30 have been developed and released. Workshops continue to be held on campus, attracting dozens of educators with every workshop offered. Many schools throughout the province have now implemented the PBL curriculum resources. Many school divisions have invited me to speak at division conferences and have provided funding for me to travel and deliver PD events in their schools. In looking forward, the College would like to build upon this success.

Future research includes an increased focus on developing PBL curriculum materials that are relevant to First Nation youth and educators within Saskatchewan. This includes creating resources for elementary and middle school years (grades 6-9). Program proposals include offering workshops in remote sites of Saskatchewan, thus taking the workshop, and curriculum materials to First Nation communities.

The agriculture industry, sister agriculture universities, and agriculture education outreach specialists from across the country have shown an interest in expanding the efforts of the College of AgBio to other regions of the country. Recently, the Council for Biotechnology Information has awarded the College $30,000 to expand the program to other parts of Canada and plans are underway to deliver workshops to educators in Manitoba and Southern British Columbia.

As interest in agricultural PBL cases and workshops grows, so too will the outreach efforts of the College of AgBio. As the world population is set to grow to 10 billion people, as oil reserves dwindle and climate change affects the world's Bioresources, the development and implementation of these educational resources is both timely and essential.

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9.0 APPENDIX

Appendix 1.0: Example of High School Science Teacher Workshop Agenda

UNIVERSITY OF SASKATCHEWAN

College of Agriculture
and Bioresources

AGENDA: SCIENCE TEACHER WORKSHOP

Thursday
8:00am Breakfast - Room **1E80**

8:30am Introductions/Workshop Overview
PBL - Jon Treloar

9:00 – 9:50 Tour of College of Agriculture & Bioresources Facilities

9:50 -10:00 Coffee Break
10:00 – 12:00
Small group work: Teachers in role of Students - PBL Case study – iPlant

12:00 – 12:45 Lunch Room **1E80** Provided by Workshop

12:45 - 1:00 small group work

1:00 – 2:30 Experiential Learning – Teachers participate in hands-on lab experiments

2:30 – 3:00 Reconvene small groups – wrap up PBL project.

3:00 -3:30 Group presentations
3:30 – 4:00 De-brief the day.

Friday
8:00am Breakfast – Room **1E80**

8:30 - 9:00am PBL – Jon Treloar
PBL Debrief – Discussion - Implementing PBL

9:00 – 10:00 Tim Molnar
U of S College of Education

10:00 – 10:15 Coffee Break
10:15 – 11:15 Facilitator Training

11:15-12:00: Assessment for PBL

12:00 – 1:00 Lunch Room **1E80**
Provided by Workshop

1:00 – 2:30 - Fish Bowl Activity PBL
High School Students working on a case for workshop teachers to observe PBL.

2:30 – 3:00 Debrief High School Students observations - discussions

3:00 – 4:00 Resources & Introduction of other PBL Cases - Summarize

4:00 End of Workshop.

LOCATION: College of Agriculture and Bioresources, University of Saskatchewan, Saskatoon, SK.
DATES: Thursday, March 10th & Friday, March 11th, 2011
TIME: Thursday: 8:00am – 4:00 and Friday: 8:00 – 4:00pm
COST: **Free – resource materials included**
MEALS: Continental Breakfast, Lunch, and Coffee Breaks (Thursday & Friday)
Note: Please wear comfortable shoes for tours and walks to the greenhouse.
If lost in the Agriculture building, call Jon 229-8947 and he will guide you to the rooms.
Parking Information: http://www.usask.ca/maps/
Public Lot P5-Under the AgBio Building.
Public Lot P4 – by the Education Building.

Appendix 2.0: Example of Teacher Workshop Evaluation Form:

UNIVERSITY OF SASKATCHEWAN

College of Agriculture and Bioresources

Bioresource Management Workshop Evaluation

Workshop Date: Oct 20th & 21st, 2011

Hosted by: U of S College of Agriculture and Bioresources

Did the PBL Workshop meet your expectations?

What aspects of the Workshop did you like the best/least?

Will you be using problem-based learning as a teaching strategy? Will you use the AgBio Resources?

What do you see as the biggest challenges to implementing PBL in your classroom?

How can the workshops be improved?

After attending the workshop, are you more likely to promote programs in the College of AgBio to your students?

Would you recommend the Bioresource Management Workshops to your colleagues?

Additional Comments:

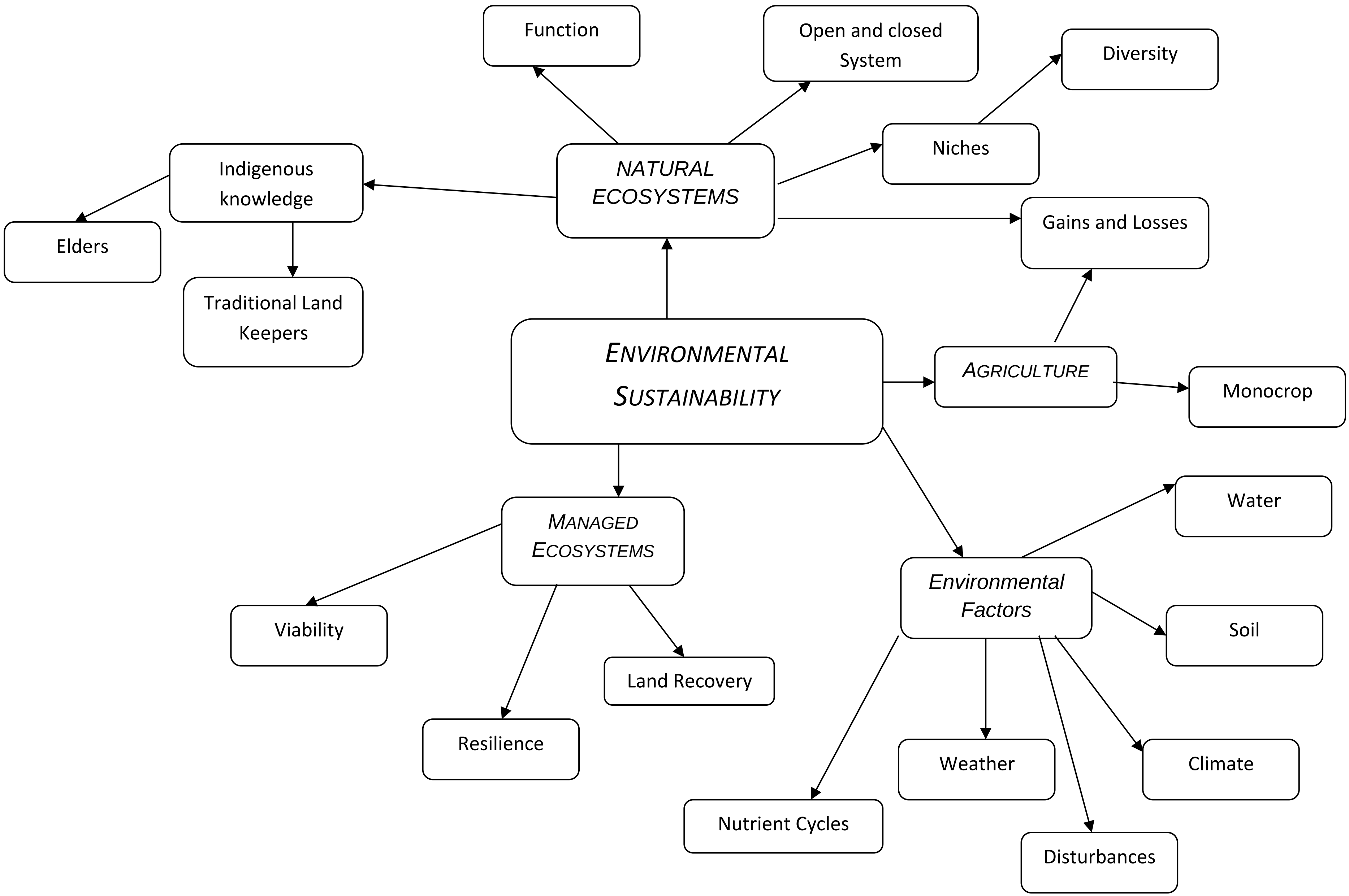
Appendix 3.0: Example of PBL Case Provided to teachers.

BIORESOURCE MANAGEMENT

Photo Courtesy of Bob Bors, Saskatoon, SK (University of Saskatchewan).

UNIVERSITY OF SASKATCHEWAN

College of Agriculture & Bioresources


Function
Open and closed System
Diversity
Indigenous knowledge
NATURAL ECOSYSTEMS
Niches
Elders
Gains and Losses
Traditional Land Keepers
ENVIRONMENTAL SUSTAINABILITY
AGRICULTURE
Monocrop
Water
MANAGED ECOSYSTEMS
Environmental Factors
Viability
Soil
Land Recovery
Resilience
Weather
Climate
Nutrient Cycles
Disturbances

FOUNDATIONAL OBJECTIVES AND LEARNER OUTCOMES

I. *Value and achieve excellence in employable skills critical to the scientific and technological world*
    i. Demonstrate skills and attitudes for conducting various science activities
    ii. Apply biotechnology and research skills in a problem-solving environment
    iii. Apply skills developed in the classroom to practicum experiences (where applicable)
    iv. Participate in a professional experience, such as job shadowing, mentorship, career or occupation exploration, a scientific conference, science fair or other competitions; complete a grant or scholarship application

II. *Demonstrate skills and attitudes when participating in collaborative Problem-Based Learning*
    i. Discriminate between what is known and unknown to identify learning issues within the context of the given problems
    ii. Access a variety of resources and research independently for the purpose of information sharing
    iii. Analyze real-world problems as a team member to determine an approach to and a solution for the given problems
    iv. Evaluate self and others in the context of team relations, and communicate for the purpose of improving team interaction and efforts

III. *Community Connection*
    i. Identify and integrate Indigenous knowledge as a valued contribution to all aspects of science and learning
    ii. Communicate with community and industry members for the purpose of sharing knowledge and building learning experiences

IV. *Key Concepts: Diversity, Energy Flow, and Sustainability*
    i. Define sustainability as it applies to social, economic and environmental factors
    ii. Identify the concept of ecological niches and give examples of species common to each
    iii. Explain the functions of the managed ecosystems (social, environmental and economic)
    iv. Investigate factors of ecosystem viability, such as soil, climate, and human influence
    v. Describe nutrient cycles in terms of gains and losses within an environment
    vi. Apply concepts of diversity and energy flow to natural and production ecosystems
    vii. Compare system sustainability of natural and monocrop ecosystems
    viii. Propose recommendations to maximize output AND sustainability in the production ecosystem

CASE FOCUS

The students will compare and apply the concepts of a natural ecosystem to a managed monocrop ecosystem. The goal is to make the managed ecosystem productive and environmentally sustaining.

The students are Agricultural Consultants who will present at an Agriculture conference. Overarching questions are:

- ✓ How does a natural ecosystem demonstrate best sustainable practices?
- ✓ What can we learn and apply from Indigenous knowledge?
- ✓ Can a managed ecosystem model the sustainable practices of a natural ecosystem while maintaining its productivity?

ROLE AND SITUATION

Students play the role of AgroEcologists who will present at an Agriculture conference. The topic is the best practices for land use and sustainability in a production monocrop agricultural systems. Each team receives a conference entry form. The conference will showcase the presentations about best practices and proactive methods of sustainability and land use for managed monocrop agricultural ecosystems.
The recommendations should be presented to an actual committee of Agriculture personnel (to be determined by the teacher – from the College of Agriculture and Bioresources, for example).

TEACHER-ANTICIPATED RESOURCES

People/Places

- Community elder
- Traditional land keepers
- Agriculture Scientists (Faculty at the College of Agriculture and Bioresources)
- Local farmers
- Specialists – soil, plants, wildlife, crop management, etc…
- Laboratories at SIAST and U of S College of Agriculture and Bioresources for demonstrations and practical work
- Other guests, speakers, and locations at teacher's discretion and identified by students

Materials and/or Technology

- Computer searches
- Scientific investigations – plant production, examination of resource management
- Books – non-fiction and historical fiction from Teacher Librarian
- Textbooks – Agroecology, Almanacs
- Other materials and technology, at teacher's discretion and identified by students

Embedded Instruction Events

- Scientific Method
- Guest Speakers
- Other, at teacher's discretion

DISCLOSURE 1

The sustainability of the planet is highly dependent on the ability of agriculture to meet many of the demands of society. It is recognized that agriculture needs to be able to produce goods today without compromising our future ability to do so. As a team of Agrologists working for One Earth Farms, your task is to investigate practices of sustainable agriculture that are suitable for farming in Saskatchewan.

You will present your findings at the Conference of Sustainable Agriculture. The conference date will be announced; more details will follow.

NAME____ DATE____________________

DISCUSSION QUESTIONS – MEET THE PROBLEM

1) **What is the problem?**

2) **What do you KNOW about the problem? Brainstorm and list all your ideas.**

3) **What do you NEED TO KNOW?**

4) **DEVELOP A PROBLEM STATEMENT**

How can we   **in such a way that**

ASK YOURSELF: Is the Problem Statement relevant to the problem?

5) **What do you NEED TO DO? Who? How? Where? When?**

NAME____ DATE____________________

INFORMATION GATHERING

1) **Write down your findings – include all data and results (use separate sheets).**

2) **How is this information relevant to the problem?**

3) **What was your resource? Is it *credible*?**

4) **Share your information at the next session.**

NAME____ DATE____________________

INFORMATION SHARING – GROUP SESSION

Each team member will share his or her findings with the group; disclosure to follow.

1) **What do you KNOW? Brainstorm and list all ideas.**

2) **What do you NEED TO KNOW? Brainstorm and list all ideas.**

3) **Revisit your Problem Statement considering what you now KNOW and what you still NEED TO KNOW.**

ASK YOURSELF: Is the Problem Statement relevant to the problem?

4) **What do you NEED TO DO? Who? How? Where? When?**

Disclosure 2

You are fortunate to know a local Ecologist. He suggests that you begin by studying forest and grassland dominated ecosystems. Look at the structure and diversity of plants.

Ecological niches can provide lots of information. How are the organisms within these ecosystems structured and how have they adapted to their conditions? Indigenous knowledge may also provide some insight.

Natural disturbances are a normal force within the environment. Identify the disturbances that may influence the grassland and forest ecosystems. What are the results of these influences? It is recommended that you look at natural patterns of succession.

DISCLOSURE 3

Plant and animal species develop adaptations in response to pressures and threats within their ecosystems. This provides them with a means of survival, which may be distinguished as resistance or as resilience.

Evidence of this behaviour can be identified through the K species and R species that are exclusive to the environment in which pressures and threats are apparent. Examine these concepts.

Disclosure 4

A closed system self-regulates gains and losses of energy and natural ecosystems resemble a closed system with respect to energy and nutrient cycles.

To best understand the concept of energy flow, the ecologist recommends that you investigate nutrient cycling.

Limit your efforts to Nitrogen, Carbon and water cycles; know the chemical forms and the specific components of the chemical reactions in the cycles.

Identify where gains and losses occur.

An agricultural ecosystem can be considered an open system as many nutrients are lost at harvest. In order for agriculture to continue to produce in the long term, sustainable methods of replacing these lost nutrients must be established.

Disclosure 5

Your most recent conversation with the ecologist draws your attention to an agricultural monocrop ecosystem. How do the different ecosystems compare?

Disturbances also occur in agriculture ecosystems; are they the same as in a natural ecosystem? Identify all influences in agriculture production.

How is succession demonstrated and in what ways does a production ecosystem differ from a natural ecosystem in terms of how plant species respond to pressures and threats?

How do resistance and resilience compare and what influences are present that do not have an influence in a natural ecosystem?

Disclosure 6

How do the different ecosystems compare? Based on what you have discovered throughout the case, your presentation should outline how you can incorporate ecological principles seen in natural ecosystems into an agricultural system in efforts to increase sustainability.