We are all Downstream – Teaching Middle Years Science from a Sustainability Perspective

Amanda Freedman Tétrault

Introduction

Sustainability is found throughout the Manitoba Curriculum, especially within the science, but the fact that it is included within many specific learning outcomes required to be taught doesn’t mean it necessarily is. It is hoped that this study will uncover the risk and protective factors in regards to the teaching of sustainability through the Manitoba science curriculum, and address these identified factors from the first part of this project through the second half development of a resource for middle years science teachers.

The rationale for this study is to investigate the needs of middle years science teachers and create a resource that can be used to teach science from a sustainability perspective.

This project is one aspect of the Manitoba CRYSTAL, which is an NSERC funded project that spans three provinces and many different institutions. This research project falls under the category of Part D, which looks at the individual learner as part of the global community and contains two research questions:

1. What are the risk and protective factors teachers identify as constraints and contribute to the implementation of a science-based sustainability curriculum while working in the global system?
2. What is the consequence in terms of student knowledge and orientation to science and sustainability as a result of being participants in a sustainability education curriculum that is structured on the foundations of The Natural Step?

Before continuing with information of study, it is important to understand the basics of Education for Sustainability (ESD). ESD incorporates three aspects that influence quality of life or sustainability (see figure 1).

- Economics
- Environment
- Human health and well-being (social)

Figure 1.1
A diagrammatic view of a commonly used version of the three aspects that influence sustainability
ConcoPhillips www.sd.conocophillips.com/.../0/sd_graphic_sm.jpg
History

The idea of Sustainable Development Education has existed in various forms for over fifty years. In the 1940s, “Environmental Studies” was the name given to teaching local geography, history and nature study in an integrated curriculum (Palmer, 1998). As the importance of the environment in education increased, environmental studies became known as “environmental education” in the United Kingdom in 1965 (Palmer, 1998). Environmental Education was also the phrasing adopted for Our Common Future, a report of the United Nations’ Commission on Environment and Development (1987).

This report, also known as the “Brundtland Report”, defined sustainable development as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (UNCED). In June of 1992 Agenda 21 was developed in Rio De Janeiro at the Rio Earth Summit. This was designed as a comprehensive plan of action to be undertaken by the United Nations and implemented by every nation in the twenty-first century. The push was on in 1992 for all governments to increase the accessibility of sustainable development education. When the Johannesburg Summit ended in 2002 the UN declared the Decade of Education for Sustainable Development to be from 2005 – 2014.

In Canada, there have been both National and Local initiatives related to ESD. For example, the Federal government created a document titled A Framework for Environmental Learning and Sustainability in Canada (2002). This guide for educators, individuals, groups and communities includes objectives, a
vision and strategies to implement. As well, the Manitoba provincial Government

**Resource Development**

When planning the development of the resource to assist educators in teaching about sustainability issues through science the researcher took into account three major contributors:

- Survey of Manitoba Teachers
- Bronfenbrenner’s Bio-ecological Systems Theory
- The Natural Step

**Survey**

The survey (see Appendix 1) distributed to approximately 200 Manitoba Middle Years science teachers yielded 51 responses. In this survey, the majority of questions were answered (some questions were left blank as “not applicable”. For example, some teachers did not use any text books in their program). The surveys were collected from January to November 2006. All of the teachers who responded taught middle years science and many of them also taught other subject areas or grades. The respondents were mainly urban with a few rural submissions.

The end result determined that two major influences continued to reappear. The two areas were time and resources. The first groupings of questions were
Lichert in nature and participants were asked to circle the answer they agreed with the most. The numbers corresponded with the following adjectives: 4 – strongly, 3 – moderately, 2 – slightly, 1 – none. A few of the key questions are listed below.

- There was more than a moderate influence of “time required to adapt sustainability issues from a source to ‘work’ in a classroom” (3.2)
- There was a moderate influence of the “time required to adapt sustainability issues from a source to meet science outcomes” (3.0)
- There was just slightly less than a moderate influence when looking at “external support such as professional development opportunities” (2.8)

Teachers also found that they believed that it was slightly less than very important to teach sustainability issues for a variety of reasons on a three point scale ranging from 1 – not necessary, 2- important, or 3 very important

- “increasing students' knowledge” (2.6)
- “affect student attitudes” (2.6)
- “assist in developing decision making skills” (2.5)
- “to help students learn to live sustainably on this planet” (2.6)

Ecological Systems Theory

Three decades ago Urie Bronfenbrenner developed his “Ecological Systems Theory” in which he explains that behaviour and development are a combined function of the many interacting systems that are occurring around the child, as well as what is occurring within the child. He focused particularly on
developmental changes triggered by life events, which may have originated in
the external environment or within the child. Essentially, whatever the trigger was
of the occurring event, it altered the existing relation between person and
environment thus creating a dynamic that may instigate developmental change
(Bronfenbrenner, 2005). The environment and the child are always interacting
and changing and we as teachers must understand that we are but one of these
interacting systems. The largest of these interacting systems is the
macrosystem.

The macrosystem refers to the consistency observed within a given
culture or subculture in the form and content of its constituent micro-,
meso-, and exosystems, as well as any belief systems of ideology
underlying such consistencies. Thus cultures and subcultures can be
expected to be different from each other but relatively homogeneous
internally in the following respects: the types of settings they contain, the
kinds of settings that persons enter at successive stages of their lives, the
content and organization of molar activities, roles, and relations found
within each type of setting, and the extent and nature of connections
existing between settings entered into or affecting the life of the
developing person” (Bronfenbrenner, 1979). (See figure 2).

Educators must be aware that there are these many interacting systems
not only impacting on the student, but also on themselves as well. For example,
the factors that may impact on the teacher’s ability to bestow valuable
sustainability information to the students may be impacted by their own internal
interest, motivation or even knowledge on the subject matter at hand. Stepping
out of the individual teacher’s realm, the micro system is entered, which may
consist of a teacher’s students, supports, and resources. Examples of supports
for the teacher are colleagues and possibly friends and family. This system is
where the teacher relates directly to others. In the “mesosystem”, the school itself
dictates the culture. If EfS is a priority for the school, then the teacher has a
greater support from the administration to teach in this manner. It stands to
reason that a school’s belief systems and values will strongly influence the
expectations endorsed at the school level. The “exosystem” is the third structure.
It refers to external influences that do not involve directly the teacher but still
influence the environment in an indirect manner. As an example, school
division’s or community support for EfS can directly influence school division
policy. Finally, the farthest structure from the teacher, the “macrosystem”, refers
to societal and cultural ideologies and laws that impinge on the individual. In the
context of this inquiry, Manitoba’s policies, curriculum, governmental agendas
and teacher education protocols both at the University and Professional learning
levels are likely to influence the school’s response to EfS as a curriculum area.

Figure 2 Bronfenbrenner’s interacting systems
The Natural Step

The Natural Step is a non-governmental organization that was started by a Swedish paediatric oncologist who realized that it has taken the Earth billions of years to transform into the atmosphere and plant life we depend upon, but in recent years humans have been destroying the very nature we rely upon to survive. Karl-Henrik Robèrt decided that society needed a framework to attack the current destructive path and change it for the better (Robert, 2002). This framework currently is used to assist businesses and communities, and this researcher is the first to utilize this program with school curriculum in developing strategies for being more sustainable. The Natural Step has a framework that allows people to see the entire system; it includes the root causes of the damaging impacts our actions have and also allows people to redesign for the problems of our society instead of just reacting to them (TNS Webpage).

This framework uses a science and systems-based approach to planning for sustainability. It provides a set of criteria that can be used to direct social, environmental, and economic actions which will also now be applied to curriculum development.

The TNS Framework is fundamentally based on both an integrated assessment of current economic, social and ecological dynamics, and on the implications of present trends for human society. The approach was developed in the late 1980s in response to growing concerns about the public health problems resulting from increasing toxins in the environment and current societal resource use practices. In an effort to provide a practical tool for assessing decisions in terms of sustainability, The Natural Step Framework was created. The TNS Framework describes core guiding principles for moving toward sustainability. It is intended to assist decision-makers by providing a pragmatic analytical tool for understanding and integrating sustainability principles into complex organizations (TNS Webpage).
These 4 System Conditions are as follows:

In the Sustainable Society, nature is not subjected to systematically increasing:

1. concentrations of substances extracted from the Earth's crust,
2. concentrations of substances produced by society,
3. degradation by physical means
   and, in that society...  
4. people are not subject to conditions that systematically undermine their capacity to meet their needs (Robert, 2002). (see Figure 3).

Figure 3 – The Natural Step Four Systems Conditions
Used with permission from The Natural Step Canada
Final Development of Resource

In the final stages of the development of the resource, the researcher utilized the three main areas as mentioned above. Other aspects that were incorporated into the development were a comprehensive literature review, the Manitoba Education Citizenship and Youth Specific Learning outcomes for the Grade 8 Water Systems Cluster, an external resource review of other resources similar in nature to what the researcher was planning on developing, internet information including lesson plans and other resources, and finally past experience and professional knowledge of the researcher. The final goals are an increase in students’ knowledge of the Manitoba Science curriculum, an increase in the students’ knowledge of sustainability and that students have the ability to apply this knowledge through action (see figure 4).
Methodology

Introduction

This research project contains three phases. The first phase relates to the creation, distribution and the analyzing of a survey. The information gathered from the survey is used to develop the resource to be piloted in Phase Two. The final phase has the adaptation of the resource piloted in Phase Two with feedback from the piloting teachers. This resource will then be shared with teachers from across Manitoba and potentially Western Canada.
Phase One

In Phase One of this study, 51 teachers completed a survey on what they deemed to be the risk and protective factors in the teaching of science from a sustainability perspective. These factors were taken into account when the teacher resource was developed at the conclusion of Phase One in this study. Phase Two of the study has the developed resource being piloted at three different schools and school divisions in a total of five classrooms. Phase Three consists of the evaluation of the effectiveness of the resource in both sustainability awareness and the utility of science in addressing sustainability challenges.

Phase Two

In Phase Two, six teachers (three pairs) are participating in the study. Each school has two participating teachers, one who will pilot the resource and one who will act as a control group. This quasi experiment also has two teachers who teach two sections of students which create an opportunity to utilize 5 piloting classrooms and five control classrooms for a total of ten participating classes. In order to determine the expected changes between the experimental and control groups, all students will write a pre and post test.

Development of the Pre and Post Test

The Pre and Post tests were developed based on Leeming et al. (1995) “Children’s Environmental Attitude and Knowledge Scale”. By separating the
topics of affinity for science, affinity for the environment, action for the environment, and knowledge of water systems (the unit of study), the ability to measure the differences between pre treatment and post treatment for the experimental group will be obvious while using the control group to demonstrate use of a non-sustainability focused curriculum. Using ANCOVA on the pre and post tests as an analyzing tool will determine how the experimental groups may have changed as compared to the control groups, and thus if the resource achieved what it was created to do. The pre and post tests are the same with the exception that the post test allows for qualitative feedback in addition to the Lichert-style scale questions. There are four categories with seven questions in each. The categories are as follows:

- Affinity for Science
- Affinity for Sustainability Issues
- Knowledge of Water Systems
- Actions Related to Sustainability

It is envisioned that by the conclusion of this unit students will have additional thoughts on the unit and their personal feelings on sustainability, thus the ability for students to share additional written feelings at the conclusion of the unit. Ancova will be used to determine the changes between the pre and post tests.

Teachers will also be giving feedback and assist in the development of this resource. The piloting teachers are asked to supply the researcher with feedback from every lesson and include comments as to what worked well in their particular situation and other items they might have needed to adapt or change.
All of the piloting teachers’ comments will be incorporated into the final version of this resource that will then be made available for any teacher who is interested.

Phase Three – Feedback

Using the feedback from the Pre/Post test as well as the journal comments from the participating teachers, the researcher will adapt and publish the resource for distribution to teachers through different venues such as at Special Area Groups (SAG) for Manitoba Teachers and other teacher workshops, but also by placing the resource on appropriate web pages such as Manitoba, Education Citizenship and Youth.

Researcher Concerns

There are several concerns the researcher has identified that may cause problems with this study. For each concern a potential solution to the concern has been noted. The first possible concern is lack of Sustainable Development knowledge by teachers using this resource. The teachers who are participating in this pilot do not have any additional knowledge than the average teacher on issues relating to sustainable development. In the resource there are some instances that “background teacher information” has been included for additional information for the teachers. It is expected that if this information is not sufficient for the piloting teachers that this information will be shared with the researcher and adaptations will be made to provide the required information for the teachers.
It is understood that many teachers may do their own research, but it will be valuable to provide them with basic knowledge.

A second concern is the different teaching styles and how the information will be conveyed to the students. There are always going to be different teaching styles for different teachers and by having more than one pilot site the researcher hopes to decrease the impact of individual teaching styles.

A concern that isn’t affected by the piloting teachers is lack of motivation of teachers to try something new. Since all of the teachers who are piloting have agreed to participate, they obviously have no qualms about trying new resources. It may be difficult to break into teachers’ classrooms who have been teaching with the same resources year after year, but by making this resource as teacher and student friendly as possible it should create an opening for other teachers to use in their classrooms.

A final concern is the different socio-economic backgrounds (and attendance) of students. It is hoped that this resource will be accessible by all, and that is part of the reason why a variety of schools were chosen to pilot this study.

The Resource

The resource as it is in its current Fourth draft form is 30 + lessons. The final lesson is a large project and teachers have the discretion to take as much or as short a time required to complete this project, depending on the nature of their individual classroom’s state and time. This resource covers the entire Manitoba
Education, Citizenship & Youth (MECY) Grade 8 Water Systems cluster, which has 18 specific learning outcomes that are required by MECY.

Each lesson contains differentiated instruction and the package contains a variety of hands-on activities and assessment strategies, which is an important aspect for teachers.

The resource looks at both local and global water concerns, and follows the commonly known phrase: “Think global, act local”. The students are required to take action and make a difference in a way that they choose.

Finally, even though this document is written in English, there is an inclusion of French black line masters that can be distributed to French students.

Summary

In conclusion, Phase One of the study received valuable information from participating teachers in the survey which then determined the development of the resource. By soliciting teachers’ opinions and thoughts on sustainability issues the resource has been developed under the guidance of a literature review, the researcher’s past educational experience and a review of similar resources, under the framework of The Natural Step and taking into consideration the Global System in the Ecological Systems Theory. The end result will hopefully have a resource that is teacher and student friendly and will be used in classrooms across Manitoba.
Appendix One: Teacher Questionnaire (Phase One)

Factors Contributing To and Impeding the Use of Sustainability Issues in Manitoba Science Curricula

Introduction:
This survey addresses two research questions:

1. In what context are teachers incorporating sustainability issues into delivery of Manitoba Curricula?
2. What are important risk factors to limit and protective factors to foster when developing sustainability-based curricular resources?

My goal is to produce a paradigm shift in students’ views toward the utility of science and mathematics is necessary and important as only then can they employ scientific endeavor to move structures, organizations, communities and activities towards sustainability, as future leaders, decision-makers, and consumers. In this section you will identify risk and protective factors that impede/enhance your ability to deliver lessons that work toward this goal. Your accurate responses to the questions below will help to answer the above two questions and guide the design of the mentioned teacher resources. Leave questions unanswered if you do not wish to respond. Add information as you feel is necessary. All references to science also include the applicable mathematics content and skills as we see them as closely related.

Section One: Biographical Information

Circle the correct response or answer in the space provided that pertains to your background:

1. Sex:  M  F

2. Years of Teaching Experience:
   1-2  3-5  6-10  11-15  16-20  more than 20.

3. Courses Currently Teaching:
   grade 6 Science  grade 7 Science  grade 8 Science

4. How do you envision your worldview?
   1  2  3  4  5
   Anthropocentric  ecocentric
Section Two: Current Teaching Practice

A. Current Sources for Sustainability Issues

In the section that follows circle the response that describes the source(s) of sustainability issues you use to teach SLO’s (student learning outcomes) and GLO’s (general learning outcomes (as in cluster 0): Never (N), Sometimes (S), Often (O), Always (A)

<table>
<thead>
<tr>
<th>Source of sustainability issue</th>
<th>Never</th>
<th>Sometimes</th>
<th>Often</th>
<th>Always</th>
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</thead>
<tbody>
<tr>
<td>1. current news events as they occur</td>
<td>N</td>
<td>S</td>
<td>O</td>
<td>A</td>
</tr>
<tr>
<td>2. current news events that I adapt to my course</td>
<td>N</td>
<td>S</td>
<td>O</td>
<td>A</td>
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<tr>
<td>3. sustainability issues discussed in text</td>
<td>N</td>
<td>S</td>
<td>O</td>
<td>A</td>
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<tr>
<td>4. sustainability issues discussed in text that I adapt to my course</td>
<td>N</td>
<td>S</td>
<td>O</td>
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<td>5. internet resources</td>
<td>N</td>
<td>S</td>
<td>O</td>
<td>A</td>
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<td>6. intern resources that I adapt to my course</td>
<td>N</td>
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<td>7. “ready-to-use” resources such as Slow the Flow Project Wet</td>
<td>N</td>
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<tr>
<td>8. “ready-to-use” resources that I adapt to my course</td>
<td>N</td>
<td>S</td>
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<td>9. guest speakers</td>
<td>N</td>
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<td>10. field trips</td>
<td>N</td>
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<td>11. my own knowledge of sustainability issues</td>
<td>N</td>
<td>S</td>
<td>O</td>
<td>A</td>
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<td>12. borrowed materials from someone who has adapted them for my particular course</td>
<td>N</td>
<td>S</td>
<td>O</td>
<td>A</td>
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B. Frequency

Circle the response which most accurately reflects your actions.
How often would you use a sustainability issue to teach outcomes of your course?
Every class   Every 2<sup>nd</sup> class   Every 3 - 4 classes   Every 5 - 8 classes

Explain whether this frequency depends on the cluster you are teaching.
C. Ready-made Resources

In the section that follows circle the response that describes the extent to which you are aware of and/or have used the following resources:
Unaware of (U)
Aware of but have never used (A)
Have used and found beneficial (B)
Have used and found limited (L)

<table>
<thead>
<tr>
<th>Resource</th>
<th>U</th>
<th>A</th>
<th>B</th>
<th>L</th>
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<tbody>
<tr>
<td>1. Manitoba Model Forest</td>
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<td>2. Manitoba Waterways Project</td>
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<td>3. internet - Millenium Ecosystem Assessment</td>
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<td>4. internet - UNESCO</td>
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<td>5. Project Wet</td>
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<td>6. Project Learning Tree</td>
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<td>7. Project Wild</td>
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<td>8. Slow the Flow</td>
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Explain what specifically you found beneficial and/or limiting about these resources.

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D. Goals for teaching Sustainability Issues

In the section that follows circle the response that describes to what extent each of the goals are important when using sustainability issues to teach SLO’s (student learning outcomes) and GLO’s (general learning outcomes (cluster 0):
Very important (VI)
Important (I)
Not important (NI)

Goal of teaching using sustainability issues:
1. increase students’ knowledge  VI  I  NI
2. affect student attitudes  VI  I  NI
3. affect student values  VI  I  NI
4. increase action-oriented behavior  VI  I  NI
5. teach a specific science outcome  VI  I  NI
6. teach a specific science skill  VI  I  NI
7. use science to analyze an issue  VI  I  NI
8. link issue to science and other disciplines  VI  I  NI
9. other ____________________

E. Context of Learning Activities Incorporating Sustainability Issues

In the space below, describe a recent teaching situations in which you perceive students were finding science applicable to sustainability issues. Describe the context (ex. grade 7, topic) and what was happening in the classroom to foster student learning. What were you doing? What were the students doing? These two descriptions should give a good representation of what you perceive as very good teaching practice.
_______________________________________________________________________
_______________________________________________________________________
_______________________________________________________________________
_______________________________________________________________________

Section Three: Risk and Protective Factors

My goal is to produce a paradigm shift in students’ views toward the utility of science and mathematics is necessary and important as only then can they employ scientific endeavor to move structures, organizations, communities and activities towards sustainability, as future leaders, decision-makers, and consumers. In this section you will identify risk and protective factors that impede/enhance your ability to deliver lessons that work toward this goal.
For our study, “risk factors” are those that impede your ability to deliver effective sustainability-based lessons which emphasize the utility and essential use of Science.

For our study, protective factors are those that enhance your ability to deliver effective sustainability-based lessons which emphasize the utility and essential use of Science.

The factors listed below are likely to influence your ability to teach using sustainability issues in your Science course(s). To what extent do you perceive these factors are likely to influence your ability to teach in this manner? Circle whether this factor would currently:
- Contribute Significantly (CS)
- Contribute (C)
- Impede (I)
- Impede Significantly (IS):

### Risk/Protective Factor

<table>
<thead>
<tr>
<th>Risk/Protective Factor</th>
<th>CS</th>
<th>C</th>
<th>I</th>
<th>IS</th>
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<tbody>
<tr>
<td>1. My particular course does not lend itself to analyzing sustainability issues</td>
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<td>2. Lack of resources</td>
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<td>3. Lack of resources for my particular course</td>
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<td>4. Lack of resources that are ready-to-use</td>
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<td>5. Lack of resources that are ready-to-use for my particular course</td>
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<td>6. Internet or other resources are not readable at student level</td>
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<td>7. Internet or other resources are not presented at student level</td>
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<td>8. Time required to adapt sustainability issues from a source to “work” in a classroom</td>
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<td>9. Time required to adapt sustainability issues from a source to meet science outcomes</td>
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<td>10. Depth to which the resources require mastery of science concepts</td>
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<td>11. Depth to which the resources require learning from various disciplines</td>
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</table>
12. Resources do not link sustainability issues to MB curricular outcomes
13. Resources are “extras” on top of curriculum
14. Resources are not local to our area
15. Resources do not require the completion of MB Science curricular outcomes
16. Resources take too much time away from achieving curricular outcomes
17. Using sustainability issues takes valuable time from achieving curricular outcomes
18. Using sustainability issues has no long-term effect
19. Sustainability issues should be taught separately from science
20. My interest and motivation to teach science this way
21. Student interest in learning science this way
22. Management issues including student behaviour
23. Influence of my teaching colleagues to teach this way
24. Support from colleagues
25. Support from administration
26. External support such as professional development opportunities.
What other factors do you perceive may influence (either positively or negatively) your ability to incorporate sustainability issues into your science course(s)?

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Section Four: Summary

Use this space to mention any concerns or comments you may have in regards to the development of a resource which uses sustainability resources to increase the utility of science in the minds of students.

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________________________________________________________________________

Thank-you for completing this survey. Place your survey in the self-addressed envelope supplied with this questionnaire and mail at your earliest convenience.

Amanda Tetrault
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Winnipeg, MB
R3Y 1Y2
References


