Gikinoo'wizhiwi Onji Waaban (Guiding for Tomorrow) Changing Climate, Changing Culture Professional Development Institute's Influence on Classroom Teachers

A Plan B Project
SUBMITTED TO THE FACULTY OF THE
UNIVERSITY OF MINNESOTA
BY

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IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF
MASTER OF ENVIRONMENTAL EDUCATION

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June 2016

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Acknowledgements

I would like to acknowledge my advisor and committee chair, Julie Ernst, as well as my committee members, Cathy Techtmann and Roxanne Gould, for their insight and guidance toward completion of this project. I would also like to express deep gratitude to my husband and best friend, Jasan Carpenter, for his positivity, patience, and ongoing support. Finally, I would like to acknowledge Gaia and especially the Lake Superior region as a great source of life, inspiration, and resilience.

Abstract

Traditional ecological knowledge of key species important to Ojibwe lifeways and scientific understanding suggest climate change is impacting the communities, natural resources, economies, and cultures in the Wisconsin Lake Superior region. In response, constituencies collaborated to create a new model for climate change education: G-WOW, or Gikinoo'wizhiwi Onji Waaban (Guiding for Tomorrow) Changing Climate, Changing Culture. A retrospective pretest-posttest determined whether the Summer 2015 G-WOW Institute met its objectives and is an effective approach to inspiring climate related service-learning projects. Means of the domains measured provide evidence the G-WOW Institute increased respondents': perceived level of climate literacy, confidence, and pedagogical skills. The G-WOW Institute also influenced current and future teaching practices regarding climate change education. Results from this study showed the success of participants transferring the model to their personal cultures and the cultures of the students. Finally, completing service-learning projects as a result of attendance further indicated the success of the G-WOW Institute by promoting community-based action toward mitigating and adapting to climate change.

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Chapter 1

Introduction

Background

Environmental issues such as climate change have been increasingly important when considering the needs of this and future generations (United Nations Economic Commission for Europe Steering Committee on Education for Sustainable Development, 2011). Human-consumption of natural resources and human contribution to climate change are issues of sustainability. Sustainability includes utilizing natural resources without depleting them (Merriam-Webster, 2016), and requires a "well-informed, democratically engaged citizenry" (Orr, 2002, p. 1459). A climate literate citizenry understand their influence on the climate and make environmentally responsible actions (NOAA, 2007). According to NOAA (2007), "Climate is an ideal interdisciplinary, integrating theme for education. Beginning with simple concepts and observations of weather and water, and building increasingly complex inquiries and investigation into the physical, chemical, biological, geographical, social, historical and even technological dimensions of climate, students and citizens have the opportunity to better comprehend the interconnectedness of this important topic and make use of this knowledge in their lives and in their communities" (p. 1).

Constituencies collaborated to create a new model for climate change education in the Lake Superior region: Gikinoo'wizhiwi Onji Waaban (Guiding for Tomorrow) Changing Climate, Changing Culture (G-WOW) (Techtmann, 2015), where mounting

evidence from place-based observations and scientific assessment have shown the impact of climate change on key indicator species for communities, natural resources, economies, and cultures. Did the G-WOW model meet its goals to provide learners knowledge to mitigate or adapt to climate change (University of Wisconsin Extension, 2014)?

Research has shown incorporating environmental education into classrooms has lifelong learning and character development impacts on youth, such as improved motivation, attitude, and sense of responsibility, as well as interest in leadership (NAAEE, 2001), increased self-esteem, and decreased drop-out rates (Wheeler, Thumlert, Glaser, Schoellhamer, & Bartosh, 2007). However, researchers agree the public confuse basic climate change concepts (Bostrom, Morgan, Fischoff, & Read, 1994; Choi, Niyogi, Shepardson, & Charusombat, 2009; Leiserowitz, Smith, & Marlon, 2010; Lombardi, Sinatra, & Nussbaum, 2010; Pruneau, Moncton, Liboiron, & Vrain, 2001; Reynolds, Bostrom, Read, & Morgan, 2010; Shepardson, Niyogi, Choi, & Charusombat, 2009) such as climate and weather (Leiserowitz et al., 2010; Reynolds et al., 2010; Shepardson et al., 2009). Students have simplistic and narrow understanding of climate change and are challenged to see how climate change will impact them personally (Shepardson et al, 2009). Research has shown people who misunderstand science concepts or environmental issues are less likely to act as stewards, practice environmental sensitivity (Boyes, Chuckran, & Stanisstreet, 1993), or take action (Lombardi, et al., 2010; Sasser, 2014).

Literature demonstrates a further challenge to sustainability as half of American's doubt human-caused climate change (Leiserowitz et al., 2010; Pruneau et al., 2001) despite a scientific consensus humans are causing climate change (Bray, 2010; Oreskes, 2004). Doran & Zimmerman (2009) ask how we "effectively communicate…to a public that continues to mistakenly perceive debate among scientists?" (p. 23).

Climate change educational resources have often been inaccurate and misleading, challenging to access, or difficult to relate to and understand (Choi et al., 2009). Educators have been challenged to gain confidence to educate about such a controversial issue as well as find curricula reducing confusion and making issues understandable (Boyes et al., 1993). Because simply flooding educators with climate change science has proved ineffectual (Reynolds et al., 2010), research discusses the importance of framing climate change education in a personally relevant way (Center for Research on Environmental Decisions, 2009; Fielding, Hornsey, & Swim, 2014; Shepardson, 2009). According to Bandura's Theory of Self-Efficacy (1977), people will avoid situations if they do not think they will be able to cope within the situation or believe they will succeed. In this context, educators may avoid the topic of climate change all together if they do not have the tools to help create climate literate students. Research on educators attending place-based, pre-service educational experiences have shown increased educator confidence in teaching the subject (Wilson, 2013). Place-based education is rooted in a local context and can generate a sense of connectedness to the natural world

(Meichtry & Smith, 2007). According to Kimmerer (2012), locally relevant information fosters connections to the natural world.

Studies have shown the influence of psychology and social psychology on climate change beliefs and behaviors (CRED, 2009; Gifford, 2008; Guy, Kashima, Walker, & O'Neil, 2014; Fielding et al., 2014). Fielding et al. (2014) stated teaching locally-relevant curricula can help breach people's mental models—or their mental frameworks keeping them from understanding the complexity of climate change. To foster an effective public response to the challenges of climate change, the Center for Research on Environmental Decisions developed *The Psychology of climate change communication* (2009) to help educators and other constituencies reduce barriers and clarify the complex, profound amount of scientific "information surrounding long-term and complex societal challenges" (CRED, 2009, p. 1). The *Psychology of climate change education* described framing climate change education locally to create understanding and connection (CRED, 2009), which also, as stated by Scannell & Gifford (2013) and Bangay & Blum (2010) leads to investment and engagement. According to CRED (2009), because "The human mind is not designed to immediately react to threats that seem to manifest themselves in the distant future, such as climate change" (p. 18), to be effective, climate change communication must reach "both processing systems of the human brain. Communicators should make use of the following experiential tools…vivid imagery… [including] real-world analogies, and concrete comparisons… [and] messages designed to create, recall, and highlight relevant personal experience and to elicit an emotional response" (p 18).

Orr (2004) affirmed, “We cannot say that we know something until we understand the effects of this knowledge on real people and their communities” (Orr, 2004, p. 13). Climate change has greatly impacted communities all over the world, especially indigenous communities’ environmental viability, cultural practices, and livelihoods (Lewis, 2008; Lynn et al., 2013; Cochran et al., 2013; Doering, Miller, Henrickson, Hosack, & Koivula, 2013; Voggesser, Lynn, Daigle, Lake, & Ranco, 2013). Traditional ecological knowledge (TEK), or cultural biological information from thousands of years of experiences with the natural world, is a frame of reference to understand the implications and impacts of climate change (Kimmerer, 2002; Wildcat, 2009). TEK bearers hold a connection to the natural world and directly depend on local resources (Kimmerer, 2002). TEK can elicit emotion through relaying climate change impacts while providing local, real-world evidence of climate change. TEK can present information on Earth systems commonly missing in conventional resource management (Berkes, 2000). Because climate change is a complex, systems issue, TEK can supplement new knowledge and increase resiliency of social-ecological systems (Berkes, 2000). Current projects attempt to document TEK to make it accessible to the public, such as North of Sixty, where researchers record the stories of communities impacted by climate change north of sixty degrees latitude and post them online (Doering et al., 2013).

Increasing evidence from both place-based observations as well as scientific understanding from The Wisconsin Initiative on Climate Change Impacts (WICCI) strongly suggest climate change is impacting the communities, natural resources,

economies, and cultures in the Wisconsin Lake Superior region. In response, constituencies collaborated to create a new model for climate change education: Gikinoo'wizhiwi Onji Waaban (Guiding for Tomorrow) Changing Climate, Changing Culture (Techtmann, 2015). The constituencies included resource management agencies such as The USDA Forest Service (The Chequamegon-Nicolet National Forest) and The National Park Service (Apostle Islands National Lakeshore)—concerned for public safety and resource management; The Great Lakes Fish and Wildlife Commission (GLIFWC)—concerned about impacts on treaty rights for traditional lifeways; and the University of Wisconsin-Extension—concerned traditional educational models focusing only on science were inadequate to create climate change literate citizenry.

Berkes (2004) asserts, "Conservation programs often need to encompass a broader view of the livelihood needs of local people and their knowledge and interests… we need to diversify the base of people who speak for the earth and build constituencies for conservation" (p. 628). According to Techtmann (2015), the G-WOW model includes outreach integrating "…place-based evidence people can observe on how climate impacts cultural practices they enjoy with scientific projections of how changes in climatic variables may affect the habitats and sustainability of species that support these practices" (p. 32) and operates on the key principles that "climate change is real, humans contribute to climate change, weather and climate are different, climate affects culture, and we can make a difference" (Techtmann, 2013, p. 7). The G-WOW model utilized The Center for Research on Environmental Decisions (2009) guidelines promoting accessible,

interdisciplinary, experiential education to the public and resonate with the public. Targeting a broad audience, from middle school to adult community members, educators, and other interested participants, G-WOW was funded by grants from the National Parks Foundation and Wisconsin Coastal Management Program-National Oceanic and Atmospheric Administration (Techtmann, 2015). Program outreach has three main components including an interactive exhibit at the Northern Great Lakes Visitor's Center in Ashland, Wisconsin, educator professional development institutes, and a web-based curriculum. G-WOW outreach is also expanding through the Chicago Botanic Garden, the Fond du Lac Tribal and Community College, and additional programs and professional development in 2016.

In 2007, the International Panel on Climate Change (IPCC) argued for both mitigation and adaptation to deal with climate change. Both mitigation and adaptation are important because no matter what is done to mitigate climate change, or for humans to intervene to reduce climate change impacts, climate change consequences require adaptation, or altering human or natural systems to lessen the consequences or capitalize the benefits from anticipated and actual climate change impacts (IPCC, 2007b). The G-WOW four-five day experiential professional development institute (the fifth day is optional) was designed to increase local climate literacy and foster movement from awareness to action by incorporating both mitigation and adaptation practices (Techtmann, 2015). By gaining access to scientific climate change research and gaining understanding of place-based evidence of the impact of climate change on key species

important to Lake Superior Ojibwe lifeways, implementers intended for participants to take action and address climate change at a community level. During the institute, participants investigated climate change impacts on cultural lifeways and collaborated with expert institute presenters who remain at the institute for the duration as institute participants. With the intention to create community-level action to mitigate or adapt to Lake Superior's changing climate, there is educator support to develop service-learning projects to address climate change. Some educators returned to the Apostle Islands National Lakeshore during the school year with their students. Some educators also shared their service-learning experiences on the "Talking Circle" blog (Techtmann, 2015, p. 34).

Since 2013, the G-WOW model utilized local experts to present the scientific research and real world evidence of climate change on traditional Ojibwe lifeways. The "Lake Superior Ojibwe have relied on the sustainability of key plant and animal species for generations to support subsistence, cultural, and spiritual practices or 'lifeways,'" (Techtmann, 2011, p. 9), and the traditional ecological knowledge (TEK) the tribes have of these natural systems "provides place-based indicators of climate change impacts for people of all cultures" (Techtmann, 2011, p. 9). G-WOW was designed to be "transferable to other cultures" and was intended to be modified to match the audiences perspectives to optimize audience affect (Techtmann, 2015). For example, where one example of teaching the impacts of climate change on a key Ojibwe indicator species is wild rice or Manoomin, an educator in Milwaukee could choose to focus on a different

key cultural indicator species important to their students—such as Perch for fish fries. By examining the audience and "connecting with what people value" (Techtmann, 2011, p. 19), G-WOW implementers operate under the assumption the model is an effective platform to provide teachers the necessary skills toward community action to mitigate or adapt to climate change.

Purpose Statement

The purpose of this study was to assess whether participating in the Summer 2015 G-WOW Professional Development Institute influenced participants' perceived level of climate literacy, pedagogical skills for teaching climate change science content knowledge, confidence regarding implementing the G-WOW model, teaching practices regarding climate change education and implementation of the G-WOW model, and intentions toward implementing climate education and/or teaching the G-WOW model in the future. Additionally, the purpose included exploring factors inhibiting or aiding the teachers' completion or non-completion of service-learning projects post attendance to the institute. Finally, the study determined teacher perceptions of the transferability of the G-WOW model to the student populations they teach.

An online quantitative survey was used to collect data from the Summer 2015 G-WOW Professional Development Institute participants. This survey assessed whether the G-WOW Institute influenced the domains of interest for this study. A follow-up

interview further explored the factors impacting service-learning project implementation as well as perceptions of G-WOW model transferability across cultures.

Research Questions

The following research questions guided this study:

1. Did participation influence classroom teachers':
    a. Perceived level of climate literacy,
    b. Pedagogical skills for teaching climate change science content knowledge,
    c. Confidence regarding implementing the G-WOW model,
    d. Teaching practices regarding climate change education and implementation of the G-WOW model,
    e. Intentions toward implementing climate education and/or teaching the G-WOW model in the future?
2. Did teacher participants implement the service-learning component of the G-WOW curriculum? What did teachers perceive as factors influencing or inhibiting their implementation of the service-learning projects?
3. Did teacher participants perceive the G-WOW model as transferable to the student populations they teach? If so, did they implement the G-WOW model in its original form or did they modify it?

Definitions of Terms

Perceived Level of Climate Science Literacy

According to NOAA (2009), a climate science literate person understands climate's influence on society and themselves as well as their influence on climate, and "knows how to assess scientifically credible information about climate, communicates about climate and climate change in a meaningful way, and is able to make informed and responsible decisions with regard to actions that may affect climate" (NOAA, 2009, p. 3). In this study classroom teachers' perceived level of climate science literacy was operationalized by participants rating perceived personal knowledge of NOAA's (2009) climate science literacy components in *Climate Literacy: The Essential Principles of Climate Sciences*.

Pedagogical Skills for Teaching Climate Change Science Content Knowledge

Pedagogical content knowledge, defined by Shulman (1986), regards teachers' knowledge of the material or subject matter as well as knowledge for teaching the content. Solis (2009) interpreted Shulman's definition of pedagogical content knowledge as, "Teachers' interpretations and transformations of subject-matter knowledge in the context of facilitating student learning," including: "(1) knowledge of representations of subject matter (content knowledge); (2) understanding of students' conceptions of the subject and the learning and teaching implications that were associated with the specific subject matter; and (3) general pedagogical knowledge (or teaching strategies)," and

"other elements: (4) curriculum knowledge; (5) knowledge of educational contexts; and (6) knowledge of the purposes of education" (p. 2).

Pedagogical skills for teaching climate change science content knowledge were operationalized by adapting Herr's (2016) components of pedagogical content knowledge for science teaching (based on Shulman's definition of pedagogical content knowledge). These components were adapted for participants to rate their knowledge, skills, and abilities in the context of climate change education prior to the institute, after the institute, and at the end of the school year. Additionally, pedagogical skills were operationalized by participants rating changes in their pedagogical knowledge and skills in how to frame climate change education from principles in *The Psychology of Climate Change Communication: A Guide for Scientists, Journalists, Educators, Political Aides, and the Interested Public* (CRED, 2009). Lastly items from Ernst's (2015) Rivers2Lakes Evaluation Report were modified to measure changes in pedagogical skills of specific climate change topics relevant to the G-WOW model as well as a specific form of teaching relevant to effective environmental and climate change education.

Confidence Regarding Implementing the G-WOW Model

Bandura (1977) defines perceived self-efficacy, or confidence, as a belief in capability to perform. Logistical barriers can impede educators perceived control and "confidence in their ability to perform" (Ajzen, 1991, p. 184). Place-based professional development has shown increases in educator confidence in teaching the subject matter (Meichtry & Smith, 2007; Wilson, 2013). Additional authors discuss the importance of

framing climate change education in a personally relevant way to foster connection and understanding (Center for Research on Environmental Decisions, 2009; Fielding, Hornsey, & Swim, 2014; Shepardson, 2009) as well as to avoid flooding educators/ students with too much information (Reynolds et al., 2010). Possessing factual information on climate change can reduce bias or over confidence of perceived climate science knowledge (Guy et. al, 2014). Increased perceived competence can increase motivation (Deci, Vallerand, Pelletier, & Ryan, 1991) of pedagogical capacity to teach climate science.

Confidence regarding implementing the G-WOW model was operationalized by using modified items from Ernst's (2015) *Rivers2Lakes Evaluation Report* instrument. These items were adapted to rate changes in pedagogical knowledge and skills prior to the institute, after the institute, and at the end of the school year. Items measuring perceived confidence of how to effectively communicate about climate change was taken from themes from The Center for Research on Environmental Decisions' *The Psychology of Climate Change Communication: A Guide for Scientists, Journalists, Educators, Political Aides, and the Interested Public* (2009) to rate changes in pedagogical knowledge and skills prior to the institute, after the institute, and at the end of the school year. Changes in perceived confidence in pedagogical knowledge and skills prior to the institute, after the institute, and at the end of the school year were also operationalized by elements of Herr's (2016) *Pedagogical Content Knowledge in Science Teaching.* Final items measuring perceived confidence regarding implementing the G-WOW model were

operationalized by participants rating their confidence prior to the institute and at the end of the school year as well as an item asking whether or not the institute changed their confidence in teaching climate change education.

Teaching Practices

Teaching practices can be defined by general pedagogical content knowledge and general pedagogical approaches for effective, relevant environmental and climate change education. These approaches include place-based education, project-based education, collaborating with other teachers, ability to communicate impacts of climate change on variables such as habitats, the sustainability of key species of Ojibwe culture, and cultural practices other than Ojibwe that are relevant to the student learner.

Changes in teaching practices or instructional approaches were operationalized by adapting components of Herr's (2016) pedagogical content knowledge in science teaching prior to the institute, after the institute, and at the end of the school year. The teaching practices regarding climate change education and implementation of the G-WOW model also included an open-ended question asking if the participant made changes in their instructional practices or curriculum as a result of attending the institute. Lastly, teaching practices were operationalized by adapted items from a pre-established instrument (Ernst, 2015) to measure changes in teacher practices and content knowledge prior to the institute, after the institute, and at the end of the school year.

Intention to Act

Intention to act is defined by a willingness, or desire, to act in an environmentally responsible way (Hines, Hungerford, & Tomera, 1986). Intention to act is operationalized in this study through measuring classroom teachers' intentions toward

future implementation of climate change education and/or teaching the G-WOW curriculum in their classrooms.

Service Learning

Service learning is defined as "a method under which students or participants learn and develop through active participation in thoughtfully organized service that: is conducted in and meets the needs of a community," is coordinated with an educational institution or community service program, "helps foster civic responsibility, is integrated into and enhances the core academic curriculum of the students, or the educational components of the community-service program in which the participants are enrolled, and provides structured time for the students or participants to reflect on the service-learning experience" (Billig, 2000, p. 659). Service learning will be operationalized by teachers indicating they engaged their students in a structured, environmentally responsible service-learning project with the intent of promoting skill building, climate change understanding, and reflection on the experience.

Place-based education

Sobel (1994) defines place-based education as "the process of using the local community and environment as a starting point to teach concepts in language arts, mathematics, social studies, science and other subjects across the curriculum. Emphasizing hands-on, real-world learning experiences, this approach to education increases academic achievement, helps students develop stronger ties to their community, enhances students' appreciation for the natural world, and creates a heightened

commitment to serving as active, contributing citizens. Community vitality and environmental quality are improved through the active engagement of local citizens, community organizations, and environmental resources in the life of the school" (Sobel, 1994, p. 6).

Traditional Ecological Knowledge (TEK)

According to Berkes (1993), traditional ecological knowledge or indigenous ecological knowledge "is a cumulative body of knowledge and beliefs, handed down through generations by cultural transmission, about the relationship of living beings (including humans) with one another and with their environment. Further, TEK is an attribute of societies with historical continuity in resource use practices; by and large, these are non-industrial or less technologically advanced societies, many of them indigenous or tribal" (p. 8).

Limitations, Delimitations, & Assumptions

There are several limitations of this study, including educators' predisposed environmental attitudes and/or behaviors as they are choosing to attend the institute. The study is also relying on perceived measures climate literacy, pedagogical skills, confidence, and intentions toward implementing future climate change education from self-reports after respondents attended the G-WOW Professional Development Institute. There is potential for a disconnect between perceived knowledge and actual knowledge in regard to environmental education (Hug & Hug, 2010), and specifically in this study

perceived climate change content knowledge could differ from actual measures of climate change content knowledge. Further, the study is not representative of all years of the G-WOW Institute, but is limited to the Summer 2015 Institute where some participants may have participated multiple years and others may have participated only in 2015. The study is also not representative of the general population as there is no control group and it is delimited to classroom teacher participants attending the G-WOW Institute in the Summer of 2015. Other examples of 2015 attendees included nonformal educators, specialized experts including scientists and tribal elders, and college students.

Additionally, a confounding variable included educators receiving climate change educational training beyond the G-WOW Institute. Further, even though respondents indicated completing service-learning projects, it is unknown the degree these projects impact student learning and behavior as well as the resilience of communities.

Significance

Clarifying concepts and climate change science are reportedly "largely inaccessible" (Reynolds et al., 2010, p. 1520) and educators are challenged to translate climate research and deliver newly available science in their classrooms (Liverman et al., 2010). As organizations provide access to climate change educational programming, assessment is essential to inform implementers if their program design to engage students in relevant, everyday activities is effective (Roth & Lee, 2004; Shepardson et al., 2009). Additionally, evaluation is important to assess current program benefits and inform future

program design and delivery (Knapp, 2000; Hug & Hug, 2010). The G-WOW model was intended to frame climate change issues in what the Center for Research on Environmental Decisions constitutes as the appropriate context: to "resonate with their audience" and to provide public access to "credible climate science" (CRED, 2009, p. 6). It was also designed to reduce logistical barriers by providing access to adequate resources (skills, knowledge, time, funding, and others' cooperation) to impact educators perceived control and "confidence in their ability to perform" (Ajzen, 1991, p. 184). Determining whether G-WOW classroom teacher participants are obtaining the intended outcomes of the program is important to identify and secure future funding opportunities as well as influence future program design and delivery for efficacy. Through program assessment, there is accountability for program design and efficacy toward meeting program objectives.

Research literature states evaluating the diverse ways climate change information is disseminated is imperative to determine the efficacy of framing climate change education for audiences (Crona, Wutich, Brewis, & Gartin, 2013). The G-WOW Institute utilizes experts in their various fields for content and experiences. Foresters, scientists, and elders from the Bad River Band of Lake Superior and the Great Lakes Indian Fish and Wildlife Commission apply their skills and traditional ecological knowledge to the experience. This research can contribute to literature by showing the methods used at the G-WOW 2015 institute fostered participants with diverse cultural backgrounds to connect or find personal understanding in a curriculum grounded in a traditional ecological

knowledge from a culture (Ojibwe) not necessarily their own. Additionally, measuring the efficacy of the impact of understanding traditional ecological knowledge from cultures whose lifeways are greatly impacted by climate change is important to empower communities with this knowledge. Berkes (2004) claims it is important for traditional ecological knowledge to not simply be used as a resource "mined by outsiders" (p. 629) but rather a cooperative, participatory approach with the community as a "partner in the process of knowledge creation and sharing" (p. 627). Berkes (2004) also asserts the research on participatory approaches is "important for civil society because it helps empower indigenous peoples and community groups…and provides place-based case studies for the interaction of researchers and stakeholders" (p. 627). Research literature has focused on "understanding public perceptions" (p. 520) of climate change and includes place-based research of climate change perspectives (Crona et al., 2013). Place-based studies are necessary because people's observations of their local environment are "situated in local and cultural contexts" (p. 520) and provide a basis to examine climate change understanding across cultures and identify patterns of climate change conceptualization across cultures (Crona et al., 2013). Hug and Hug (2010) advocates for both quantitative and qualitative evaluation methods to understand programming efficacy to contribute to the "cumulative body of results and long term goals of EE environmental literacy and quality-of-life" (p. 163).

Research on climate change programming shows also communities can become more connected to their place when programming includes teaching about how

communities are impacted (Elder, 2003). Ideally this connection leads to the skills, affect, and behavior of an environmentally responsible citizenry (Disinger, 2005). Climate change proves an urgent issue and urgent environmental issues increase the demand for evaluating environmental education programming to inform program design for improvements in efficacy and delivery (Hug & Hug, 2010). Hug and Hug (2010) also state assessment provides "valuable insights to improve educational programming" which "ultimately influences human impacts on the environment" (Hug & Hug, 2010, p. 163).

Chapter 2

Literature Review

The Need for Climate Change Education

According to Orr (2002), "Sustainability, in short, constitutes a series of public choices that require effective institutions of governance and a well-informed democratically engaged citizenry" (p. 1459). Sustainable development, according to the United Nations Economic Commission for Europe (UNECE) Strategy for Education for Sustainable Development, involves "equality and mutual respect among people, countries, cultures and generations," fostering "harmony with nature," and meeting the needs of this generation without eliminating future generations' capacity to meeting their needs (UNECE, 2011, p. 1). Climate change is a sustainability issue as the changing climate is greatly impacting the sustainability of the planet including human rights to clean air, water, and the right to live and exist within our global community (World people's conference on climate change and the rights of mother earth, 2010). Climate change is impacting communities' viability, cultural practices, and livelihoods—especially indigenous communities living in more sensitive areas (Cochran et al., 2013; Doering et al., 2013; Lewis, 2008; Lynn et al., 2013; Roehrig, Campbell, Dalbotten, & Varma, 2012; Voggesser et al., 2013). Educational approaches must be considered to achieve a climate literate citizenry. Sustainability science is an emerging field attempting to research dynamic interactions between nature and society and meeting this and future generations needs while, as regarded by Kates et al. (2001), "Recognizing wide range of

outlooks regarding what makes knowledge usable within both science and society" (p. 641). According to Kates et al. (2001), sustainability science involves "combining different ways of knowing and learning" (p. 641) and place-based models. To obtain a climate literate populous, community members must understand their influence on the climate and act environmentally responsibly (NOAA, 2007), much like environmentally literate citizens will, by the definition of environmental literacy, have the skills, affect, and behavior of an environmentally responsible citizen (Disinger, 2005). Further, climate literacy includes understanding of functions of weather and climate as well as their relation to human activities, effectively communicating about climate change, and making responsible, scientifically informed decisions concerning the climate (NOAA, 2007).

However, despite a scientific consensus that humans are causing climate change (Bray, 2010; Oreskes, 2004), people still doubt human-caused climate change (Reynolds et al., 2010; Pruneau et al., 2001; Leiserowitz et al., 2010). In fact, 96.2% of specialized climate scientists who have published peer-reviewed papers agree humans significantly contribute to temperature increases (Doran & Zimmerman, 2009, p. 22). According to a 2009 study from the University of Illinois, 82% of 3142 earth scientists agree humans are a contributing factor to temperature increases; 90% agreed temperatures are rising (Doran & Zimmerman, 2009, p. 22). This survey included 90% PhD and 7% master's degree respondents (Doran & Zimmerman, 2009, p. 22). Concurrently, in 2010, Anderegg, Prall, Harold, and Schneider, conducted a literature review showing approximately 97% of

well-published scientists agree the climate is changing as a result of greenhouse gas emissions (primarily human caused carbon dioxide emissions) (p. 12,107). In spite of this scientific consensus, a 2010 survey by Yale showed only 50% of Americans commit human activities are a cause for climate change (Leiserowitz, 2010, p. 14).

Laypeople's perceptions of climate change have been measured over time by a 2010 study by Reynolds, et al. From 1992 to 2009, a matched group of survey respondents showed people have a better understanding of the specific causes of climate change since 1992, yet still have misconceptions due to their preexisting mental models (Reynolds et al., 2010). Another review of studies between 1993 and 2005 confirmed people have misconceptions about climate change (Shepardson et al., 2009). Generally, researchers agree the public confuses basic climate change concepts (Bostrom et al., 1994; Choi et al., 2009; Leiserowitz et al., 2010; Lombardi et al., 2010; Pruneau, et al. 2001; Reynolds et al., 2010; Shepardson et al., 2009) such as climate and weather (Leiserowitz et al., 2010; Reynolds et al., 2010; Shepardson et al., 2009). Doran and Zimmerman (2009) explain the debate on the "authenticity of global warming and the role played by human activity" as "largely nonexistent among those who understand the nuances and scientific basis of long-term climate processes. The challenge, rather, appears to be how to effectively communicate this fact to policy makers and to a public that continues to mistakenly perceive debate among scientists" (Doran & Zimmerman, 2009, p. 23). There can be confusion in climate change perceptions in communities due to misunderstanding the difference between climate and weather. Finnis, Sarkar, &

Stoddart (2014) surveyed 97 Newfoundland residents (rural, non-native) and found they had trouble distinguishing the difference between local weather variability and long-term climate change. Weather and climate vary by length of time, where weather is a short-term and climate is atmospheric behavior over the long-term (NASA, 2016). This has been a theme amongst the public who receive their knowledge from media or sources where information is often oversimplified, dramatized, and focuses less on natural variability (Finnis, et al., 2015).

There are many psychological influences to consider on people's understanding of climate change (Fielding et al., 2014). To understand some people's psychological influences, it is essential to understand how people think about or understand the world around them. According to CRED (2009), "A mental model represents a person's thought process for how something works (i.e., a person's understanding of the surrounding world). Mental models, which are often based on incomplete facts, past experiences, and even intuitive perceptions, help shape actions and behavior, influence what people pay attention to in complicated situations, and define how people approach and solve problems. Perhaps most important to climate change communicators, mental models serve as the framework into which people fit new information" (p. 3). Peoples' mental models of climate change are regarded as inaccurate and simple, and, in essence, challenge deeper understanding of climate change concepts (Bostrom et al., 1994; Kempton, 1997; Liverman et al., 2010; Reynolds et al., 2010). Consequently, with half the population doubting human-caused climate change, people's mental models, or the

"engines of inference" (Reynolds et al., 2010, p. 1522), make communicating and educating about climate change challenging. If people' preexisting mental models are inaccurate, people can repeatedly misinterpret the new information, or have a confirmation bias. A confirmation bias means they avoid or forget new information that will cause them to change their behavior or existing mental models (CRED, 2009). Further, people may only absorb what matches their preexisting mental model due to "selective knowledge uptake," or filtering (CRED, 2009, p. 3). Reynolds, et al. (2010) states climate change public policy decisions and politics are likely to improve with better informed mental models, but simply flooding people with information will not be effective.

The complexity of climate change and overall simplicity of people's mental models (Liverman et al., 2010) exacerbates knowledge gaps and misconceptions—challenging informed decision making (Leiserowitz et al., 2010) and climate literacy. Some research shows people who misunderstand science concepts are less likely to act as stewards or practice environmental sensitivity (Boyes et al., 1993) and misunderstanding can result in inaction (Lombardi et al., 2010). Further research states climate change knowledge is "limited to the domain of climate change cognition" and does not "address the problem of translating knowledge into action" (Guy et al., 2014, p. 428). Transformative learning, however, can reshape "current frames of reference" and prompt "beliefs guiding action" (Bangay & Blum, 2010, p. 8).

According to Fielding et al. (2014) in Developing a Social Psychology of Climate Change, "Although it seems intuitively likely that having greater knowledge about climate change should be related to climate change attitudes, findings in relation to knowledge have been mixed" (p. 414). Climate knowledge is often self-reported, or measured with proxy measures such as scientific literacy, which can make it difficult to draw conclusions or positive relationships between environmental attitudes and knowledge (Guy et al., 2014; Fielding, 2014). Guy et al. (2014) further concludes people accept climate change as a reality if they possess factual knowledge. However, people's self-perceived knowledge may boost their confidence into believing they have climate change knowledge and exacerbate their individual ideologies about the causes of climate change. However, as further stated by Guy et al., "possessing factual information on the issue can neutralize the bias of individualistic ideology on climate change opinion" (Guy et al., 2014, p. 428), and potentially get past people's prior ideologies. Attitudes prior to receiving climate change messages greatly impact people's responses to the information, such as rejecting the information if the science does not align with their prior beliefs (Fielding, 2014).

Essentially, environmentally literate people will be able to utilize their skills and knowledge and make environmentally sound decisions (NAAEE, 2011). Heimlich & Ardoin (2008) state effective efforts to change environmental behavior result from combining pro-environmental attitudes, building self-esteem, and developing skills. As the theory of planned behavior (Ajzen, 1991) states, perceived behavioral control,

subjective norms, and attitudes lead to intention and then behavior. Self-esteem can be improved (Lakshmanan, Heath, Perlmutter, & Elder, 2011) and skills can be learned (Annett, 1995), but behavior cannot be directly taught (Heimlich & Ardoin, 2008). There are many factors impacting behaviors (Heimlich & Ardoin, 2008), and proving these variables (such as external and circumstantial factors, environmental awareness, attitudes, skills, and knowledge) impact changes in behavior is challenging (Elder, 2003). Though behavior is more challenging to measure than other components of environmental literacy, according to the The North American Association for Environmental Education, behaviors are conveyed through "competencies, knowledge, and dispositions" (2011). However, pro-environmental attitudes (Bell, Greene, Fisher, & Baum, 1996; Heimlich & Ardoin, 2008; Monroe, 2003) or knowledge alone rarely lead to behavioral change (Heimlich, et al. 2008). Toure-Tillery & Fishbach (2014) also assert there are three types of motivations including cognitive, affective, and behavioral, and though "behavior is not merely the outcome of motivation…researchers often use behavior to infer motivation" (p. 332). Increased environmental knowledge has shown positive attitudes towards the environment and more responsible environmental behavior and sustainable actions (Bradley, Waliczek, & Zajicek, 1999; McMillan, Wright, & Beazley, 2004).

Anthropocentric worldviews, or seeing nature as a resource for human use, has greatly contributed to environmental degradation (Kimmerer, 2012; Berkes, 2004) and the challenge of climate literacy. A combined effort with media, researchers, and politicians can better clarify what human activities influence climate change, and, in turn,

foster responsible decision making through understanding the human influence (Reynolds et al., 2010). People see climate change as a threat to others, elsewhere, whether in other countries, elsewhere in the United States, or as an impact for plants and animals (CRED, 2009). Orr (2004) in *What is Education For?* writes, "We cannot say that we know something until we understand the effects of this knowledge on real people and their communities" (p. 13). Most Americans remain disconnected from what is impacting themselves or communities or do not feel a personal connection to climate change (Fielding et al., 2014). Further, according to Shepardson, et al. (2009), few secondary students see the overall impacts of climate change on society or humans, though understand some specific consequences such as skin cancer. Students' climate change knowledge is often incorrect and fragmented (Dijkstra & Goedhart, 2012). Further, students, like adults, are also unable to personally connect to specific climate change impacts. For example, when asked the implications of climate change, students who will geographically will experience more blizzards as a result of climate change often respond there will be more hurricanes (Shepardson et al., 2009). Many do not see climate change impacting their life or their lifetime (Shepardson et al., 2009 from Pruneau 2001, p. 130). Students often learn science concepts from science textbooks filled with misinformation (Choi, et al. 2009). For example, Choi et al. in 2009 quoted a science textbook as stating, "Researchers are not sure exactly when, if at all, the Earth's global climate will begin to change" (p. 897). Confusing curricula does not help reduce the misconceptions, but rather promotes an "inability to connect interrelated scientific concepts" (Choi et al.,

2009, p. 897). Overall, students have simplistic and narrow conceptions of climate change, lack systems understanding, and are challenged to conceptualize local impacts of climate change (Shepardson et al., 2009). Boyes, et al. in *How Do High School Students Perceive Global Climate Change: What are its Manifestations? What Are its Origins? What Corrective Action Can Be Taken?* (1993) concludes it is, "A task of educators…to disentangle these various issues, without adopting a completely non holistic approach, which is seen by many as a contributing cause of environmental insensitivity" (p. 556).

Effective Approaches to Environmental and Climate Change Education

Knowing the benefits and importance of environmental education can motivate teachers to incorporate it into their K-12 curricula (Knapp, 2000). Formal and non-formal studies show focus on specific teaching methods, such as issues-based environmental education, can engage students and teach them problem-solving skills when immersed in authentic environmental problems (Elder, 2003). Shepardson et al. (2009) considers, "Planning curriculum and designing instruction…a difficult and challenging process made even more taxing by the scientific complexity of global warming and climate change. Add to this mix the necessity to build from students' conceptions and you have an even more daunting task of developing conceptually rich and personally relevant learning experiences" (p. 23). Weilbacher (1997) calls for "carefully constructed curricula featuring focused, sequential, knowledge-based programs" (p. 19). Further goals for environmental curriculum development include

ecological knowledge, personal and societal environmental impacts, and the means to make decisions to act on environmental issues (Hungerford, Peyton, & Wilke, 1980). According to Jickling (2005), reducing gaps between school curriculum and real-world issues, fostering ethical understanding, and creating caring, critical thinkers through competency creates active citizens. If educators have access to interdisciplinary curricula that builds toward scientific understanding, they can reduce students' misconceptions (Shepardson et al., 2009).

Research suggests effective educational approaches for climate literacy as it does to foster environmental literacy. The Center for Research on Environmental Decisions (2009) states rather than studying "analytical climate change data to increasing climate change literacy," experiential ways of learning with "…local, place-based evidence of climate change" (p. 9) is more effective and can provide an alternative means for the public to gain access to credible science. Elder (2003) in *A Field Guide to Environmental Literacy*, states if educators can show the impact of climate change on communities the breach between humans and the Earth can heal (Elder, 2003). Similarly, CRED (2009) calls for increasing climate literacy through personal connections.

Educators/communicators need to highlight the current impacts of climate change on relevant regions within the US to respond to the distance between the impact of climate change on others versus themselves (CRED, 2009). Further, framing climate change in a way to encourage engagement is critical for people to reduce the distance between the future and the present and the impact perceived for others rather than

themselves (Fielding et al., 2014). CRED (2009) also discusses, "Despite evidence that the experiential processing system is the stronger motivator for action, most climate change communication remains geared towards the analytical processing system. Personal or anecdotal accounts of negative climate change experiences, which could easily outweigh statistical evidence, are rarely put into play" (CRED, 2009, p. 41). Place-based education includes creating meaningful or transformative experiences in "the local environment" and aligns with the goals of improving education outcomes and achieving a sustainable society by developing in students a sense of connectedness to where they live" (Meichtry & Smith, 2007, p. 15). In essence, fostering connectedness to place through education contributes to a more sustainable global community (Meichtry & Smith, 2007). Place-based education has also shown "positive impacts on teachers' confidence" and "connecting that teaching to society and real-life" (Meichtry & Smith, 2007, p. 22). An evaluation of a professional development program by Rivera, Manning, & Krupp in 2013 found a place-based professional development institute in Hawaii "significantly increased" teacher confidence levels from prior to the institute (p. 217). Wilson, in Professional Development for Science Teachers (2013), states although there is a lack of theoretical understanding about the mechanisms for teacher learning, increased self-efficacy leads to increased persistence and confidence, and, in turn, to increased motivation.

A combination of place-based and project-based education and sustainability content are regarded as ideal environmental education approaches by other authors as

well (Elder, 2003). Evaluations of interdisciplinary project or issue-based environmental education have shown improvements in students' in-school behaviors, engagement and motivation toward learning (Athman & Monroe, 2004; Meichtry & Smith, 2007; Powers, 2004) and greater job satisfaction for educators (Meichtry & Smith, 2007). Additionally, place-based education evaluations have shown locally relevant, real world, and hands-on, outdoor curricula increases student achievement, creates personal connections with nature, and fosters stewardship (Ernst, 2005). According to CRED (2009), "By framing climate change as a local issue, communicators not only increase their audience's sense of connection to and understanding of climate change, but also promote the development of local and regional solutions that could transfer well to the national and global arenas and, further, inspire future action everywhere" (p. 10).

Conceptualizing climate change in the present, with local, relevant consequences and contexts can help people with investment and engagement (Scannell & Gifford, 2013; Bangay & Blum, 2010) and results in enhanced participation in communities (Elder, 2003; Powers, 2004). Education philosophers such as Piaget and Dewey considered the best situation for learning is purposive learning where students are "actively involved in their learning" (Billig, 2000, p. 659). Experiences and activities produce more environmentally responsible behaviors (Robertson & Kruegly-Smolska, 1997). Service-learning is a specific approach to promote active citizenry (Powers, 2004, p. 18) and includes actively participating in the community and meeting the needs of the community (Billig, 2000). Through service learning, communities encourage active

student involvement in community projects as well as increased relationships between governments and schools (Powers, 2004). Communities view service-learning participants as valued community resources (Billig, 2000), and service learning contributes to social capital while building mutually beneficial networks from cooperation and coordination and overall healthier communities (Powers, 2004). Case studies show service learning through 4-H and FFA has built social capital, developed leaders, and increased community viability in a "complex, changing world" (Henness, Ball, & Moncheski, 2013, p. 94).

Henness et al. (2013) discusses, "By shifting the focus from the individual to the community, social capital allows us to better understand the broad public value of education and youth programs" (p. 75). Students engaging in service-learning programs experience increased positive behaviors; social competence; increased social and personal responsibility; educational competence; respectful and caring behaviors toward teachers and peers; increased self-esteem; better ability to trust and be trusted; empathy; career knowledge; and overall capacities to "become active, positive contributors to society" (Billig, 2000, p. 661). Effective environmental education involves students engaging to find solutions to issues (Elder, 2003), through methods such as service learning. Rather than dictating, Elder (2003) states literacy programs should provide "children the knowledge, skills, and attitudes to make an informed choice" (Elder, 2003, p. 66), and Bangay & Blum (2010) states literacy programs must empower students "to understand and critically engage with climate environmental change" (p. 12).

Much like place-based education, service-learning projects contribute to positive student outcomes. Billig, in *Research on K-12 School-Based Service-learning: The Evidence Builds* (2000), states the content of the project or activity shapes the outcome, "…if the service is in the area of the environment, then the particular academic or civic or career outcomes will occur more often with in a related field—for example, higher grades in science, better understanding of ecology, greater caring about the environment, and better understanding of careers in environmental science" (p. 662). Additionally, Billig (2000) states deeper understanding and longitudinal studies are needed to augment understanding of service-learning outcomes, but as mediators and partners, educators must be well-prepared to facilitate and assist but not make all of the decisions for the students to experience the benefits (Billig, 2000).

Though community-based conservation efforts have been increasing, evaluations show failure due to implementation approaches or the linking of development and conservation objectives (Berkes, 2004). Communities are dynamic, according to Berkes (2004), and communities have the capacity for "renewal and reorganization, learning and adaptation, and ability to deal with change" (p. 623). For effective, community-based conservation efforts, humans need to see the interconnected systems, or social-ecological systems, where humans are a part of the ecosystem (Berkes, 2004). It takes time to obtain intimacy with place and or a sense of place (Lopez, 1989), and with the development of technologies and shift of populations from rural to urban, first-hand, place-based experience is diminishing (Lopez, 1989). Beyond a sense-of-place, authentic

experiences provide how things have "traditionally…been fitted together in a community" to form a sense of community (Lopez, 1989, p. 61). Adaptive management, according to Berkes (2000), "acknowledges that environmental conditions will always change, requiring societies to respond by adjusting and evolving" (p. 1260), involves social learning, and is designed to improve ways societies can respond to uncertainty. Social-ecological systems resiliency is increased by combining new knowledge with traditional knowledge (Berkes, 2000).

Approaches to sustainability science integrate multiple ways of learning and knowing (Kates et al., 2001). Roth & Lee (2004) concurs it is necessary for science education to utilize different forms of knowledge, such as traditional and relational, for active participants in science-related issues. According to Shepardson, et al. (2009), to build toward an understanding of climate science and create active citizens, interdisciplinary climate change curricula must including health implications, populations, and environmental and resource implications (Shepardson, et al. 2009). According to Fielding, et al. (2014), stronger intentions to act are also a result of climate change education that focuses on loss prevention (Fielding et al., 2014). Traditional ecological knowledge (TEK) is a way of knowing environmental and resource implications on populations. Much like adaptive management, TEK can inspire ecosystem conservation, adaptation, and maintenance from "monitoring the status of the resource…[and] change in ecosystems" (Berkes, 2000, p. 1254). TEK "refers to the knowledge, practice, and belief concerning the relationship of living beings to one

another and to the physical environment, which is held by peoples in relatively non-technological societies with a direct dependence upon local resources" (Kimmerer, 2002, p. 432-433). Utilizing TEK as a way of knowing provides relevant, real-world information from the cumulative experiences of the people within a location (Berkes, 1993; Wildcat, 2009) and contains a "wealth of biological information" and a "cultural framework of respect, reciprocity, and responsibility in which it is embedded" (Kimmerer, 2002, p. 432).

TEK encourages "mutualistic relationships" with nature (Kimmerer, 2012, p. 317), and is used in conjunction with scientific because it provides an alternative perspective to scientists, land managers, or others with vested interests in the land such as forest company (Berkes, 2004). TEK can inspire new models for sustainable development and foster working partnerships between resource users, scientists (Kimmerer, 2002; Berkes, 2004), and resource managers (Berkes, 2004). Scientists can benefit from these interrelationships because TEK can further validate their research (Kimmerer, 2012). TEK can better reach a more diverse student audience such as Native American students by incorporating spirit, compassion, and holism into science (Kimmerer, 2002) as well as acknowledging the relationships between humans and nature (Kimmerer, 2002; Roehrig et al., 2012).

Fostering understanding about the complexity of the Earth's climate system is considered a central goal of climate change education (NOAA, 2009). Because many people in contemporary communities have lived in a place for a limited amount of time,

unlike TEK bearers, they lack the understanding of the longer-term concept of climate. People's short-term, personal experiences of local weather variability is confused with the long-term concept of climate (Finnis, Sarkar, & Stoddart, 2015). The simplicity of the public's perception of the difference between weather variability and long-term climate change contributes to the overall misunderstanding of climate change and can impact action toward climate mitigation and adaptation (Finnis, et al., 2015). Therefore, communicating about weather variability is imperative to improve public perceptions of climate change. Framing climate change education with multi-generational knowledge (such as TEK) and explicitly discerning climate as a long-term measure can provide educators understanding of the implications and complexity of climate change (Kimmerer, 2002; Wildcat, 2009).

Barriers for Teachers Regarding Climate Change Education

Educators often experience barriers to incorporating climate change education and environmental education in general into their classrooms. Ham and Sewing (1987) categorized the barriers into logistical, attitudinal, conceptual, and educational. Logistical barriers include existing curriculum pressures, limited time (Bartosh, Tudor, Ferguson, & Taylor, 2006; Robertson & Kruegly-Smolska, 1997; Ham & Sewing, 1987), lack of funding (Bartosh et al., 2006; Ham & Sewing, 1987; Rivera et al., 2013; Robertson & Kruegly-Smolska, 1997), and insufficient access to equipment or materials (Rivera et al., 2013; Robertson & Kruegly-Smolska, 1997). Even though standardized

tests are often seen as a barrier to incorporating environmental education (Bartosh et al., 2006; Robertson & Kruegly-Smolska, 1997; Ham & Sewing, 1987), incorporating environmental education programs improves achievement in social science, science, reading, and math, and generates higher standardized test scores than schools not using environmental programs (Bartosh, et al. 2006).

Additionally, if educators have negative attitudes about teaching environmental education, it is unlikely they will teach about it (Ham & Sewing, 1987). Attitudes are "the outcome of a cognitive process of evaluating beliefs about the attitude object; for example, a person who has positive beliefs about a climate change policy is likely to hold favorable attitudes to that policy" (Fielding et al., 2014, p. 414). In 2006, Bartosh et al. quoted several authors stating environmental education can help develop environmental and positive environmental attitudes. According to Fielding et al. (2014), "Cognitive approaches to understanding attitudes (e.g. expectancy-value models) have been at the forefront of how we understand attitude formation" (p. 414).

Conceptual barriers can include not knowing how to integrate environmental education into classrooms or what resources or content to utilize. Educators often conceptualize environmental education narrowly as science education, outdoor education, or something separate from their curriculum all together (Ham & Sewing, 1987). Reportedly, environmental curricula is often limiting, difficult to teach and understand, and only implemented by science teachers (Elder, 2003). In 2000 a study by the North American Association for Environmental Education (NAAEE) showed nearly half of

educators do not see the relevance of environmental education within their curriculum (McCrea & deBettencourt, 2000, p. 39). If educators see environmental education as limited in scope and separate from their curriculum, they will not put forth the effort to incorporate it into their classrooms. The National Oceanic and Atmospheric Administration (2007) sees climate as "an ideal interdisciplinary, integrating theme for education," which can build from concepts and observations to complex investigations and inquiries in a multitude of subjects (NOAA, 2007, p. 1). Further, NOAA considers climate a topic that can be utilized in the learners lives and communities (NOAA, 2007). Conflicting ideas on what to implement into the classroom and questionable efficacy of resources available has also proved confusing for educators (Robertson & Kruegly-Smolska, 1997). Teachers are also challenged to help students make the connections between science and their everyday lives (Roth & Lee, 2004). Therefore, it is essential to assist educators in accessing these programs that will engage students in relevant, everyday activities students can resonate with and personalize (Roth & Lee, 2004; Shepardson et al., 2009).

Educational barriers also include teachers lacking confidence to incorporate environmental education in schools. Sometimes educators are uncertain if the content is permitted (Robertson & Kruegly-Smolska, 1997). Curricula that questions cultural beliefs has been challenged to make it into classrooms (Robertson & Kruegly-Smolska, 1997). Though few educators (less than 1%) see administrative or parental resistance as a barrier to general environmental education (Elder, 2003, p. 24). Environmental education

that is incorporated into classrooms is often limited to commonly accepted school gardens, composting (Robertson & Kruegly-Smolska, 1997), and recycling programs (Robertson & Kruegly-Smolska, 1997; McCrea & deBettencourt, 2000). Often using such commonly accepted approaches can make it easier to teach to less-enthusiastic participants (Robertson & Kruegly-Smolska, 1997). However, there are additional means to reduce barriers to implementing environmental education.

Teacher Professional Development

Professional development reduces educator barriers and creates accessible, interdisciplinary curricula while having a lasting, positive effect on both the teacher and student. Though resulting behaviors can vary individually, in the context of climate change education, educators need the self-efficacy to manage teaching their students about a complex and challenging situation—climate change. Researchers show the positive relationship between attending professional development institutes including increased self-efficacy, changed behaviors, and increased student achievement (Lakshmanan et al., 2011). Lakshmanan et al. (2011) expresses the need for long term studies to determine student outcomes as a result of increased educator self-efficacy, yet educator self-efficacy and comfort has reportedly increased as a result of learning new methods and techniques implemented after attending professional development institutes (Lakshmanan et al., 2011; Wilson, 2013). Teachers need to feel competent in the content or material to increase their confidence in teaching the material. Perceived competence

has “been connected to intrinsic motivation” (p. 334) according to Deci, Vallerand, Pelletier, & Ryan (1991).

According to Bandura’s Theory of Self-Efficacy (1977), people will avoid situations if they do not think they will be able to cope within the situation or believe they will succeed. If they view they will be able to handle the situation, they will get involved. Further, according to Ajzen’s Theory of Planned Behavior (1991), behaviors are most closely determined by intentions (including influencing motivations). The stronger the intention (or effort) put forth to perform an activity increases the probability of performing the activity. Three independent factors influence intention, including “attitude toward the behavior,” “subjective norms,” and “perceived behavioral control” (Ajzen, 1991, p. 188). Subjective norms include “perceived social pressure to perform or not perform the behavior” (Ajzen, 1991, p. 188). Socially identifying with others will influence or change behavior in regard to climate change (Fielding et al., 2014). Reducing logistical barriers by providing access to adequate resources (skills, knowledge, time, funding, and others’ cooperation) educators’ *actual* control to teach about climate change education could increase. Further, the educators’ *perception* of control relates to perceived self-efficacy and “confidence in their ability to perform” (Ajzen, 1991, p. 184). Both initiating and maintaining behaviors are influenced by self-efficacy (Bandura, 1977). Further, Ajzen (1991) states, “perceived behavioral control, together with behavioral intention, can be used directly to predict behavioral achievement” (Ajzen, 1991, p. 184). For example, if two educators intend to teach about

climate change and one educator is confident in their ability whereas the other has doubts, the educator who is confident in their climate change teaching ability is more likely to initiate and maintain teaching the content.

Professional development institutes provide opportunities for cooperative and collaborative learning communities which increase content knowledge and, in turn, educator self-efficacy (Heimlich & Ardoin, 2008). By including the "best available research evidence" in a professional development training (Grinberg & Gummer, 2013, p. 749), educators can gain access to clarifying concepts and results on climate change studies that are reportedly challenging to access (Reynolds et al., 2010). Further, access to this information can help educators remove the challenge of translating climate research and delivering newly available science to their students (Liverman et al., 2010).

To produce environmentally literate students, educators need the commitment, skills, and knowledge to "environmentalize their curriculum" (Wilke, 1985, p.1) or an extensive environmental concept knowledge (Robertson & Kruegly-Smolska, 1997). General educator training teaches effective environmental education methodology and inspires bringing environmental education into school curricula (Tilbury, 1992). Thomas Guskey (2003) in *What makes professional development effective?* looked at published lists of characteristics of effective professional development and concluded that though efficacy can be viewed differently, most frequently the most important aspect is "helping teachers to understand more deeply the content they teach and the ways students learn" (p. 749). The United Nations Educational, Scientific, and Cultural Organization

Educating for a Sustainable Future (UNESCO) (1997) claims, "The most frequent cause of curriculum failure is inadequate teacher training" (p. 26), and Knapp (2000) states, "Research in the field [environmental education] consistently supports the notion that the most successful way to implement any environmental education curriculum is through in-depth workshops" (Knapp, 2000, p. 4). According to Knapp (2000), in-depth workshops, or "aggressive in-service and pre-service training" (p. 7) can provide the adequate training, skills, and materials to prepare teachers as effective environmental educators. Pre-service educators are a key audience for environmental education workshops because they are establishing their routines and roles as educators; they can learn to use resources available and establish environmental education into their teaching style (Taylor, 1988). In-service teachers are proficient in their trained disciplines, but lack multidisciplinary methods encouraging participants to think comprehensively (Taylor, 1988). Additionally, the social learning environments fostered in professional development workshops often address real-life situations (Heimlich & Ardoin, 2008, p. 228), and, ideally provide ample time to work together and exchange ideas and strategies (Grinberg & Gummer, 2013). In the past an inadequacy of "teacher inservice opportunities," as stated by Wade (1996) impeded schools from incorporating environmental education and called for educators to reflect on their own environmental approaches to adopt collaborative, community-based approaches. Wilson (2013) claims educators now have more opportunities for professional development.

Professional development provides opportunity for meaningful experiences and to build on prior knowledge and experiences. Choosing to attend a place-based, relevant professional development shows some motivation toward teaching climate change education. Professional development can create an opportunity for learners to find meaning in their experience. The G-WOW Institute is an experiential professional development opportunity for educators to build on their pre-existing knowledge. Constructivism, or the constructivist model of knowledge, means the learner constructs their understanding through coordinating new information with preexisting mental structures and reflecting on their experiences (Bodner, 1986). Under the theory of constructivism, if the educator attending the professional development spends time reflecting on the place-based experience, they will be able to construct their own relevant understanding.

Cultural Climate Change Education Program Example

The professional development program, CYCLES: Teachers Discovering Climate Change from a Native Perspective, was developed in response to "generally irrelevant" (p. 74) Western models of science curricula focusing on reductionist approaches and targets underserved Native American school communities (Roehrig et al., 2012). CYCLES provides a model aligned with Native American concerns about water and land management in relation to climate change (Roehrig et al., 2012). This three-year professional development program is designed to "implement culturally relevant

approaches to teaching climate change science with their [teachers'] Native American students" (p. 75) and meet the need for well informed, climate literate Native American citizens ready to be actively involved in their communities (Roehrig et al., 2012). Targeting middle and high school teachers from five Northern Minnesota reservations, CYCLES utilizes place-based, inquiry-based, and interdisciplinary approaches to align with the holistic, Indigenous perspectives (Roehrig et al., 2012). CYCLES encourages students to "maintain their sense of place an cultural connections to the land" (p. 79) while utilizing current scientific findings and exploring "culturally important community resources" (p. 81) such as manoomin (wild rice). Both traditional ecological knowledge and scientific explanations interconnections are utilized to meet the complex, multidisciplinary issue of climate change (Roehrig et al., 2012). While this approach is not directly transferable to other communities through a written curriculum or activities set, appropriate local contexts can be developed "in collaboration between scientists, educators, and members of the reservation community" (Roehrig et al., 2012).

Chapter 3

Methodology

Introduction

The purpose of this exploratory study was to investigate if participation in the G-WOW professional development institute influenced classroom teachers' perceived level of climate literacy, pedagogical skills for teaching climate change science content knowledge, and G-WOW implementation confidence, teaching practices, and intentions toward future implementation. This study also explored the implementation of service-learning projects and factors influencing or inhibiting service-learning project implementation. Additionally, data collected included gathering teacher participants' perceptions on G-WOW model transferability to the student populations they teach and any modifications they may made to implement the model. This study used a single-group, retrospective pretest-posttest design to address the following research questions:

1. Did participation influence classroom teachers':
    a. Perceived level of climate literacy,
    b. Pedagogical skills for teaching climate change science content knowledge,
    c. Confidence regarding implementing the G-WOW model,
    d. Teaching practices regarding climate change education and implementation of the G-WOW model,
    e. Intentions toward implementing climate education and/or teaching the G-WOW model in the future?

2. Did teacher participants implement the service-learning component of the G-WOW curriculum? What did teachers perceive as factors influencing or inhibiting their implementation of the service-learning projects?
3. Did teacher participants perceive the G-WOW model as transferable to the student populations they teach? If so, did they implement the G-WOW model in its original form or do they modify it?

Design

A retrospective pretest-posttest design was chosen for this study, in light of the content focus of the professional development and curriculum model. The complexity of climate science and climate education pedagogy seemingly may challenge teachers to accurately assess domains of their own climate literacy or their own pedagogical content knowledge before participating in the professional development institute. After participation, teachers may have a better understanding of the topics and assess their pre-participation levels more accurately. Following approval of the study by the Institutional Review Board (See Appendix A), data was collected through an online questionnaire and followed by inviting participation in a semi-structured phone interview. The semi-structured phone interview was used to gain clarification of the factors influencing implementation of the service-learning component of the G-WOW model and perceptions of the transferability of the G-WOW model. The influence of the professional development institute on the domains of interest for this study were better understood

through integrating the interview data with the questionnaire data. While the interview was one source of data for this study, the overarching paradigm for the study was quantitative and the textual data from the interview was analyzed through a quantitative lens.

Population and Sample

The population of interest was classroom teachers who attended the G-WOW Professional Development Institute. The accessible population was classroom teachers who participated in the most recent professional development offering, the 2015 summer institute. While there were 30 attendees, not all were classroom teachers (community members, nonformal educators, and content experts also attended). Because of the distinct differences across nonformal and formal settings, the study was delimited to classroom teachers. All classroom teachers who participated in the 2015 institute were invited to participate in the study.

Instrumentation

Two instruments were used in this study, including a retrospective pretest-posttest questionnaire administered online (See Appendix B) and a semi-structured phone interview (See Appendix C).

Online Questionnaire

The questionnaire contained seven sections, reflecting the seven domains addressed in the research questions stated prior.

Perceived Level of Climate Literacy

The first section of the questionnaire developed included questions regarding *perceived level of climate literacy.* This section was based on five statements corresponding with NOAA's climate literacy principles (NOAA, 2007). Respondents could answer their agreement of their personal knowledge on a five-point scale. The options and scores included: strongly disagree (1), somewhat disagree (2), neither disagree nor agree (3), somewhat agree (4), strongly agree (5). Responses were averaged, with a higher mean response indicating a higher *perceived level of climate literacy.*

Pedagogical Skills for Teaching Climate Change Science Content Knowledge

The second section of the questionnaire involved three series of items to measure *pedagogical skills for teaching climate change science content knowledge* adapted from several sources to be relevant to the G-WOW curriculum. The first series (eight items) was adapted from the recommendations for effective climate change communication by the Center for Research on Environmental Decisions (CRED, 2009). The second series of items were adapted from Ernst's (2015) evaluation report of a place-based curriculum (seven items). The final series of items in the second section were based on the tenets of general pedagogical science content knowledge as set forth by Herr (2016) (five items).

All three series in the second section were scored on a five-point scale. Responses could range from one, being a low level of pedagogical knowledge and skills to five, being a high level of pedagogical knowledge and skills. The response means for each of the sections of items were recorded and then averaged to ascertain the section means and changes from pre-institute, post-institute, and at the end of the school year. The higher the scores on this second section indicate higher *pedagogical skills for teaching climate change science content knowledge.*

Confidence Regarding Implementing the G-WOW Model

There were two series of items in the questionnaire to address *confidence regarding implementing the G-WOW Model* in the third section of the questionnaire. The first series in this section included measuring *confidence regarding implementing the G-WOW Model* by using answers from items in the *pedagogical skills for teaching climate change science content knowledge* section. This series of items used was adapted to be relevant to the G-WOW participants from elements for effective climate change communication (eight items), place-based education (seven items), and general pedagogical science content knowledge (five items). Responses could range from one, being a low level of confidence in pedagogical knowledge and skills to five, being a high level of confidence in pedagogical knowledge and skills. Scores were averaged to obtain the mean of items pre, post, and at the end of the school year. The higher the averaged scores on this section indicate higher *confidence regarding implementing the G-WOW Model.* Changes in *confidence regarding implementing the G-WOW Model* were

determined by comparing the scores from pre-institute, post-institute, and at the end of the school year.

The second series of items was designed to measure *confidence regarding implementing the G-WOW Model* pre and post-institute by asking respondents to answer two items. The first item was based on a five-point scale ranging from strong disagreement to strong agreement whether respondents agree they are confident about teaching climate change education. Responses were scored from strongly disagree (1), disagree (2), neither agree nor disagree, agree (4), strongly agree (5). The higher the score, the stronger the agreement of *confidence regarding implementing the G-WOW Model.* The greater the difference of means from pre to post-institute, the stronger the change in *confidence regarding implementing the G-WOW Model.* The second item in this series asked respondents to rate their agreement to the statement "The institute changed my confidence about teaching climate change education." Responses were scored from strongly disagree (1), disagree (2), neither agree nor disagree, agree (4), strongly agree (5). The higher the score, the stronger the agreement it was the institute that changed the respondents' *confidence regarding implementing the G-WOW Model.*

Teaching Practices Regarding Climate Change Education and Implementation of the G-WOW Model

The fourth section of the questionnaire was used to discern *teaching practices regarding climate change education and implementation of the G-WOW Model*, respondents were asked to answer three series of items. The first items addressed

whether or not respondents used content or instructional practices in their classroom (five items) based on the key principles of the G-WOW Institute. Items were scored based on two possible answers including: *no* (1) or *yes* (2). Responses were averaged pre and post-institute to evaluate change in *teaching practices regarding climate change education and implementation of the G-WOW Model* after attending the G-WOW Institute.

The second series of items was based on items of general pedagogy (five items) (Herr, 2016). These were the same items used to measure *pedagogical skills for teaching climate change science content knowledge*, and were scored on a five-point scale from one, a low level of pedagogical knowledge and skills to five, a high level of pedagogical knowledge and skills. The higher the mean of the responses indicated a higher personal rating in using *teaching practices regarding climate change education and implementation of the G-WOW Model*. Changes in *teaching practices regarding climate change education and implementation of the G-WOW Model* were determined by comparing the scores from pre-institute, post-institute, and at the end of the school year.

The final part of this section was an open ended question asking whether respondents made changes to their instructional practices or curriculum based on their participation in the institute. Respondents were asked to write an open-ended response to describe what the changes were, or if they did not make any changes, why not. Responses indicating changes were summarized and included as indicators specifying what types of changes in *teaching practices regarding climate change education and implementation of the G-WOW Model* were made as a result of the institute.

Intentions toward Implementing Climate Education and/or Teaching the G-WOW Model in the Future

The fifth section of the questionnaire was used to measure *intention toward implementing climate education and/or teaching the G-WOW Model in the future.* These five items were the same five items used to measure *teaching practices regarding climate change education and implementation of the G-WOW Model* pre or post-institute. Respondents were asked whether they plan to use the content or instructional approaches in the future. All of the content or approaches based on key principles of the G-WOW Institute. The five items had two possible responses each, including *no* or *yes*. They were scored *no* (1) or *yes* (2). The responses were averaged with a higher score predicting a higher *intention toward implementing climate education and/or teaching the G-WOW Model in the future.*

Service-learning Component Implementation

The sixth section of the questionnaire was designed to determine whether or not respondents implemented the service-learning component of the G-WOW curriculum and identify factors influencing or inhibiting their implementation of the service-learning projects. The first part of this section included an open-ended question asking respondents if they implemented a service-learning project with their students that involved environmental stewardship, climate change adaptation, or climate change mitigation and, if so, to describe the project. If respondents did not implement a project, they were asked to respond why. These responses were summarized and used to indicate

if projects were implemented and what types of projects were being implemented. This item was also used to discover why projects may not have been implemented.

Additionally, the items designed to measure *factors perceived as influencing or inhibiting service-learning project implementation* were adapted from Ernst (2015). These eighteen factors were rated on a seven-point scale and scored as follows: completely prevented implementation (1), strongly prevented implementation (2), somewhat of an obstacle to implementation (3), was not an obstacle to implementation (4), somewhat assisted implementation (5), strongly assisted implementation, (6) completely assisted implementation (7). The response scores from each item were averaged to discern whether the factors inhibited or assisted implementation. The higher the mean, the stronger the factor assisted implementation.

Perceptions of G-WOW Transferability to Student Populations

The final section of the questionnaire addressed respondents perceptions of the transferability of the G-WOW model to the student populations they teach. The first part included items where respondents selected one, two, or all three statements indicating they use the G-WOW Model in it's original form utilizing Ojibwe cultural practices, in a modified form utilizing cultural practices important to their own culture, or in a modified form utilizing species important to the culture(s) of their students. On the forth item the respondents could select they do not use the G-WOW Model in any capacity. The second part was an open-ended question asking for specific descriptions of how respondents have modified the model if they have used the model and modified the model.

Demographics

The questionnaire also included demographic items to gather data on teachers' years of teaching experience, grade level(s) taught (K-2, 3-5, 6-8, 9-12, or 13+), subject(s) taught (science, language arts, social studies, math, specialty, or combination), school setting (urban, suburban, or rural), and proximity to a tribal school, reservation, or tribal community.

The questionnaire was reviewed for content validity by the thesis committee guiding this study (of which content expertise in instrumentation, indigenous communities and learning, and climate science are represented).

Interview

The second instrument was an interview guide used in the semi-structured phone interview (see Appendix C). The purpose of the interview was to address the following two research questions more in-depth:

1. Did teacher participants implement the service-learning component of the G-WOW curriculum? What did teachers perceive as factors influencing or inhibiting their implementation of the service-learning projects?
2. Did teacher participants perceive the G-WOW model as transferable to the student populations they teach? If so, did they implement the G-WOW model in its original form or do they modify it?

While the questionnaire addressed these two research questions, the interview format allowed the participant to further expand on their responses to the questionnaire, adding depth and insight that allowed further "sense-making" from the questionnaire data. The semi-structured interview structure allowed for follow-up questions, depending on the participant's responses and unanticipated responses that lead to questions not thought of during instrument development. In addition, the interview uncovered confounding variables, such as additional training or influences on climate science or climate education.

Data Collection Procedures

Data collection took place in April 2016, following approval of the study by the Institutional Review Board (See Appendix A). Teachers received a recruitment email invitation to participate in the study. This email contained consent information, as well as a link to the Qualtrics survey. After one week, the teachers received a reminder email, thanking those who had completed the survey and asking them complete it if they have not yet done so. The teachers received two more reminders which also thanked them for their participation. The online questionnaire was open for a total of two weeks.

In addition, teachers were invited to participate in the phone interview through the initial email; if they were interested, they were asked to reply to the email indicating a general time frame (day of the week, general time period) they were available for a 20 minute phone interview. One teacher indicated an interest in the phone interview and

was contacted by email to arrange a day and time for the phone interview. The phone interview was conducted in May 2016. The phone interview was annotated by the interviewer and lasted approximately twenty minutes. A final email was sent to the interviewee thanking them for their time, effort, insight, and participation.

Data Analysis

Descriptive statistics were used on the items measuring changes pre participation to post participation in the G-WOW Professional Development Institute and, in some instances, at the end of the school year. Descriptive statistics were also used to summarize responses to the second and third research questions. Finally, further analyses explored potential modifications classroom teachers make to the G-WOW model and compared demographic information with responses on the transferability of the curriculum to the teachers' student populations. Data from the phone interview was summarized and added to supplement questionnaire data.

Chapter 4

Results

Introduction

The purpose of this study was to describe the influence of the 2015 G-WOW Institute on classroom teachers' perceived level of climate literacy, pedagogical skills for teaching climate change science content knowledge, and confidence regarding implementing the G-WOW model. Additionally, this study describes teaching practices regarding climate change education and implementation of the G-WOW model, intentions toward implementing climate education and/or teaching the G-WOW model in the future, and the implementation of the service-learning component of the G-WOW curriculum, factors influencing or inhibiting their implementation of the service-learning projects, and perceptions of the transferability of the G-WOW model to the student populations they teach.

The following research questions guided this study:

1. Did participation influence classroom teachers':
    a. Perceived level of climate literacy,
    b. Pedagogical skills for teaching climate change science content knowledge,
    c. Confidence regarding implementing the G-WOW model,
    d. Teaching practices regarding climate change education and implementation of the G-WOW model,

e. Intentions toward implementing climate education and/or teaching the G-WOW model in the future?

2. Did teacher participants implement the service-learning component of the G-WOW curriculum? What did teachers perceive as factors influencing or inhibiting their implementation of the service-learning projects?
3. Did teacher participants perceive the G-WOW model as transferable to the student populations they teach? If so, did they implement the G-WOW model in its original form or do they modify it?

Classroom Teachers' Questionnaire Results

The classroom teachers' questionnaire indicated responses from nine of the twenty total classroom teacher participants in the 2015 G-WOW Institute. The questionnaire consisted of items designed to answer the domains of the research questions.

Demographics

Most respondents self-reported they had *11-19 years* (six respondents) of teaching experience on their end of the school year questionnaire. Other respondents reported *1-5 years* (one respondent), *6-10 years* (one respondent), or *more than 20 years* (one respondent) (see Table 1).

Table 1
Years of Teaching Experience

Years of Teaching Experience	Respondents
1-5	1
6-10	1
11-19	6
20+	1

Respondents could answer more than one group of grade levels they teach, and most respondents self-reported they taught *9-12 grade levels* (five respondents) or *6-8 grade levels* (four respondents) on their end of the school year questionnaire. Other respondents answered *3-5 grade levels* (three respondents), *K-2 grade levels* (two respondents), or *Grade 13 and above* (one respondent) (see Table 2).

Table 2
Grade Level(s) Taught

Grade Level(s) Taught	Respondents
K-2	2
3-5	3
6-8	4
9-12	5
13+	1

Note. Respondents could select more than one answer according to what grade level(s) they taught at the time of the end of the school year questionnaire.

Respondents selected each subject they teach on their end of the school year questionnaire. Most respondents self-reported they taught a *combination of subjects* (four

respondents) or *language arts* (three respondents). Other respondents answered *science* (two respondents), *social studies* (one respondents), or *specialty* (one respondent) (see Table 3).

Table 3
Subject(s) Taught

Subject(s) Taught	Respondents
Science	2
Language Arts	3
Social Studies	1
Math	0
Specialty	1
Combination	4

Note. Respondents could select more than one answer according to what subject(s) they taught at the time of the end of the school year questionnaire.

Respondents reported their school setting as *rural* (eight respondents), *suburban* (one respondent), or *urban* (0 respondents) on their end of the school year questionnaire (see Table 4).

Table 4
School Setting

School Setting	Respondents
Urban	0
Suburban	1
Rural	8

Most respondents reported teaching w*ithin several miles of a tribal school, reservation, or tribal community* (three respondents), w*ithin a reservation or tribal*

school (2 respondent), or w*ithin several hours from a tribal school, reservation, or tribal community* (two respondents) on their end of the school year questionnaire. One respondent reported teaching *within an hour from a tribal school, reservation, or tribal community* and another reported teaching *more than several hours from a tribal school, reservation, or tribal community* (one respondent) (see Table 5).

Table 5
Proximity to a Tribal School, Reservation, or Tribal Community

Proximity	Respondents
Within a reservation or tribal school	2
Within several miles of a tribal school, reservation, or tribal community	3
Within an hour from a tribal school, reservation, or tribal community	1
Within several hours from a tribal school, reservation, or tribal community	2
More than several hours from a tribal school, reservation, or tribal community	1

Perceived Level of Climate Literacy

Participants were asked to indicate their perceived level of climate literacy at the end of the school year. Results suggest teachers perceived having knowledge of key climate-related concepts, with highest perceived knowledge regarding knowing how to assess scientifically-credible climate change information and understanding the climate's influence on me and societyand my influence on the climate. See Table 6 for the results from these items.

Table 6
Results of Respondents Perceived Climate Literacy

Statement	Mean (SD)
I understand the essential principles of Earth's climate system.	4.10 (1.20)
I know how to assess scientifically credible information about climate.	4.20 (1.23)
I communicate about climate and climate change in a meaningful way.	4.00 (1.15)
I am able to make informed and responsible decisions with regard to actions that may affect climate.	4.10 (1.29)
I understand the climate's influence on me and society and my influence on the climate.	4.20 (1.23)
Mean	4.12 (1.22)

Note. Based on a 5-point scale: 1=strongly disagree, 2=somewhat disagree, 4=neither disagree nor agree, 4=somewhat agree, 5=strongly agree.

Pedagogical Skills for Teaching Climate Change Science Content Knowledge

Participants were asked to indicate their perceived level of *pedagogical skills for teaching climate change science content knowledge* prior to and after the institute, as well as at the end of the school year. They rated the extent to which they agree with each statement on a scale from 1 (low) to 5 (high). These items combined (overall mean) indicate perceived growth in pedagogical skills form before to after the institute, and further growth during the school year (M=2.48, SD=1.10; M=4.10, SD=0.72; M=4.17, SD=.88, pre-institute, post-institute, and end of school year respectively).

In addition to the combined analysis that yielded the overall mean, the sets of items were also analyzed as subdomains of pedagogical skills (see Table 7). The subdomain, pedagogical skills relating to climate change communication

showed increase across and during gate year of curriculum implementation (M=2.46, SD=1.13; M=4.04, SD=0.72; M=4.18, SD=0.80, pre-institute, post-institute, and end of school year respectively) (see Table 8). The second set of subdomains, general principles of the G-WOW Model (see Table 9), also showed an increase across the institute and during the year of curriculum implementation (M=2.38, SD=4.24; M=4.24, SD=0.74; M=4.30, SD=0.91, pre-institute, post-institute, and end of school year respectively). The third set of subdomains, based on general pedagogical skills in relation to climate change, also showed an increase across the institute and during the year of curriculum implementation (M=2.60, SD=1.02; M=4.02, SD=0.69; M=4.03, SD=0.93, pre-institute, post-institute, and end of school year respectively) (see Table 10).

Table 7
Respondents Rate Respondents Rate Their Pedagogical Knowledge and Skills to Teach Climate Change Science Content Knowledge.

Subdomain	Pre-Institute Mean (SD)	Post-Institute Mean (SD)	End of School Year Mean (SD)
Pedagogical skills relating to climate change communication	2.46 (1.13)	4.04 (0.72)	4.18 (0.80)
General principles of the G-WOW Model	2.38 (1.15)	4.24 (0.74)	4.30 (0.91)
General pedagogical skills in relation to climate change	2.60 (1.02)	4.02 (0.69)	4.03 (0.93)
Mean	2.48 (1.10)	4.10 (0.72)	4.17 (0.88)

Note. Based on a 5-point scale: 1=low 5=high.

Table 8

Pedagogical Skills Relating to Climate Change Communication: Respondents Rate Their Pedagogical Knowledge and Skills to Teach Climate Change Content Knowledge.

Pedagogical Skills Relating to Climate Change Communication	Pre-Institute Mean (SD)	Post-Institute Mean (SD)	End of School Year Mean (SD)
Frame climate change education in a way that shows present impacts and losses	2.22 (0.83)	4.11 (0.60)	4.22 (0.67)
Frame climate change education in a way that shows future impacts and losses	2.56 (1.24)	4.11 (0.60)	4.33 (0.71)
Frame climate change education in a way that shows the impact to human systems such as human health and the economy	2.56 (1.01)	4.00 (0.50)	4.22 (0.67)
Interpret scientific data and utilize it in experiential education for your students	2.33 (1.12)	3.67 (0.87)	3.78 (0.97)
Use vivid imagery to communicate climate change education	2.44 (1.13)	3.89 (1.05)	4.11 (1.17)
Use understandable language to communicate climate change education	2.56 (1.13)	4.11 (0.60)	4.22 (0.67)
Frame climate change education in a way that addresses the uncertainty of climate change	2.67 (1.22)	4.22 (0.67)	4.22 (0.67)
Utilize climate change curricula and resources to teach climate change education	2.33 (1.32)	4.22 (0.83)	4.33 (0.87)
Mean	2.46 (1.13)	4.04 (0.72)	4.18 (0.80)

Note. Based on a 5-point scale: 1=low 5=high.

Table 9

General Principles of the G-WOW Model: Respondents Rate Their Pedagogical knowledge and skills to Teach Climate Change Science Content Knowledge.

General Principles of the G-WOW Model	Pre-Institute Mean (SD)	Post-Institute Mean (SD)	End of School Year Mean (SD)
Teach my students about global climate change related science	2.89 (1.45)	4.22 (0.83)	4.22 (0.83)
Teach my students about locally relevant climate change science	2.11 (0.93)	4.33 (0.71)	4.33 (1.00)
Teach my students about climate change impacts relevant to Ojibwe lifeways and culture	2.11 (1.36)	4.33 (0.87)	4.44 (0.88)
Teach my students about climate change related topics that are relevant to my students' cultural heritage	2.11 (0.93)	4.11 (0.78)	4.44 (0.73)
Teach my students about the relevance and contribution of Traditional Ecological Knowledge to climate change education	2.22 (0.97)	4.11 (0.60)	4.11 (0.93)
Support my students in learning real-world examples of climate change	2.78 (1.20)	4.33 (0.71)	4.33 (1.00)
Involve my students in service learning and stewardship of aquatic or terrestrial habitats in ways that are harmonious with historical, cultural, natural, and economic values in The Lake Superior region	2.44 (1.24)	4.22 (0.67)	4.22 (0.97)
Mean	2.38 (1.15)	4.24 (0.74)	4.30 (0.91)

Note. Based on a 5-point scale: 1=low 5=high.

Table 10
General Pedagogical Skills in Relation to Climate Change: Respondents Rate Their Pedagogical knowledge and skills to Teach Climate Change Science Content Knowledge.

General Pedagogical Skills in Relation to Climate Change	Pre-Institute Mean (SD)	Post-Institute Mean (SD)	End of School Year Mean (SD)
Collaborate with other teachers about climate change education	2.33 (1.00)	4.00 (1.00)	3.89 (1.27)
Expand and think across disciplines in teaching climate change education	2.56 (1.01)	4.22 (0.67)	4.11 (0.78)
Utilize teaching methodology necessary to teach effective climate change education	2.89 (1.27)	4.11 (0.60)	4.11 (0.93)
Assess student learning about climate change	2.44 (0.73)	3.56 (0.53)	3.78 (0.97)
Incorporate climate change education into my classroom	2.78 (1.09)	4.22 (0.67)	4.25 (0.71)
Mean	2.60 (1.02)	4.02 (0.69)	4.03 (0.93)

Note. Based on a 5-point scale: 1=low 5=high.

Confidence Regarding Implementing the G-WOW Model

The results regarding participants' perceptions of their pedagogical skills indicated an increase in skills across their participation in the institute and implementation of the G-WOW model during the school year (M=2.48, SD=1.10; M=4.10, SD=0.72; M=4.18, SD=0.80, pre-institute, post-institute, and end of school year) (see Table 11). Similarly, results also indicated an increase in participants' confidence in teaching climate change education (M=3.33, SD=1.12; M=4.44, SD=0.73, pre-institute and post-institute respectively). Participants showed agreement their

confidence in teaching climate change education was changed by the G-WOW Institute (M=4.44, SD=0.73).

Table 11
Respondents Rate Their Confidence Based on Perceived Pedagogical knowledge and skills to Teach Climate Change Science Content Knowledge.

Subdomain	Pre-Institute Mean (SD)	Post-Institute Mean (SD)	End of School Year Mean (SD)
Pedagogical Skills Relating to Climate Change Communication	2.46 (1.13)	4.04 (0.72)	4.18 (0.80)
General Principles of the G-WOW Model	2.38 (1.15)	4.24 (0.74)	4.30 (0.91)
General Pedagogical Skills in Relation to Climate Change	2.60 (1.02)	4.02 (0.69)	4.03 (0.93)
Mean	2.48 (1.10)	4.10 (0.72)	4.17 (0.88)

Note. Mean of statements Based on a 5-point scale: 1=low 5=high.

Teaching Practices Regarding Climate Change Education and Implementation of the G-WOW Model

Classroom teacher participants self-reported their *teaching practices regarding climate change education and implementation of the G-WOW Model* by answering statements based on the key principles of the G-WOW Institute as well as statements based on general pedagogy. They indicated *yes* (2) or *no* (1) to whether they use the content or instructional practice pre-institute and/or post-institute on an end of the school year questionnaire. An overall mean increase from pre-institute to post-institute (M=1.35, SD=0.48; M=1.96, SD=0.13, pre-institute and post-institute respectively)

suggests the influence of the institute on respondents *teaching practices regarding climate change education and implementation of the G-WOW Model* (see Table 12).

Results of *teaching practices regarding climate change education and implementation of the G-WOW Model* individual statements show a strong increase in each teaching practice from pre-institute to post-institute. Responses on using *place-based evidence of climate change* increased from pre-institute to post-institute (M=1.50, SD=0.53; M=2.00, SD=0, pre-institute to post-institute respectively), showing no variance from individual responses post-institute and full agreement respondents are using *place-based evidence of climate change* after attending the institute. This suggests the institute influence on the use of *place-based evidence of climate change.* The second approach, using *project-based approaches to climate change education* increased substantially from pre-institute to post-institute (M=1.38, SD=0.52; M=2.00, SD=0, pre-institute and post-institute respectively), suggesting the institute's influence on teaching practices on *project-based approaches to climate change education.* Respondents reported increases in *collaboration with other teachers about climate change education* from pre-institute to post-institute (M=1.50, SD=0.53, M=1.89, SD=0.33, pre-institute and post-institute respectively) as well, indicating the institute influence on *collaboration with other teachers about climate change education.* The most substantial increase in pre-institute to post-institute means for *teaching practices regarding climate change education and implementation of the G-WOW Model* were seen on the statements: *impacts of climatic variables on habitats and the sustainability of key species of Ojibwe*

culture (M=1.25 SD=0.46; M=1.89, SD=0.33, pre-institute and post-institute respectively), and *impacts of climatic variables on cultural practices other than Ojibwe that are relevant to the student learner* (M=1.13, SD=0.35; M=2.00, SD=0, pre-institute and post-institute respectively). These changes suggest strong institute influence on both teaching practices including *impacts of climatic variables on cultural practices on habitats and the sustainability of key species of Ojibwe culture* and on *cultures other than Ojibwe that are relevant to the student learner*.

Table 12
Respondents Indicate Their Use of Teaching Practices Regarding Climate Change Education and Implementation of the G-WOW Model

Content or Instructional Approach	Pre-Institute Mean (SD)	Post-Institute Mean (SD)
Place-based evidence of climate change	1.50 (0.53)	2.00 (0)
Project-based approaches to climate change education	1.38 (0.52)	2.00 (0)
Collaboration with other teachers about climate change education	1.50 (0.53)	1.89 (0.33)
Impacts of climatic variables on habitats and the sustainability of key species of Ojibwe culture	1.25 (0.46)	1.89 (0.33)
Impacts of climatic variables on cultural practices other than Ojibwe that are relevant to the student learner	1.13 (0.35)	2.00 (0)
Mean	1.35 (0.48)	1.96 (0.13)

Note. Based on 2-points: 1=no, 2=yes.

Participants also self-reported their *teaching practices regarding climate change education and implementation of the G-WOW Model* on statements adapted from Herr's (2016) general pedagogical content knowledge tenets. These tenets were operationalized

for this study. These responses were taken pre-institute, post-institute, and at the end of the school year on an end of the school year questionnaire and based on a five-point scale from one (low) to five (high). There was a marked increase in the means for all of statements from pre-institute to post-institute with no significant additional increase in the overall end of the school year mean (M=2.60, SD=1.02; M=4.02, SD=0.69; M=4.03, SD=0.93, pre-institute, post-institute, and end of school year respectively).

When assessing the *teaching practices regarding climate change education and implementation of the G-WOW Model* pedagogical practices results individually, an obvious pattern emerges of significant growth from pre-institute to post-institute with little to no change from post-institute to the end of the school year. There was a strong increase in scores from pre-institute c*ollaborate with other teachers about climate change education* to post-institute (M=2.33, SD=1.00; M=4.00, SD=1.00, pre-institute and post-institute respectively), suggesting the institute influenced the practice: *collaborate with other teachers about climate change education* (see Table 13). The next practice, *expand and think across disciplines in teaching climate change education* also revealed a notable increase from pre-institute to post-institute (M=2.56, SD=1.01; M=4.22, SD=0.67, pre-institute and post-institute respectively), implying attending the institute influenced respondents capacity to *expand and think across disciplines in teaching climate change education.* Additionally, respondents' answers showed change in *utilizing teaching methodology necessary to teach effective climate change education* from pre-institute to post-institute (M=2.89, SD=1.27; M=4.11, SD=0.60, pre-institute

and post-institute respectively), demonstrating attending the institute provided perceived proficiency in *utilizing teaching methodology necessary to teach effective climate change education*. *Assessing student learning about climate change* saw the strongest increase from pre-institute to post institute (M=2.44 SD=0.73; M=3.56, SD=0.53, pre-institute and post-institute respectively), indicating a strong difference in how respondents perceived their ability to *assess student learning about climate change* after attending the institute. The final practice, *incorporating climate change education into my classroom*, increased from pre-institute to post-institute (M=2.78, SD=1.09; M=4.22, SD=0.67, pre-institute and post-institute respectively) as well.

Though there was no significant change in overall means from post-institute to the end of the school year (M=4.02, SD=0.69; M=4.03, SD=0.93, post-institute and end of the school year respectively), there was a slight decrease in ratings in two categories including: *Collaborate with other teachers about climate change education* (M=3.89, SD=1.27) and *expand and think across disciplines in teaching climate change education* (M=4.11, SD=0.78). The other practices, including u*tilize teaching methodology necessary to teach effective climate change education* (M=4.11, SD=0.93)*, assess student learning about climate change* (M=3.78, SD=0.97)*, and incorporate climate change education into my classroom* (M=4.25, SD=0.71), increased slightly.

Table 13
Respondents Indicate Their Use of Teaching Practices Regarding Climate Change Education and Implementation of the G-WOW Model

Statement	Pre-Institute Mean (SD)	Post-Institute Mean (SD)	End of School Year Mean (SD)
Collaborate with other teachers about climate change education	2.33 (1.00)	4.00 (1.00)	3.89 (1.27)
Expand and think across disciplines in teaching climate change education	2.56 (1.01)	4.22 (0.67)	4.11 (0.78)
Utilize teaching methodology necessary to teach effective climate change education	2.89 (1.27)	4.11 (0.60)	4.11 (0.93)
Assess student learning about climate change	2.44 (0.73)	3.56 (0.53)	3.78 (0.97)
Incorporate climate change education into my classroom	2.78 (1.09)	4.22 (0.67)	4.25 (0.71)
Mean	2.60 (1.02)	4.02 (0.69)	4.03 (0.93)

Note. Based on a 5-point scale: 1=low 5=high.

Open ended results from the question on whether respondents changed their *teaching practices regarding climate change education and implementation of the G-WOW Model* revealed all "yes" responses. One indicated incorporating Ojibwe culture and climate change information into their classroom. Another indicated aligning the curriculum to NGSS standards and a twelve week unit of study with field work, climate camp, and community service based assessment. One respondent committed to planting a flower garden each year at the school, where several said they now utilize relevant, local examples of climate change for their students. Other respondent noted they connect

guidance lessons to decision making. Another respondent eluded they now use a Native American perspective to climate change. Finally, one indicated they use both scientific evidence and TEK and require students to create documentaries using both to create a more "powerful message about climate impacts on traditions that are important to them [the students]."

Intentions toward Implementing Climate Education and/or Teaching the G-WOW Model in the Future

Respondents self-reported their use of G-WOW Model content and teaching approaches pre-institute, post-institute, and their plan to use them in the future on an end of the school year questionnaire (see Table 14). The overall mean for *intention toward implementing climate education and/or teaching the G-WOW Model in the future* shows a strong increase across pre-to post-institute and intention to use in the future (M=1.35, SD=0.48; M=1.96, SD=0.13; M=1.98, SD=0.07, pre-institute, post-institute, and intention to use in the future respectively), leading to the interpretation the institute successfully influenced the use of the specific climate education content and instructional approaches in the classroom. Looking at the content and approaches individually, teacher participants self-reported a strong intention to use all of main content and approaches of the G-WOW Model in the future, indicating a lasting influence of the institute on *intention toward implementing climate education and/or teaching the G-WOW Model in the future* in respondents' classrooms. This includes intending to use the following specific content and approaches: *Place-based evidence of climate change* (M=2.00,

SD=0)*, project-based approaches to climate change education* (M=2.00, SD=0)*, collaboration with other teachers about climate change education* (M=1.88, SD=0.35)*, impacts of climatic variables on habitats and the sustainability of key species of Ojibwe culture* (M=2.00, SD=0)*, and impacts of climatic variables on cultural practices other than Ojibwe that are relevant to the student learner* (M=2.00, SD=0).

Table 14
Respondents Indicate Their Intention Toward Implementing Climate Education and/or Teaching The G-WOW Model in the Future

Content or Instructional Approach	Pre-Institute Mean (SD)	Post-Institute Mean (SD)	Plan to Use in the Future Mean (SD)
Place-based evidence of climate change	1.50 (0.53)	2.00 (0)	2.00 (0)
Project-based approaches to climate change education	1.38 (0.52)	2.00 (0)	2.00 (0)
Collaboration with other teachers about climate change education	1.50 (0.53)	1.89 (0.33)	1.88 (0.35)
Impacts of climatic variables on habitats and the sustainability of key species of Ojibwe culture	1.25 (0.46)	1.89 (0.33)	2.00 (0)
Impacts of climatic variables on cultural practices other than Ojibwe that are relevant to the student learner	1.13 (0.35)	2.00 (0)	2.00 (0)
Mean	1.35 (0.48)	1.96 (0.13)	1.98 (0.07)

Note. Based on 2-points: 1=no, 2=yes.

Service-learning Component Implementation

When reviewing results from the open-ended answers to the service learning question, "Did you implement a service-learning project that included environmental

stewardship, climate change adaptation, or climate change mitigation," eight respondents indicated they implemented a service-learning project in some form. One respondent indicated "factors outside of my control inhibited the project." The responses on the actual project that was implemented varied greatly. One respondent indicated they added the curriculum to their existing American marten project, where others indicated they created butterfly or flower gardens. One indicated they used a specific component of the curriculum resource called "BudBurst" and incorporated the concepts therein locally. A couple respondents said they completed beach sweeps or Adopt a Beach programs, or their students presented information on the National Marine Sanctuary processes to high school students. Additionally, a theme from respondents was several indicating their students created climate change documentaries that reached over five hundred viewers and included arguments using both scientific data and the impacts of climate change on their own family or cultural practices. Other projects include creating posters stating "I Can…" and indicating what the students can do to help mitigate climate change.

Factors Perceived as Influencing or Inhibiting Service-learning Project Implementation

Classroom teacher participants self-reported the extent each of the factors influenced their implementation/lack of implementation of an environmental stewardship or climate change related service-learning project with their students in an end of the school year questionnaire (see Table 15). Teachers responded the factors most strongly *influencing service learning implementation*: *G-WOW Changing Climate, Changing*

Culture Institute (M=5.89, SD=0.93)*, subject taught* (M=5.67, SD=1.32), *comfort level with teaching in general* (M=5.56, SD=1.33), *grade level taught* (M=5.56, SD=1.01), *administrative support* (M=5.56, SD=1.13), and *school climate* (M=5.56, SD=1.13). The next rated highest factors contributing to *influencing service learning implementation* included: *personal environmental content knowledge* (M=5.44, SD=1.33)*, community interest/community partners* (M=5.33, SD=1.00), *access to natural area* (M=5.22, SD=1.48), *other training or professional development opportunities (Other than G-WOW)* (M=5.11, SD=1.05), and *support from students' parents* (M=5.00, SD=1.12). Additionally, means of factors such as: *emphasis on state standards* (M=4.89, SD=1.17), *transportation* (M=4.78, SD=1.99), *safety, liability, and classroom management when outside the classroom* (M=4.75, SD=1.04), *funding* (M=4.44, SD=0.78), and *emphasis on state testing* (M=4.11, SD=0.78) and *planning time* (M=4.00, SD=1.94) were all still at or above the mark for not being an obstacle for implementation, though *transportation* and *planning time* had the largest standard deviations inferring this was more of an obstacle to some respondents but still not of consequence when considering the mean.

Table 15
Respondents Indicate the Extent Each Factor Influenced Implementation of an Environmental Stewardship or Climate Change Related Service-learning Project

Factor	Mean (SD)
G-WOW Changing Climate, Changing Culture Institute	5.89 (0.93)
The subject taught	5.67 (1.32)
Comfort level with teaching in general	5.56 (1.33)
Administrative support	5.56 (1.13)
School climate	5.56 (1.13)
The grade level taught	5.56 (1.01)
Personal environmental content knowledge	5.44 (1.33)
Community interest/community partners	5.33 (1.00)
Access to natural area	5.22 (1.48)
Procedural/pedagogical knowledge of how to carry out service-learning projects	5.22 (1.30)
Other training or professional development opportunities (NOT G-WOW)	5.11 (1.05)
Support from students' parents	5.00 (1.12)
Emphasis on state standards	4.89 (1.17)
Transportation	4.78 (1.99)
Safety, liability, and classroom management when outside the classroom	4.75 (1.04)
Funding	4.44 (0.78)
Emphasis on state testing	4.11 (0.78)
Planning time	4.00 (1.94)
Mean	5.12 (1.27)

Note. Based on a 7-point scale: 1=completely prevented implementation, 2=strongly prevented implementation, 3=somewhat of an obstacle to implementation, 4=was not an obstacle to implementation, 5=somewhat assisted implementation, 6=strongly assisted implementation, 7=completely assisted implementation.

Perceptions of G-WOW Transferability to Student Populations

Classroom teacher participants self-reported their adaptations of the G-WOW Model whether using the curriculum examples relevant to Ojibwe culture (which could be their culture or their students' culture) or modifying the curriculum to cultural practices relevant to their personal culture or their students' culture. Respondents could answer each statement more than once on the end of the school year questionnaire. Five respondents indicated they use the model *in it's original form utilizing Ojibwe cultural practices*, seven respondents indicated they use the model *in a form utilizing cultural practices important to their own culture*, six respondents indicated they use the model *in a modified form utilizing species important to the culture(s) of their students*, and no respondents indicated they do not use the G-WOW model (see Table 16).

Table 16
Respondents Indicate Their Use of the G-WOW Model

Statement	Responses
In original form utilizing Ojibwe cultural practices	5
In a modified form utilizing cultural practices important to their own culture	7
In a modified form utilizing species important to the culture(s) of their students	6
I do not use the G-WOW model	0

Classroom teacher participants self-reported the transferability of the G-WOW Model to their end of school populations on an end of the school year questionnaire.

Respondents indicated the G-WOW Model is transferrable to the student populations of the respondent (M=4.67, SD=0.71).

Open ended results from the question, "Have you modified the G-WOW model to implement it into your classroom?" showed all positive responses indicated all respondents have modified G-WOW in some way when implementing it into their classroom. One response was similar to a descriptions in the service-learning project open-ended response, indicating that the G-WOW Model was added to their current Marten project. Another answer eluded the G-WOW Model enhances other lesson plans in specific content areas. One respondent specified they utilize the curriculum by showing Ojibwe seasonal activities impacted by climate change. Another responded the lessons or parts of lessons are used in addition to incorporating cultural impacts caused by climate change. Further, a respondent indicated making activities from the website and modifying maps to their local area. In addition to utilizing the model as is, one respondent created templates for their students to connect climate change to personal traditions, hobbies, or culture. Finally, a respondent indicated making connections with the G-WOW model for "connections of guidance concepts to the environment."

Interview Results

The single interview results supported the results of the questionnaire, but provided additional information on the respondent. For example, when asked, "What types of formal or informal training have you had prior to G-WOW and after G-WOW

that influences your knowledge and understanding of climate change?" the interviewee responded that they became aware of environmental issues through natural science and science classes during college. The interviewee said they had also attended the G-WOW Institute during 2014, so the 2015 G-WOW Institute was their second time attending. Additionally, the interviewee said they have an interest in pursuing a Master's Degree as a result of inspiration from the G-WOW Institute. They said attending made them more aware of cultural practices in their family and provided a "different outlook on life and schooling."

In response to "What inhibited or aided your implementation of the G-WOW climate change curriculum?" the interviewee stated the curriculum is implemented with seasonally relevant practices, such as wild ricing when school starts. Additionally, they complete a flower garden and tree plantings to work toward student awareness on what they can do to participate. They said the service project is to get students to think more about playing outside, buying local, growing their own vegetables, and recycling rather than focusing their energy on video games. At home, the interviewee says they are more responsible with their consumption as a result of the G-WOW Institute. By considering how to reduce and recycle, and figuring out ways to do things differently such as growing more of their own food. They said they now consider ways to produce more oxygen as a direct result of attending the institute, and had no experience implementing service-learning projects prior to attendance. Additionally, the pre-existing climate literacy the

interviewee had came from their Bachelor's Degree and the media. They became more aware after attending the G-WOW Institute.

In response to "What types of models of climate change education do you incorporate now and plan to incorporate into your classroom in the future? Why or why not?" the interviewee again discussed phenology studies and a garden box. They said they are also considering other school projects such as rain gardens because the garden box is likely to stay a permanent fifth grade project. The respondent says there is a lack of awareness for students about climate change and the students need to know the reality of it because some people, even the interviewee's father, claims climate change is not real. The interviewee said kids need to learn the awareness to help bridge the disconnect so their grandchildren can practice things such as wild ricing. The respondent admitted there is not enough service learning at their school, and they are trying to think of different projects to implement.

The interviewee committed the curriculum model was transferable to their students but to use it with their younger population of students, such as second grade students, they found more engaging activities to add. Finally, the respondent said the G-WOW Institute was a major influence on their knowledge, skills, and ability to support their students in completion of a service-learning project. Not only did it provide ideas, but provided the knowledge so they could look up additional ideas. The interviewee said it was unfortunate they were unable to travel to the Northern Great Lakes Visitors Center with the students this year due to lack of response from the program implementers, but

last year they had been able to bring the students for additional lessons. They said the students really enjoyed traveling and learning more about climate change in 2014.

Chapter 5

Discussion

Introduction

The collective results of this study are strongly positive. The results suggest teacher participants' perceived level of climate literacy, pedagogical skills for teaching climate change science content knowledge, and confidence regarding implementing the G-WOW mode increased after attending the G-WOW Institute. Climate literacy, pedagogical skills, and confidence are all components of bringing meaningful climate change education into classrooms, and likely these attributes contributed to teachers' implementation of a service-learning project.

Literature supports creating meaningful climate change communication through appealing to both processing systems in the brain including both the analytical, which can help absorb facts and make decisions, with experiential, which can be a "stronger motivator for action" (CRED, 2009, p. 16). Research shows that inaction can be a result of misunderstanding science concepts (Boyes et al., 1993; Lombari et al., 2010). Thus, while a grounding in foundational knowledge pertaining to climate change concepts is likely integral to personal environmental action, it is also important for teachers to have experiences providing the understanding, skills, and resources necessary to apply the knowledge to their life and community. While the voluntary nature of institute participation, the small sample, and the potential for intervening variables are limitations to this study, the results of this study suggest the importance of programs and models

such as G-WOW in supporting teachers in teaching climate change education with their students.

Demographics

Out of a sample size of twenty, nine respondents completed the online questionnaire. Most were experienced classroom teachers with *11-19 years experience* (66%), teaching in *rural* settings (89%) w*ithin or within several miles of a tribal school, reservation, or tribal community* (56%). Even though there was little variance on school setting or teaching experience, the student audience ranged from *3-5 grade levels* (33%), to *13+* (11%), with most respondents teaching *9-12 grades* (56%) or *6-8 grade levels* (44%). Most respondents teach a *combination of subjects* (44%) or *language arts* (33%), with less *science* (22%), *social studies* (11%), or *specialty* (11%) teachers. Due to a limited number of respondents and the delimitation to classroom teachers, this study is not generalizable beyond the 2015 summer classroom teacher participants. Future evaluations with larger sample sizes could allow for analyzing the results in terms of demographics to see if the treatment is equally effective across variables such as grade level, prior teaching experience, and subject areas. Further, a design with a control group would strengthen internal validity and subsequent findings. It is also unclear from this study the degree to which there was a nonresponse bias. Future evaluations might consider providing teachers with an incentive to participate in the evaluation, to increase sample size and decrease the potential for a nonresponse bias.

Perceived Level of Climate Literacy

The respondents' overall response mean of 4.12 (4=somewhat agree, 5=strongly agree) suggests classroom teachers somewhat to strongly agree they are personally

climate literate after attending the G-WOW Institute. The five statements respondents agreed to correspond with NOAA's essential climate literacy principles (NOAA, 2007). This suggests classroom teachers perceive they are climate literate after attending the G-WOW Institute. However, because this question was designed to measure how they perceive climate literacy at the time of the questionnaire, it does not discern changes in climate literacy. Questions designed to measure change follow in regard to the domains of pedagogical skills, confidence, and teaching practices. Assessing climate literacy is important because climate literacy involves making responsible, scientifically informed decisions concerning the climate (NOAA, 2007). Therefore, to assess whether these classroom teacher respondents are going to be able to make informed decisions regarding the climate and invite their students to do the same, it is necessary they are climate literate. It is important to note that this study measured perceived knowledge, which can measure differently than actual knowledge. Additionally, it is important to consider responses on this climate literacy domain in regard to measures of confidence as well, because having confidence in their personal climate literacy can be motivation to perform, or teach, climate change education.

Pedagogical Skills for Teaching Climate Change Science Content Knowledge

While having the knowledge is important, pedagogical skills for teaching climate change science content knowledge is crucial as well. Classroom teacher participants self-reported their *pedagogical skills for teaching climate change science content knowledge* by answering a series of questions adapted from recommendations for effective climate

change communication by the Center for Research on Environmental Decisions (2009), items from Ernst's (2015) evaluation report of a place-based curriculum, and tenets of general pedagogical science content knowledge as delineated by Herr (2016). With one being low and five being high, these three series indicated significant increases from pre-institute mean of 2.48 to post-institute mean of 4.10, suggesting a positive influence of the institute on *pedagogical skills for teaching climate change science content knowledge*. With another small increase from the post-institute mean of 4.10 to a mean at the end of the school year of 4.18, an inference of the influence of practicing implementing the curriculum increasing their pedagogical skills in the classroom. This final increase could be small because there was little room for more growth due to such a large increase pre-institute to post-institute.

Looking at the subdomains separately, the general principles of the G-WOW Model items were adapted from Ernst's (2015) evaluation report of a place-based curriculum but adapted to the principles and curricular goals of G-WOW, saw the largest increase from pre-institute means from 2.38 to 4.24, as well as the highest end of the school year rating. This could be due to the specificity of the items to the G-WOW Institute's content. The increase shows the respondent's perceive their pedagogical knowledge and skills to implement climate change curriculum in their classrooms increased from pre-institute to post-institute. By the end of the school year (at the time of the questionnaire), classroom teachers rated themselves even higher, at a mean of 4.30. Specifically, they rated their abilities high in factors important to implementing the G-

WOW curriculum including: local and global climate change science, climate change science relevant to Ojibwe culture and the culture of the students, utilize traditional ecological knowledge, provide real-world examples of climate change, and foster opportunities for service learning and stewardship in the Lake Superior Region.

The second subdomain, general pedagogical skills in relation to climate change, was adapted delineated by Herr's general pedagogy themes (2016) and designed to measure perceived general pedagogical skills in relation to climate change. These results followed a similar trend with a large increase from the pre-institute mean of 2.60 to the post-institute mean of 4.02 and only a slight increase at the end of the school year to 4.03. Again, respondents perceived significant increases in their pedagogical science content knowledge in reference to climate change education, specifically: collaboration with other teachers, thinking across disciplines, utilizing effective methodology, assessing student learning, and incorporating into the classroom.

The notable increases from the pre-institute mean of 2.46 to post-institute mean of 4.04 on the first subdomain, pedagogical skills relating to climate change communication. Again, an increase from the post-institute mean of 4.04 to the end of the school year mean of 4.18 could be due to time to practice the curriculum or time to do more personal research on the curriculum resources or additional resources.

Pedagogical skills for teaching climate change science content knowledge are important to create meaningful, relevant experiences for audiences. Because fifty-percent of Americans doubt human-cause climate change (Reynolds et al., 2010; Pruneau et al.,

2001; Leiserowitz et al., 2010), it is important to be able to reduce misconceptions and misunderstanding in youth. Research shows confusing curricula does not help students understand local content relevant to the audience (Shepherdson, et al, 2009), for example, climate change's present impact on human communities (Pruneau et al., 2001; Shepardson et al., 2009). Due to the changes from pre-institute means to post-institute means, the G-WOW Institute seams to be helping create connections to present impacts on communities for the participants. Research shows that connecting the classroom with real-world issues and using methods that fosters competency and critical thinking can lead to active citizens (Jickling, 2005), which we can infer the participants are obtaining the pedagogical skills to act toward completing service learning projects. Educators equipped with *pedagogical skills for teaching climate change science content knowledge* can help foster pro-environmental attitudes in their students which ideally lead to changes in environmental behavior for both the classroom teachers and their students. Because of the significant increase from pre-institute to post-institute means, the G-WOW Institute could be regarded as having a positive impact on respondents *pedagogical skills for teaching climate change science content knowledge.* The interview also supported the questionnaire results in this domain. Because educators rated themselves highly in their pedagogical skills to interpret climate science and communicate locally relevant climate education in a meaningful way, it would be beneficial to do additional research to determine if the students are receiving the intended understanding leading to environmentally responsible behaviors.

Confidence Regarding Implementing the G-WOW Model

According to the theory of self-efficacy (confidence), educators need to feel confident in their ability to teach the content to be motivated (Bandura, 1977). In essence, if they are comfortable with the content (Deci et al., 1991), or they perceive they are competent, their confidence can increase (Guy et al., 2014). In addition to understanding the content, locally-based or place-based-education has been shown to boost educators' confidence as well (Meichtry & Smith, 2007). Results from this self-report questionnaire correspond with research stating new methods and techniques learned from professional development institutes can help increase self-efficacy and comfort (Lakshmanan et al., 2011; Wilson, 2013).

This study specifically focused on measuring changes in *pedagogical skills for teaching climate change science content knowledge* and *confidence* from pre to post-institute. Respondents' *pedagogical skills for teaching climate change science content knowledge* (1=low, 5=high) means increased from 2.48 pre-institute to 4.10 post-institute, indicating respondents were much more confident in their pedagogical skills post-institute than pre-institute. The additional increase from 4.10 post-institute to 4.17 at the end of the school year can be speculated as respondents gaining further confidence from practicing their pedagogical skills and/or gaining additional content knowledge and experience after implementing the curriculum.

Additionally, respondents agreed their confidence changed *from* attending the institute. When asked whether respondents had changes in *confidence about teaching*

climate change education, they responded with a pre-institute mean of 3.33 to 4.44 (3=neither agree nor disagree, 4=agree, 5=strongly agree) after attending the institute. When asked whether it was *the institute that changed confidence about teaching climate change education,* a mean of 4.44 showed respondents agree to strongly agree. Respondents believe attending the institute increased their confidence, and the interview answers corroborated with the results of the questionnaire. Even though the interviewee had been exposed to some climate literacy concepts and content prior to attendance, attending the institute gave her a "different outlook on life and schooling," and the knowledge and resources to continue researching for more ideas for service-learning projects and practicing more environmental responsibility at home and with the students at school.

As Lakshmanan et al. (2011), suggests, longer term studies to determine student outcomes as a result of increased educator self-efficacy are necessary to determine the full impact of educator self-efficacy on students. Further study could be done to determine the impact of educator self-efficacy for students. Because classroom teacher participants reported more confidence in their abilities due to attending the G-WOW Institute, this place-based, experiential institute supports other findings, such as Rivera, Manning, & Krupp (2013), where place-based professional development increased confidence scores from pre-institute to post-institute. Additionally, looking at increases in confidence in conjunction with the participants' intentions to implement climate

change education in the future, the G-WOW Institute provided a transformative learning experience for the educators.

Teaching Practices Regarding Climate Change Education and Implementation of the G-WOW Model

The focus of this research domain was on changes of *teaching practices regarding climate change education and implementation of the G-WOW Model* but did not focus on measuring changes in educators' or students' mental models. Educators chose to attend the Changing Climate, Changing Culture (G-WOW) Institute, and could possibly be predisposed to climate literacy and be motivated to incorporate climate change education into their classrooms. *Teaching practices regarding climate change education and implementation of the G-WOW Model* were measured through content and instructional approaches as well as pedagogical skills relevant to climate change education. These two measures were used to discern classroom teachers' potential to reshape or form climate literate mental models for students through their content knowledge and instructional approaches for effective climate change communication. If educators are creating transformative learning experiences, they may be able to reshape or develop students' mental models and foster beliefs which invite action (Bangay & Blum, 2010). Even though measuring changes for students could be a possibility for future research, it is important to know if educators are using pedagogical skills to create transformative experiences—especially through personal relevance (CRED, 2009; Fielding et al., 2014;

Shepardson, 2009), which are proven more effective than flooding students with analytical data (Reynolds et al., 2010).

Results from the end of the school year questionnaire showed respondents experienced significant changes in their *teaching practices regarding climate change education and implementation of the G-WOW Model* in addition to changes to their pedagogical skills and confidence after attending the G-WOW Institute. A mean increase from pre-institute of 1.35 to post-institute 1.96 (*no*=1, *yes*=2) indicated after attending the G-WOW Institute, respondents answered "yes" to changing their content and instructional approaches to those regarded as more conducive to effective environmental and climate change education. *Pedagogical skills for teaching climate change science content knowledge* also showed a notable increase showing respondents' self-rating was much stronger on the post-institute mean of 4.02 (1=low, 5=high) to the pre-institute mean of 2.60. There was little additional increase in the overall end of the school year mean 4.03, possibly due to having such a strong increase from pre-institute to post-institute, leaving little room for additional growth by the end of the school year. The interview respondent said they experienced significant changes in their confidence to implement climate change education, supporting the questionnaire results.

In the open-ended portion of the questionnaire, respondents reported changes such as incorporating Ojibwe culture and climate change information, aligning climate change curriculum with science standards and developing a twelve week unit of study, planting a flower garden, utilizing locally relevant impacts, connecting guidance lessons

to decision making, public presentations of students' cultural practices or family traditions being impacted by climate change, adopting a beach and learning about National Marine Sanctuaries. This shows projects with great depth were completed, as well as projects creatively incorporating current community events and issues.

Some institute participants were able to bring their students to the Apostle Islands National Lakeshore or the Northern Great Lakes Visitors Center during the school year which could also have further influenced the teachers' and students' experiences, which the interviewee said they were able to do in 2014 but not 2015. The influence of participants and student groups having supplementary communication or additional experiences with G-WOW partners cannot be determined from the domains of this study.

Intentions toward Implementing Climate Education and/or Teaching the G-WOW Model in the Future

Respondents showed a strong change in *intention toward implementing climate education and/or teaching the G-WOW Model* from pre-institute mean of 1.35 to a post-institute mean of 1.96 (1=*no*, 2=*yes*). *Intention toward implementing climate education and/or teaching the G-WOW Model in the future* had a similar mean of 1.98 when compared to post-institute implementation responses (1.96). This small change could be due to a ceiling effect from the significant change from pre-institute to post-institute.

Respondents reported changes in implementing climate change education and/or the G-WOW model and plans to continue to implement climate change education in the future corroborates with research suggesting increasing confidence and content

knowledge can lead to motivation or action. According to Hines, Hungerford, & Tomera's (1986) Model of Environmentally Responsible Behavior, knowledge and skills could be an influence on intention to act or incorporate environmentally responsible curricula into classrooms. This increase of content knowledge, confidence, and skills leading to incorporation of climate change education into the classroom corresponds with the interview results. The interviewee said their students lack awareness of climate change and as an instructor they needed the knowledge, ideas, and resources to be able to bring climate change curriculum into their classroom. Additionally, they have plans to continue implementing projects and the curriculum in future years showing an intention to act in an environmentally positive way.

Future studies could elaborate on these findings and research whether respondents follow-through on their plan to continue to incorporate climate change education into their classrooms. Further, it could be beneficial to complete further study to discern if classroom teachers retain the knowledge and incorporate the curriculum into their classroom future years.

Service-learning Component Implementation

According to NAAEE (2011), environmentally literate people will be able to utilize their skills and knowledge and make environmentally sound decisions. In this study, results showed respondents' agreement of personal climate literacy and implementation of service-learning projects. All respondents said they planned service-

learning projects but only one respondent claimed they were unable to implement it by the end of the school year "due to circumstances beyond my [their] control."

Open-ended answers to the service learning question, "Did you implement a service-learning project that included environmental stewardship, climate change adaptation, or climate change mitigation?" varied. One response indicated they added the curriculum to their American marten project, where others indicated they created butterfly gardens or flower gardens. Some said they completed beach sweeps or Adopt a Beach programs and learning about National Marine Sanctuary processes and presenting what the learned to high school students. Finally, a group of respondents indicated their students create climate change documentaries including arguments using both scientific data and whether or not their own family or cultural practices will be impacted by climate change. These documentaries were presented at a public event with over five hundred people in attendance. Other projects include creating posters stating "I Can…" and what the students can do to help mitigate climate change.

The open-ended responses of the service-learning projects revealed respondents completed diverse service-learning projects, and some projects were more focused on community outreach than others. Respondents answers showed some projects extended beyond the typical environmental education projects limited to commonly accepted school gardens, composting (Robertson & Kruegly-Smolska, 1997), and recycling programs (Robertson & Kruegly-Smolska, 1997; McCrea & deBettencourt, 2000). Seeing projects such as the documentaries and critical thinking projects such as "I Can"

posters invites students to think beyond the classroom and foster environmentally responsible behaviors beyond participation in service learning at school. Place-based education has been regarded as having the ability to connect teaching to relevant, real-world examples (Meichtry & Smith, 2007), and in reviewing the open-ended responses the completed projects showed connections to relevant school and community projects. Additionally, responses indicated they were using two goals of the G-WOW curriculum to varying degrees, including linking local, place-based evidence with scientific climate research and promoting action through individual and community-level response. The interviewee said projects will be committed in perpetuity with specific grade levels, such as the fifth graders will be in charge of maintaining the rain garden each year. Also, the interviewee stated they are working on creating a school culture of service learning through implementing more school-wide projects next year and in the future. The interviewee said through the projects they are trying to meet the needs of the community by creating understanding of the impacts of climate change and what can be done to help.

Factors Perceived as Influencing or Inhibiting Service-learning Project Implementation

Barriers to incorporate environmental education can fall into different categories, including logistical, attitudinal, conceptual, and educational (Ham & Sewing, 1987). Respondents *factors perceived as influencing or inhibiting service-learning project implementation* were measured on a 7-point scale: 1=completely prevented implementation, 2=strongly prevented implementation, 3=somewhat of an obstacle to

implementation, 4=was not an obstacle to implementation, 5=somewhat assisted implementation, 6=strongly assisted implementation, 7=completely assisted implementation. The overall mean was 5.12, indicating most of the factors were perceived as assisting service-learning project implementation rather than inhibiting it. It is noteworthy the response of the *G-WOW Changing Climate, Changing Culture Institute* factor mean was 5.89, indicating it strongly assisted implementation of service-learning projects. Though all the category means were at or above four, indicating they were not an obstacle to implementation, two factors including *planning time* (4.00) and *emphasis on state testing* (4.11) had the lowest means. Factors measured with their means included: *G-WOW Changing Climate, Changing Culture Institute* (5.89), *subject taught* (5.67), *comfort level with teaching in general* (5.56), *grade level taught* (5.56), *administrative support* (5.56), *school climate* (5.56), *personal environmental content knowledge* (5.44)*, community interest/community partners* (5.33), *access to natural area* (5.22,), *other training or professional development opportunities (Other than G-WOW)* (5.11), *support from students' parents* (5.00), *emphasis on state standards* (4.89), *transportation* (4.78), *safety, liability, and classroom management when outside the classroom* (4.75), *funding* (4.44), *emphasis on state testing* (4.11), and *planning time* (4.00).

Though confounding variables such as additional training sought were not specifically identified in the study, looking to the response from *other training or*

professional development opportunities (Other than G-WOW) (5.11), we can see there is some influence of other sources than G-WOW that somewhat assisted implementation.

Overall, the results from this questions indicates the respondents did not experience barriers significant to inhibit implementation of service-learning projects. In fact, as the interview corroborated as well, these factors were perceived mostly conducive to completion of climate-related service-learning projects. The interviewee did commit there is a general lack of service learning in their school and they are working to create a culture of service learning.

Even though participants did not receive funding to complete service-learning projects, service-learning projects were completed. The participants chose to attend the institute and could therefore be predisposed or motivated toward completing service learning projects. Further, most of the respondents have taught for eleven or more years, which could make them more proficient in implementing service-learning projects without additional funding. The G-WOW Institute is, overall, attracting experienced classroom teachers—potentially motivated in completion of service-learning projects or stewardship projects. If, in future institutes, the audience demographics change to less motivated or less experienced educators, funding may be necessary to incentivize completion of service-learning projects.

Perceptions of G-WOW Transferability to Student Populations

One of the main goals of the G-WOW curriculum is that it is attempting to provide culturally relevant climate change perspectives that are transferrable across

different cultures. When respondents were asked to indicate their use of the G-WOW model in relation to Ojibwe culture, their personal culture, and their students' culture, all respondents indicated they use the G-WOW model in some form regardless of their proximity to a reservation, tribal school, or tribal community. Seven of nine (78%) of respondents indicated they use the curriculum in a modified form utilizing cultural practices important to their own culture, six of nine (67%) indicated they use the curriculum a modified form utilizing species important to the culture(s) of their students, and five of nine (56%) indicated they use the curriculum in the original form utilizing Ojibwe cultural practices. Though we do not know from the questionnaires the specific culture of the respondents or the students, the responses suggest the transferability across cultures as only two of nine respondents (22%) teach within or within a tribal school, reservation, or tribal community. Open ended responses indicated all respondents have modified G-WOW in some way when implementing it into their classroom, which could be interpreted as respondents seeing the model as transferable or modifiable. Several responses specifically indicated making activities more locally relevant and modifying climate maps to their local area, and another respondent created templates for their students to connect climate change to their personal traditions, hobbies, or culture.

In the result of the interview, the interviewee indicated an ability to utilize the curriculum "as is," but stated they were able to find additional resources and ideas for transferability to a wider age group of students.

The questionnaire and interview responses show G-WOW implementers are meeting their goal of creating a transferable curriculum. The G-WOW model, while providing traditional ecological knowledge of the impact of climate change on key species important to Ojibwe lifeways, is reaching participants across cultures and perceived as transferable to participants teaching to both Ojibwe and non-Ojibwe students.

Recommendations

After reviewing the results of this study, there are several recommendations for G-WOW implementers to consider for future programming and future research. First, consider the implications of the results of this study. The positive results are indications the content, methods, and experiences of the 2015 G-WOW Institute were effective. If changes are made to future professional development institutes due to new collaborations, changes in funders, or other circumstances, consider measuring results of the new institute and comparing them to the results of this study to understand any differences. Replications of this study for future years' participants could measure the effects of modifying the curriculum for different communities and populations as the project expands. Further explore which specific approaches of the professional development experience assists curriculum implementation. Discern the elements which made the curriculum transferable and maintain them to continue to implement an effective curriculum transferable across cultures.

Additionally, consider comparing actual climate literacy pre-posttests with this study's perceived climate literacy results. These results will have the potential show the accuracy of respondents' perceptions and strengthen findings. Furthermore, reviewing self-report results of service learning completion to the online G-WOW Talking Circle Blog could reveal if completed projects are being posted and shared. If projects are not being shared, determine why and consider reaching out to educators to encourage sharing projects to supplement the available resources for other teachers' to obtain project ideas.

Continue improving available resources for participants and repeat teachers to increase their pedagogical content knowledge and confidence in new content while following the recommendations of effective climate change communication. The factors regarded with the lowest ratings to assisting service learning completion were planning time and funding. Consider incorporating additional methods to help teachers plan and fund projects, such as obtaining project stipends, implementing mentorship support, and creating access to additional resources for project support such as online train the trainer videos. Consider continuing demographics records on the experience level of the participants to determine the efficacy of the curriculum on less experienced educators.

Finally, consider measuring the influence of the curriculum on the participants' students. As the students are potentially receiving the benefits of the changes in teacher confidence, teaching practices, and pedagogical content knowledge, they are also experiencing service learning experience and potentially creating connections to the issue and the environment. It is important to measure whether participating in classroom

projects based on the G-WOW curriculum transfers to impact students' attitudes, knowledge, and behaviors both in the classroom and in their communities.

Conclusion

Results from this exploratory study provide evidence the Summer 2015 G-WOW Professional Development Institute increased respondents': perceived level of climate literacy, confidence regarding implementing the G-WOW model, and pedagogical skills for teaching climate change science content knowledge. Further, the G-WOW Institute influenced teaching practices regarding climate change education and implementation of the G-WOW model and intentions toward implementing climate education and/or teaching the G-WOW model in the future. Additionally, questionnaire respondents competed climate relevant service-learning projects. Finally, participants perceive the G-WOW Model as transferrable across cultures to the student populations they teach.

While it would be beneficial to the field of environmental education to complete more research on the long-term impact of the G-WOW Institute as well as the impact of the curriculum on the classroom participants' students, the results of this study indicate the G-WOW Institute is regarded as having a positive influence on the respondents to incorporate relevant climate change education and service-learning projects with their student audiences. Considering the experiential and place-based teaching methods of the G-WOW Institute is important in considering methods for forming and implementing successful climate change education. Results from this study indicate the G-WOW

Institute successfully created professional development combining multiple ways of knowing to create personal relevancy for the audience. These ways of knowing include analytical science on a local and global scale as well as traditional ecological knowledge of species important to cultural lifeways (Ojibwe).

The G-WOW Institute combined experts' analytical science and communities' traditional ecological knowledge to inspire transformative experiences significant enough to obtain these positive, collective results. Participants perceived the G-WOW model as transferable across cultures, meaning participants cultivated connections to the content despite their cultural identity. These connections helped participants understand their influence on the climate and climate's influence on them, and helped motivate experiential learning for their students through service-learning projects. It is important when developing curricula and professional development to look at the success of G-WOW extending beyond conventional environmental educational approaches of simply increasing awareness. G-WOW inspired service-learning project completion, which literature suggests encourages students to engage in their communities, think critically, and act responsibly. For the sustainability of this and future generations, it is imperative youth understand their actions make a difference and apply their knowledge toward community-based action.

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Appendix A

IRB Approval

Patricia Carpenter <carpe494@d.umn.edu>

1603E85702 - PI Carpenter - IRB - Exempt Study Notification

irb@umn.edu <irb@umn.edu> Fri, Apr 8, 2016 at 11:00 AM
To: carpe494@umn.edu

TO : jernst@umn.edu, carpe494@umn.edu,

The IRB: Human Subjects Committee determined that the referenced study is exempt from review under federal guidelines 45 CFR Part 46.101(b) category #2 SURVEYS/INTERVIEWS; STANDARDIZED EDUCATIONAL TESTS; OBSERVATION OF PUBLIC BEHAVIOR.

Study Number: 1603E85702

Principal Investigator: Patricia Carpenter

Title(s):
G-WOW Changing Climate, Changing Culuture: Professional Development's Influence on Teachers

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This e-mail confirmation is your official University of Minnesota HRPP notification of exemption from full committee review. You will not receive a hard copy or letter.

This secure electronic notification between password protected authentications has been deemed by the University of Minnesota to constitute a legal signature.

The study number above is assigned to your research. That number and the title of your study must be used in all communication with the IRB office.

Research that involves observation can be approved under this category without obtaining consent.

SURVEY OR INTERVIEW RESEARCH APPROVED AS EXEMPT UNDER THIS CATEGORY IS LIMITED TO ADULT SUBJECTS.

This exemption is valid for five years from the date of this correspondence and will be filed inactive at that time. You will receive a notification prior to inactivation. If this research will extend beyond five years, you must submit a new application to the IRB before the study's expiration date. Please inform the IRB when you intend to close this study.

Upon receipt of this email, you may begin your research. If you have questions, please call the IRB office at (612) 626-5654.

You may go to the View Completed section of eResearch Central at http://eresearch.umn.edu/ to view further details on your study.

The IRB wishes you success with this research.

We value your feedback. We have created a short survey that will only take a couple of minutes to complete. The questions are basic, but your responses will provide us with insight regarding what we do well and areas that may need improvement. Thanks in advance for completing the survey. http://tinyurl.com/exempt-survey

Appendix B

Q1.1 Please rate the extent you agree or disagree to how each statement applies to you personally, in other words, your own personal knowledge.

	Strongly disagree (1)	Somewhat disagree (2)	Neither agree nor disagree (3)	Somewhat agree (4)	Strongly agree (5)
I understand the essential principles of Earth's climate system. (1)	❍	❍	❍	❍	❍
I know how to assess scientifically credible information about climate. (2)	❍	❍	❍	❍	❍
I communicate about climate and climate change in a meaningful way. (3)	❍	❍	❍	❍	❍
I am able to make informed and responsible decisions with regard to actions that may affect climate. (4)	❍	❍	❍	❍	❍
I understand the climate's influence on me and society and my influence on the climate. (5)	❍	❍	❍	❍	❍

Q2.1 Please rate your knowledge, skills, and ability PRIOR to the institute, AFTER the institute, and RIGHT NOW for each of the following items...

	PRIOR to the Institute					RIGHT NOW					AFTER the Institute				
	Low 1 (1)	3 (2)	4 (3)	5 (4)	High 5 (5)	Low 1 (1)	2 (2)	3 (3)	4 (4)	High 5 (5)	Low 1 (1)	2 (2)	3 (3)	4 (4)	High 5 (5)
Frame climate change education in a way that shows PRESENT impacts and losses (1)	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍
Frame climate change education in a way that shows FUTURE impacts and losses (2)	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍
Frame climate change education in a way that shows the impact to human systems such as human health and the economy (3)	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍
Interpret scientific data and utilize it in experiential education for your students (4)	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍
Use vivid imagery to communicate climate change education (5)	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍
Use understandable language to	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍

communicate climate change education (6)															
Frame climate change education in a way that addresses the uncertainty of climate change (7)	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍
Utilize climate change curricula and resources to teach climate change education (8)	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍

Q2.2 Please rate your knowledge, skills, and ability PRIOR to the institute, AFTER the institute, and RIGHT NOW for each of the following items...

	PRIOR to the Institute					RIGHT NOW					AFTER the Institute				
	Low 1 (1)	3 (2)	4 (3)	5 (4)	High 5 (5)	Low 1 (1)	2 (2)	3 (3)	4 (4)	High 5 (5)	Low 1 (1)	2 (2)	3 (3)	4 (4)	High 5 (5)
Teach my students about GLOBAL climate change related science (1)	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍
Teach my students about LOCALLY relevant climate change science (2)	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍
Teach my students about climate change impacts relevant to Ojibwe life ways and culture (3)	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍
Teach my students about climate change related topics that are relevant to my students' cultural heritage (4)	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍
Teach my students about the relevance	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍

and contribution of Traditional Ecological Knowledge to climate change education (5)															
Support my students in learning real-world examples of climate change (6)	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍
Involve my students in service learning and stewardship of aquatic or terrestrial habitats in ways that are harmonious with historical, cultural, natural, and economic values in The Lake Superior region (7)	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍

Q2.3 Please rate your knowledge, skills, and ability PRIOR to the institute, AFTER the institute, and RIGHT NOW for each of the following items...

	PRIOR to the Institute					RIGHT NOW					AFTER the Institute				
	Low 1 (1)	3 (2)	4 (3)	5 (4)	High 5 (5)	Low 1 (1)	2 (2)	3 (3)	4 (4)	High 5 (5)	Low 1 (1)	2 (2)	3 (3)	4 (4)	High 5 (5)
Collaborate with other teachers about climate change education (1)	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍
Expand and think across disciplines in teaching climate change education (2)	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍
Utilize teaching methodology necessary to teach effective climate change education (3)	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍
Assess student learning about climate change (4)	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍
Incorporate climate change education into my classroom (5)	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍

Q3.1 Please indicate if and when you used or plan to use the following content and instructional approaches in your classroom.

	This year (AFTER participating in the institute)		Plan to use next year/In the FUTURE		PRIOR to the Institute	
	No (1)	Yes (2)	No (1)	Yes (2)	No (1)	Yes (2)
Place-based evidence of climate change (1)	❍	❍	❍	❍	❍	❍
Project-based approaches to climate change education (2)	❍	❍	❍	❍	❍	❍
Collaboration with other teachers about climate change education (3)	❍	❍	❍	❍	❍	❍
Impacts of climatic variables on habitats and the sustainability of key species of Ojibwe culture (4)	❍	❍	❍	❍	❍	❍
Impacts of climatic variables on cultural practices OTHER THAN Ojibwe that are relevant to the student learner (5)	❍	❍	❍	❍	❍	❍

Q3.2 Did you make changes to your instructional practices or curriculum based on your participation in the institute?

If so, please describe what changes? (1)

If not, please describe why not. (2)

Q4.1 The following statements pertain to this form of teaching: Providing climate change learning experiences for your students that are culturally relevant, interdisciplinary, and involve the use of real world projects. Now please read the descriptors in the first column. Please choose which descriptor best describes how you were prior to the institute, and select that descriptor in the second column. Now think about these descriptors regarding how you are right now. Please select the descriptor that best describes how you are right now and indicate that in the third column.

	PRIOR to the institute (1)	This year (AFTER participating in the institute) (2)
Little or no knowledge of this form of teaching. (1)	❍	❍
In the process of learning about this form of teaching (what it is and what it required, how to do it, etc.) (2)	❍	❍
Using this form of teaching, but it was taking me a lot of time and effort; or I used this form of teaching and was still trying to get a handle on it (3)	❍	❍
Using this form of teaching routinely; I didn't need to put as much effort into figuring out how to make this work (4)	❍	❍
Using this form of teaching and felt it was effective; I adapted it in ways that made my students learn even better (5)	❍	❍
Using this form of teaching and trying to collaborate or coordinate with others to do so (6)	❍	❍
Using this form of teaching and re-evaluating the quality of this form of teaching, or looking at ways to expand upon this form to teaching, or using it in a way to renew my interest in teaching or to set new goals for myself (7)	❍	❍

Q4.2 Did you implement a service-learning project with your students that involved environmental stewardship, climate change adaptation, or climate change mitigation?

If so, please describe your project. (1)

If not, please describe why not. (2)

Q4.3 Please indicate how each of these factors influenced the implementation/lack of implementation of an environmental stewardship or climate change related service learning project with your students.

	Completely Prevented Implementation (1)	Strong Obstacle to Implementation (2)	Somewhat of an Obstacle to Implementation (3)	Was not an Obstacle to Implementation (4)
G-WOW Changing Climate, Changing Culture Institute (1)	❍	❍	❍	❍
Other training or professional development opportunities (NOT G-WOW) (2)	❍	❍	❍	❍
My personal environmental content knowledge (3)	❍	❍	❍	❍
Procedural/pedagogical knowledge of how to carry out service learning projects (4)	❍	❍	❍	❍
Comfort level with teaching in general (5)	❍	❍	❍	❍
The grade level I teach (6)	❍	❍	❍	❍
The subject I teach (7)	❍	❍	❍	❍
Emphasis on state standards (8)	❍	❍	❍	❍
Emphasis on state testing (9)	❍	❍	❍	❍
Funding (10)	❍	❍	❍	❍
Administrative support (11)	❍	❍	❍	❍
Planning time (12)	❍	❍	❍	❍
Transportation (13)	❍	❍	❍	❍
Access to natural area (14)	❍	❍	❍	❍
Community interest/community partners (15)	❍	❍	❍	❍
Support from students' parents (16)	❍	❍	❍	❍
School climate (17)	❍	❍	❍	❍
Safety, liability, and classroom management	❍	❍	❍	❍

when outside the classroom (18)				

	Somewhat Assisted Implementation (5)	Strongly Assisted Implementation (6)	Completely Assisted Implementation (7)
G-WOW Changing Climate, Changing Culture Institute (1)	❍	❍	❍
Other training or professional development opportunities (NOT G-WOW) (2)	❍	❍	❍
My personal environmental content knowledge (3)	❍	❍	❍
Procedural/pedagogical knowledge of how to carry out service learning projects (4)	❍	❍	❍
Comfort level with teaching in general (5)	❍	❍	❍
The grade level I teach (6)	❍	❍	❍
The subject I teach (7)	❍	❍	❍
Emphasis on state standards (8)	❍	❍	❍
Emphasis on state testing (9)	❍	❍	❍
Funding (10)	❍	❍	❍
Administrative support (11)	❍	❍	❍
Planning time (12)	❍	❍	❍
Transportation (13)	❍	❍	❍
Access to natural area (14)	❍	❍	❍
Community interest/community partners (15)	❍	❍	❍
Support from students' parents (16)	❍	❍	❍
School climate (17)	❍	❍	❍
Safety, liability, and classroom management when outside the	❍	❍	❍

classroom (18)			

Q5.1 Have you modified the G-WOW model to implement it into your classroom?
If Yes, Please describe how you have modified the model. (1)
If No, Please describe how you used the model as is. (2)

Q5.2 Please rate the extent to which you agree with the statement.

	Strongly Disagree (1)	Disagree (2)	Neither Disagree nor Agree (3)	Agree (4)	Strongly Agree (5)
The G-WOW model is transferable to the student populations I teach (1)	❍	❍	❍	❍	❍

Q5.3 Please rate the extent to which you agree or disagree with the statement.

	Strongly Disagree (1)	Disagree (2)	Neither Agree nor Disagree (3)	Agree (4)	Strongly Agree (5)
I was confident about teaching climate change education PRIOR to attending the summer institute (1)	❍	❍	❍	❍	❍
I am confident about teaching climate change education RIGHT NOW (2)	❍	❍	❍	❍	❍
The institute has changed my confidence about teaching climate change education (3)	❍	❍	❍	❍	❍

Q5.4 Please check ALL of the items that apply.

	In original form utilizing Ojibwe cultural practices (1)	In a modified form utilizing cultural practices important to my culture (2)	In a modified form utilizing species important to the culture(s) of my students (3)	I do not use the G-WOW model (4)
I use the G-WOW model in this form or these forms: (1)	❑	❑	❑	❑

Q6.1 What grade level(s) do you teach? Please check all that apply.

- ❑ K-2 (1)
- ❑ 3-5 (2)
- ❑ 6-8 (3)
- ❑ 9-12 (4)
- ❑ 13+ (5)

Q6.2 Number of years of teaching experience?

- ❍ 1-5 years (1)
- ❍ 6-10 years (2)
- ❍ 11-19 years (3)
- ❍ 20+ years (4)

Q6.3 What is your school setting?

- ❍ Urban (1)
- ❍ Suburban (2)
- ❍ Rural (3)

Q6.4 What subject(s) do you teach? Please check all that apply.

- ❑ Science (1)
- ❑ Language Arts (2)
- ❑ Social Studies (3)
- ❑ Math (4)
- ❑ Specialty (5)
- ❑ Combination (6)

Q6.5 Which of the following best describes you? I teach...

- ❍ Within a reservation or tribal school (1)
- ❍ Within several miles of a tribal school, reservation, or tribal community (2)
- ❍ Within an hour from a tribal school, reservation, or tribal community (3)
- ❍ Within several hours from a tribal school, reservation, or tribal community (4)
- ❍ More than several hours from a tribal school, reservation, or tribal community (5)

Appendix C

Interview Guiding Questions

2. What types of formal or informal training have you had prior to G-WOW and after G-WOW that influences your knowledge and understanding of climate change?
3. What inhibited or aided your implementation of the G-WOW climate change curriculum?
4. What types of models of climate change education do you incorporate now and plan to incorporate into your classroom in the future? Why or why not?
5. Was the curriculum model transferable to your students or what types of modifications did you make to make it relevant to your students?
6. What influence did the institute have on your knowledge, skills, and ability to support your students in completion of a service-learning project?