PERCEPTIONS OF COLLABORATION: A COMPARISON OF EDUCATORS AND SCIENTISTS FOR COSEE GREAT LAKES

DISSERTATION

Presented in Partial Fulfillment of the Requirements for
the Degree Doctor of Philosophy in the Graduate
School of The Ohio State University

By
Chankook Kim, M.C.P., M.A.S.

*****

The Ohio State University
2007

Dissertation Committee:

Professor Rosanne W. Fortner, Adviser

Professor Craig B. Davis

Professor Thomas Koontz

Professor Joseph A. Gliem

Approved by:

____

Adviser

Natural Resources Graduate Program

ABSTRACT

The Great Lakes region of North America, holding 20% of the world's fresh water and home to ¼ of the U.S. population, can provide its 13 million K-12 learners with a relevant context for science learning, unique opportunities for exploring local environmental issues, and connections to global issues. By linking Great Lakes research scientists with educators, students, and the public, the COSEE (Centers for Ocean Sciences Education Excellence) Great Lakes pursues its goal of enhancing science and environmental literacy of both adults and students.

This doctoral research had a three-fold purpose in the COSEE Great Lakes context. First, this study aimed to characterize the population of Great Lakes scientists and K-12 teachers in the Great Lakes region targeted as potential audiences for activities of COSEE Great Lakes. Second, this study aimed to identify factors that may affect educational collaboration between teachers and scientists. Third, this study was conducted as a part of an ongoing process of evaluating overall COSEE program outcomes related to increasing educational collaborations.

This dissertation consists of three research reports on professional development and interprofessional collaboration of K-12 teachers and scientists. The first report in Chapter 2 investigates primary and secondary teachers' views of collaboration with scientists and incorporates the findings of teacher surveys into discussions about professional development programs for educators. From 180 schools randomly selected in the eight Great Lakes States, 194 primary and secondary educators responded to a mailed survey**.** Through the survey responses, the educators reported that while they have positive attitudes toward their collaboration with scientists, their professional preparation has not equipped them with enough understanding of the process of science and the professions of scientists. Regression analysis shows that five predictor variables account for a majority of the variance in explaining educators' experience in collaboration with scientists (a combined predictive ability of 32%): attitudes towards collaboration, professional preparation (science competencies), teaching experience in years, contemporary views of science/science education and perceived institutional supports.

The second report in Chapter 3 is an attempt to reveal interactions in education by scientists whose research is focused on the Great Lakes, and incorporates the findings into discussions about scientists' potential for the role of education partner. In this parallel study, marine and aquatic scientists were recruited to complete a survey at a conference on Great Lakes research in 2006. Through 94 scientist responses, scientists reported that they were involved in educational outreach more frequently as a "resource" than a "partner" in Morrow's framework (2000). Professional training of scientists and their lack of knowledge in education may explain the ways in which scientists are involved in educational outreach. The results show that most scientists had little chance to obtain knowledge in professional *education* during their professional *science* training.

Scientists’ lack of knowledge in education was demonstrated by their unfamiliarity with key terms/concepts in education. Regression analyses shows that four predictor variables account for a majority of the variance in explaining scientists’ experience in collaboration with teachers (a combined predictive ability of 42%): familiarity with terms in education, professional training (educational competencies and collaborative cultures) and age.

The third report in Chapter 4 elaborates on the results and discussions in Chapters 2 and 3 by comparing the two groups and by identifying implications of the findings for teacher-scientist collaboration. Comparing responses from educators (n=194) and scientists (n=94), this study answers how educators differ in the perceptions of education collaboration from scientists, in addition to two other research questions: how do educators in the Great Lakes region collaborate with scientists, and what barriers may deter their participation in collaboration. Regression analyses for the two groups suggest that to foster mutual learning in teacher-scientist collaboration, further consideration must be given to increasing educators’ science competencies and scientists’ collaborative attributes when we develop professional development programs for educators and scientists.

Dedicated to

My wife, Eunju

&

My parents

ACKNOWLEDGMENTS

I am gratefully indebted to my adviser, Dr. Rosanne Fortner, for guiding me throughout my study as well as my life at Ohio State. You have been a teacher, mentor and friend to me. You also showed me what a teacher should be like.

I wish to thank my committee members, Dr. Craig Davis, Dr. Tomas Koontz, and Dr. Joseph Gliem for their thoughtful suggestions on my programs and my dissertation.

I am grateful to many teachers and scientists who shared their thoughts, concerns, and experiences about educational collaboration. I also thank all members of COSEE Great Lakes who supported the process of this dissertation.

Throughout my graduate work in Korea and in the United States, I have met many ones who supported me personally and professionally. I want to express my appreciation to all of them who taught me in so many ways.

I am grateful to my fellow graduate students who helped me immeasurably through shared discussions. I wish to thank Pastor Lee and friends at Korean Church of Columbus who have provided me invaluable encouragements and prayers.

Special thanks and loves go to my wife Eunju, my son Yejun, and two families across an ocean. Only with their support, encouragements, and, most importantly, prayers, I could come here up to now.

Praise my dear Lord who leads my every path!

Partial support for the research came from the National Science Foundation and the National Oceanic and Atmospheric Administration under Grants No. 0528674 (NSF) and NA06OAR4170017 (NOAA). Opinions, findings, conclusions and recommendations expressed in this material are those of the author and do not necessarily reflect the views of the National Science Foundation or the National Oceanic and Atmospheric Administration.

VITA

July 5, 1974……………. Born- Sangju, Republic of Korea

1997…………………… B.S. Science (Chemistry) Education, Seoul National University

2002…………………… M. City Planning, Seoul National University

2007…………………… M. Applied Statistics, The Ohio State University

2003-present……………Graduate University Fellow, Graduate Teaching and Research Associate, The Ohio State University

PUBLICATIONS

1. Kim, C. and R.W. Fortner. 2007. "Educators' views of collaboration with scientists." American Secondary Education, 35(3): 29-53.

2. Kim, C. and R.W. Fortner. 2007. "Perceptions of cultural differences and collaboration among environmental scientists and educators." Proceedings of the 2006 annual conference, North American Association for Environmental Education, St. Paul, Minnesota [Online]. Available at http://www.naaee.org/conference-history/2006-proceedings

3. Kim, C. and R.W. Fortner. 2006. “Issue-specific barriers to addressing environmental issues in the classroom.” The Journal of Environmental Education, 37(3): 15-22.

4. Kim, C. and R.W. Fortner. 2006. “Preparing environmental educators through online course discussion.” Proceedings of the 2005 annual conference, North American Association for Environmental Education, Albuquerque, New Mexico [Online]. Available at http://www.naaee.org/conference/conference-history/proceedings-2005-albuquerque-nm

5. Kim, C., E. Lee and R.W. Fortner. 2006. “Teaching environmental decision-making: A sustainable transportation example.” Proceedings of the 2005 annual conference, North American Association for Environmental Education, Albuquerque, New Mexico [Online]. Available at http://www.naaee.org/conference/conference-history/proceedings-2005-albuquerque-nm

6. Kim, C. and R.W. Fortner. 2005. “Abstract: Issue-specific barriers to addressing environmental issues in the classroom.” The Ohio Journal of Science, 105(1).

7. Kim, C. and D.S. Lee. 2002. “Teachers’ perspectives on environmental education and expectations for learners’ changes.” The Environmental Education, 15(1), 101-114 (in Korean)

FIELDS OF STUDY

Major Field: Natural Resources

Specialization: Environmental Education and Communication

Sub-specialization: Ecosystem Science and Management

Minor Field: Research Methods in Human Resource Development

TABLE OF CONTENTS

Page

LIST OF TABLES

CHAPTER 1

INTRODUCTION

“Now I will tell you something!’ said the boy to the little figure in the canoe. I have learned in school that when this snow in our Nipigon country melts, the water flows to that river. The river flows into the Great Lakes, the biggest lakes in the world. They are set like bowls on a gentle slope. The water from our river flows into the top one, drops in the next, and on to the others. Then it makes a river again, a river that flows to the Big Salt Water. …You will go with the water and you will have adventures that I would like to have.”

— Holling Clancy Holling (1941), Chapter 2

1.1 Overview

In many nations including the United States, science literacy has emerged as a central goal of education (e.g., AAAS, 1993). Science literacy, among various definitions, has commonly been described as embracing abilities required to construct understandings of science, to apply the understandings to realistic issues involving science, technology, society and the environment, and to inform and persuade other people to take action based on these science ideas (Yore, 2003). During the same periods, environmental literacy has been one of important objectives in environmental education with an idea that environmentally literate citizens would be able to behave in a responsible manner, respecting the environment (Hares et al, 2006).

In fact, science and environmental literacy are not totally separate goals. Both include, but reach beyond, scientific knowledge about nature and its processes. The features of science and environmental literacy reflect similarities and differences between the recommended approaches to environmental and science education (Cantrell & Barron, 1994). Central to environmental literacy is the ability of students to master critical-thinking skills that will prepare them to evaluate issues around them and make informed decisions (NSTA, 2003), just as science literacy is aimed to help students develop the habits of scientific inquiry, and provide them with opportunities to apply concepts to real-life situations.

The *environment* offers a relevant context for the learning, making it an essential component of a comprehensive science education. The Great Lakes, with 20% of the world's fresh water and the characteristics and interdisciplinary processes of an inland sea, provide for ideal science learning in the region. The system provides unique opportunities for exploring various local environmental issues and also allows local links to global issues. Thus, there are multiple possibilities to enhance science and environmental literacy by linking the Great Lakes to the lives of students and/or adults in the region.

This dissertation consists of three research reports on professional development and interprofessional collaboration of K-12 teachers and scientists. The first report in Chapter 2 investigates primary and secondary teachers' views of collaboration with scientists and incorporates the findings of teacher surveys from eight Great Lakes states into discussions about professional development programs for educators. The second report in Chapter 3 is an attempt to reveal interactions in education by scientists whose research is focused on the Great Lakes, and incorporates the findings into discussions about scientists' potential for the role of education partner. The third report in Chapter 4 elaborates on the results and discussions in Chapters 2 and 3 by comparing the two groups and by identifying implications of the findings for teacher-scientist collaboration.

This introductory chapter provides a contextual background of the present study and a functional definition of "educational collaboration." It introduces three areas of teacher-scientist collaboration literature and describes their relationship to the research: roles of scientists in science education, professional cultures of teachers and scientists, and barriers to educational collaboration among the two professions.

1.2 Contextual background

1.2.1 COSEE Great Lakes and educational collaboration

The Centers for Ocean Sciences Education Excellence (COSEE), supported by the National Science Foundation (NSF) and to some extent the National Oceanic and Atmospheric Administration (NOAA), promote the development of effective partnerships between research scientists and educators with the goal of increasing science literacy. As the tenth member of the National COSEE Network, COSEE Great Lakes pursues the goal through standards-based science curricula and programs that bridge the ocean and freshwater sciences. With science partners in NOAA's Great Lakes Environmental Research Laboratory (GLERL), the Cooperative Institute for Limnology and Ecosystem Research (CILER) and the USEPA's Great Lakes National Program Office [GLNPO], COSEE Great Lakes works with educators and scientists from the eight Great Lakes states on ocean/aquatic science literacy efforts.

The overall goal of the Great Lakes COSEE network is to link current Great Lakes research scientists with formal and informal educators, students, and the public to enhance the science and environmental literacy of both adults and students. Through a comprehensive eight-state collaboration of research scientists, informal, and formal educational organizations, Great Lakes research is integrated into educational programs and materials. Table 1.1 describes organizational goals and objectives of COSEE Great lakes.

COSEE Great Lakes Goals

- Inspire citizens to become more scientifically literate and environmentally responsible through standards-based science curricula and programs that bridge the ocean and freshwater sciences
- Create dynamic linkages between the education and research community
- Implement coordinated research, education and outreach initiatives connecting Great Lakes topics and issues with counterpart ocean science concepts
- Link COSEE science literacy and education/research goals with regional and national audiences
- Improve ocean/Great Lakes sciences education throughout the Great Lakes region
- Involve regional Tribal educational institutions, teachers and students in Great Lakes/ocean sciences

COSEE Great Lakes Objectives

- Facilitate collaborative relationships that improve communication between Great Lakes researchers and 4-10th grade educators and students
- Assist research scientists in gaining better access to educational organizations and use appropriate pedagogy in relating the Great Lakes/ocean sciences story
- Enhance teacher capabilities for accessing science information and delivering high quality educational programs in Great Lakes/ocean sciences
- Integrate ocean and Great Lakes research into existing high quality educational materials
- Make research findings about the Great Lakes available to the public to encourage public science literacy and appreciation of water resources
- Increase access to Great Lakes/ocean sciences information for underrepresented groups
- Facilitate direct student connections to Great Lakes/ocean sciences experiences
- Collaborate with existing COSEE programs in uniquely synergistic ways to advance mutual goals

Table 1.1: Goals and objectives of the Centers for Ocean Sciences Education Excellence (COSEE) Great Lakes (from http://coseegreatlakes.net/about/goals).

Among many efforts for educational collaboration to achieve goals and objectives of COSEE Great Lakes, primary activities or tasks focusing on Great Lakes and oceanic research include: Teacher enhancement through research encounters; research scientist interaction with teachers, students and informal educators; public education on Great Lakes and ocean sciences; teacher engagement in curriculum development, student connections via stewardship projects/summits, and active collaboration with other COSEE centers. Through the activities that involve educators, the project expects that more than 2,000 teachers will enhance their Great Lakes/ocean sciences competencies and develop working relationships with researchers during the period 2005-2010, and more than 350 researchers will be engaged in the education of new audiences.

1.2.2 This study in COSEE Great Lakes

This doctoral research had a three-fold purpose in the COSEE Great Lakes context. First, this study aimed to characterize the population of Great Lakes scientists and K-12 teachers in the Great Lakes region targeted as potential audiences for activities of COSEE Great Lakes. For the purpose, a pair of baseline surveys, "Perceptions of cultural differences and collaboration among scientists and educators," worded parallel for the two groups was developed (Appendix A & B). This study investigated the ways in which K-12 teachers and scientists are involved in educational collaboration, and barriers that deter their participation. Such information on targeted audiences is of particular value to COSEE Great Lakes and other COSEEs in facilitating scientist-educator interactions and improving scientists' educational outreach capacity.

Second, this study aimed to identify factors that may affect educational collaboration between teachers and scientists. For the purpose, relative contribution of variables in predicting teachers' and scientists' collaboration experience was examined, with the idea that maximizing predictor variables might increase collaboration. By considering a set of factors that accounts for a large proportion of collaboration experience, this study is able to guide the process of planning/adjusting professional development programs for the two groups in COSEE Great Lakes (e.g., School for Scientists or summer research institutes).

Third, this study was conducted as a part of an ongoing process of evaluating overall COSEE program outcomes related to increasing educational collaborations. COSEE Great Lakes planning includes a number of opportunities for educators and scientists to engage in collaborative interactions through 2010. Following those efforts, COSEE Great Lakes expects to repeat the survey as reported in this study for two groups: those who are actually COSEE program participants and the general scientist and teacher population of the region. That follow-up study will gauge program effectiveness and help identify the need for future directions.

1.3 Collaboration - What is collaboration?

Collaboration is generally defined as a mutually beneficial relationship between individuals, groups, and organizations in which they work together to achieve common goals (Uchida, 2005; Mattessich, Murray-Close & Monsey, 2004). In his book, *Shared Minds: The New Technologies of Collaboration*, Schrage (1990) defines collaboration as "the process of shared creation – two or more individuals with complementary skills interacting to create a shared understanding that none had previously possessed or could have come to on their own" (p.40). In *Interaction*, Friend and Cook (2007) define collaboration as "a style for direct interaction between at least two co-equal parties voluntarily engaged in shared decision making as they work toward a common goal" (p.7).

Considered alone, however, these definitions present only hints at the subtleties of collaboration. Therefore, Friend and Cook (2007) identified several elements of collaboration, *defining characteristics* of collaboration, to more fully explain their basic definition: Collaboration is voluntary; collaboration requires parity among participants; collaboration is based on mutual goals; collaboration depends on shared responsibility for participation and decision making; individuals who collaborate share resources; and individuals who collaborate share accountability for outcomes.

One of the difficulties in defining collaboration is related to different patterns of interactions and levels in sharing resources, power, and authority. Collaboration, a term which is commonly interchanged with coordination and cooperation in practical use, is differentiated from those constructs in most scholarly works (e.g., Mattessich, Murray-Close, & Monsey, 2001). According to Mattessich et al (2001), *Cooperation* is characterized by informal relationships that exist without any commonly defined mission, structure, or planning effort. Information is shared as needed, and authority is retained by each organization. Resources are separate as are rewards. *Coordination* is characterized by more formal relationships and an understanding of compatible missions. Some planning and division of roles are required, and communication channels are established. Authority still rests with the individual organizations. Resources are available to participants and rewards are mutually acknowledged. Distinguished from cooperation and coordination, *Collaboration* connects a more durable and pervasive relationship. Collaborations bring previously separated organizations into a new structure with full commitment to a common mission. Such relationships require comprehensive planning and well-defined communication channels operating on many levels. Authority is determined by the collaborative structure. Each member of the collaboration contributes its own resources and reputation. Resources are pooled or jointly secured, and the products are shared (Mattessich et al. 2001, p. 60-61).

In this study, we functionally defined "educational collaboration," often part of "education and public outreach" (EPO) from the scientists' side, as efforts among K-12 teachers and scientists to improve students' science literacy. This includes the full spectrum of lower to higher levels of involvement of teachers and scientists (e.g., resource role to partner role of scientists).

1.4 Teacher-scientist collaboration for K-12 science education

1.4.1 Roles of scientists in science education

Traditionally, many scientists have made school visits and taught single lessons for education and outreach. Such involvement is important, but represents only a small sample of the spectrum of roles scientists can play (Morrow 2000). There are much broader and deeper ways that the expertise of scientists may contribute to improving science education. Morrow (2000) suggests a framework to describe the different levels of scientists' involvement for K-12 science education: Scientists can serve in K-12 education as *advocates*, *resources*, or *partners*. An advocate generally empowers others in their educational outreach efforts, for example by speaking out in support of science education. Acting as a resource, such as making presentations, judging a science fair, or serving on an advisory board for a science education project is a good intermediate level of involvement. Partnership between scientists and educators might take the form of mentoring teachers or students, implementing curriculum with teachers, or other intensive involvement. Such partnership activities can be mutually beneficial both to scientists and educators. Clearly, scientists have resources and expertise to offer to the K–12 community. At the same time, scientists themselves can accrue benefits from engaging in educational outreach, such as improvement of teaching skills, communication with a broader audience about research, and learning about education theory (Dolan et al. 2004).

1.4.2 Scientists in teacher professional development

Most teacher professional development efforts that connect the scientist with the science educator have focused on the transfer of knowledge, structured to make efficient use of the time of both teacher and scientist. A high proportion of the teacher-enhancement programs that connect teachers and scientists take the form of short-term encounters such as workshops, summer courses, classroom visits, or short-term internships. Such programs also often assume that in the domain of science content, and sometimes even in the pedagogy associated with advanced science concepts, the scientist is to set the agenda and teach the teachers (Drayton & Falk, 2006). According to Supovitz & Turner's (2000) synthesis of the literature, however, high quality teacher professional development must be both intensive and sustained while immersing participants in inquiry process. In practice, scientists as content providers for a teacher workshop seldom reach this level of involvement. Instead, Drayton and Falk (2006) described five general approaches to the "use" of scientists in science education in the literature. Table 1.2 shows how collaboration activities in COSEE Great Lakes can be interpreted in these frameworks.

The scientist is a key member of a curriculum development effort. In many of the major curriculum projects, scientists have taken a leading role in shaping the content and approach. The goal has very often been to bring aspects of current science research into the curriculum. In some projects, the goal is to tap a scientist for very specific research results. In others, the scientist's role is to help curriculum developers understand the structure of the field, and find a way to make it accessible.

The scientist is a deliverer of content in teacher enhancement (inservice or preservice) as lecturer in a course, or workshop leader. This may take the form of targeted sessions on specific science concepts, often to support teachers' learning about specific curriculum pieces. It may also take the form of the scientist's participation in a larger workshop format, in which the science content is embedded in a pedagogical context (e.g., to enhance teachers' understanding of how to guide inquiry in a particular topic area). The summer institute is the commonest format for this.

The scientist is a visitor to the classroom, or accessible to answer queries and seek resources for students, teachers, or parents. This is perhaps the most common practice involving scientists in K-12 education, and the easiest to plan and carry out. Scientists' participation may take the form of classroom visits and demonstrations, science fair judging, homework help through email, or other means. Alternatively, the students go to the scientist's workplace for a visit, which may include tours, job shadowing, formal presentations, hands-on activities, and so on. Such relationships can be extended in various ways, for example, in projects in which students participate in student–scientist partnership.

Scientist–student (–teacher) partnerships. In this approach, the scientist's involvement is not aimed primarily at teachers' learning. Rather, students or teachers are incorporated into a scientist's research work, usually in collecting data; the scientist(s) on the project typically shape the research question, evaluate the data, and provide advice on the data collection and the interpretation of results. In another paradigm which focuses less on formal science learning, the teacher may facilitate the scientist's acting as mentor to students, so that the students learn about the scientist's life and career path, as well as science content.

The scientist is a teacher mentor, or provides a teacher with the opportunity to work on a research project. Projects that take this approach place a high emphasis on teachers' understanding of how science is actually practiced, as well as improving their content knowledge. Sometimes this takes the form of the teacher being teamed with a scientist, to work on the teaching of a lesson. This can take place in preservice settings, as an element of student teaching for prospective teachers. Most often, this takes the form of short laboratory internships or summer employment, sometimes with follow-on contact during the ensuing year.

Role (Morrow, 2000)	Scientists as (Drayton & Falk, 2006)	Common format	Sample activities/programs in COSEE Great Lakes
Scientist as Resource	A visitor to the classroom	Classroom visits, science fair judging, job shadowing	None in current program
	A deliverer of content in teacher enhancement	Summer institutes	**Lake Exploration Workshops.** Week-long resident workshops, with one or more scientists present for each day **Teachable Moment.** Short single-topic workshop led by scientist and COSEE staff **Marine Immersion.** Partner programs providing science of lakes or oceans. Variable involvement of scientists.
	A deliverer of content in student experiences		**Student Connections to Great Lakes/Ocean Sciences & Research.** Includes O'LAKERS group field trips, Great Lakes Ecology Course for high schools
Scientists as Partner	A key member of a curriculum development	Curriculum projects	**Lake Exploration Workshops** include an outcome curriculum project frequently assisted by scientists. **Teaching with GLOS.** Development of tools and educational materials with scientists to facilitate the use of GLOS/IOOS datasets for teaching
	A partner or mentor to students	Scientist–student partnerships	**Student Connections to Great Lakes/Ocean Sciences & Research.** Includes Student Summits to report Great Lakes research projects with scientists
	A teacher mentor	Short laboratory internships, summer employment	**Lake Guardian Workshop.** Scientists stay all week with teachers aboard the *R/V Lake Guardian*, guiding research methods and data collection/analysis **LimnoLinks.** Research scientist interactions with educators via workshops, "house-calls" and a school for scientists at the annual meeting of the International Association for Great Lakes Research. Scientist as learner for EPO.

Table 1.2: Roles of scientists in science education, approaches for teacher-scientist collaboration, and sample activities in COSEE Great Lakes (from Morrow, 2000; Drayton & Falk, 2006)

A growing body of research suggests that collaboration with scientists can be a powerful way to affect teachers' understanding of science, science learning and teaching, and eventually may lead to improved student achievement (Dresner & Worley, 2006; Fortner, Corney & Mayer, 2005; Kahle & Kronebusch, 2003; Caton, Brewer & Brown, 2000; Von Secker & Lissitz, 1999). So the role of scientists as partners in science education, and especially in teacher professional development, has grown in importance (Drayton & Falk, 2006). Therefore, Loucks-Horsley, Love, Stiles, Mundry & Hewson (2003) suggest that one of principles in quality professional development experiences is to provide opportunities for teachers to work with other experts (scientists) in learning communities to improve their practice (p.47).

1.5 Professional cultures of teachers and scientists

Culture is a complex concept, with many different definitions. But, simply put, "culture" refers to a group or community with which we share common experiences that shape the way we understand the world (DuPraw & Axner, 1997). This study used a functional definition: When groups of people develop their own sets of beliefs about themselves and others, such groups constitute, functionally, a "culture" (Carr, 2002).

Several studies have documented different cultures in the profession of K-12 teachers and scientists (Tanner et al., 2003; Carr, 2002; Turner, Miller & Mitchell-Kernan C., 2002; Duggan-Haas et al., 2000; Duggan-Haas, 1998). The culture of science departments where most research scientists are trained is different from that of teacher education programs in many aspects. Science training culture has been described as typically teacher centered, lecture based and competitive. In contrast, teacher education culture promotes classrooms which are student-centered, discussion-based and cooperative. For example, in his article *Two programs, two cultures: The dichotomy of science teacher preparation,* Duggan-Haas (1998) examined the perspectives of new teachers transitioning between science departments and teacher education programs and found a dichotomous relationship between cultures with regard to teaching and learning. "It seems that every instructional characteristic [use of lecture, cooperative learning, textbook use, methods of assessment] of one program is reversed in the other" (p. 3).

With a cultural difference model, Carr (2002) analyzed a collaborative, interdepartmental project between scientists and teachers, and found several notable differences, including different approaches to learning and knowing. In a teacher education department, everybody is seen as a co-learner, and knowledge is gained through not only individual effort but also a result of relationships and dialogue. In a science department, on the other hand, learning is the assimilation of knowledge delivered by experts. Features of cultural differences reported by Carr (2002) and Duggan-Haas (1998) are summarized in Table 1.3. In short, teachers are prepared in more *collaborative* disciplinary cultures while scientists are prepared in more *lone-scholar* disciplinary cultures (Turner et al., 2002).

Pattern of difference	**Teacher Education**	**Science**
Learning and knowing	Knowledge is gained through not only individual effort, but as a result of dialogue.	Learning is the assimilation of knowledge delivered by experts.
Course instruction	Group work/discussion	Mostly lecture
Use of cooperative learning	Embrace	Shun
Decision-making style	Group consensus	Delegation by authority
Teacher-student relationships	Personal	'Unapproachable' faculty
Approaches to completing tasks	Tasks are seen as ongoing and the process malleable.	Tasks meticulously planned and carried out with efficiency.
Communication style	Direct/clear communication is valued but sometimes sacrificed for relationships.	Direct/clear communication is highly valued and rarely compromised.
Attitude toward conflict	Direct conflict is avoided.	Conflict is an integral part of the process of creating knowledge.
Attitudes toward disclosure	Disclosure of weakness, lack of knowledge, or apprehension is expected.	Disclosure of weakness, lack of knowledge, or apprehension is avoided.

Table 1.3: Patterns of cultural differences between teacher education departments and science departments (from Carr, 2002; Duggan-Haas, 1998)

Such different cultures in professional preparation may directly contribute to cultural tendencies and differences between scientists and K-12 teachers in how they interact across cultures. Based on their experience over eight years of 4-day workshops on education and public outreach, Morrow & Dusenbery (2004) reported the cultural differences observed with over 400 scientists, engineers and education managers. While scientists are seen as intellectually confident, competitive, critical and less socially adept, teachers are often less intellectually confident, collaborative, appreciative, and have good social skills. These compressions into two categories could be an oversimplication, and by no means all distinctions apply to all teachers and scientists. Nevertheless, they can suggest a lens for considering professional cultures of teachers and scientists for educational collaboration of both professions (Turner et al., 2002). When K-12 teachers collaborate with scientists, both groups need to understand the distinct academic cultures and recognize obstacles such as differing perspectives on teaching and learning (Carr, 2002; Duggan-Haas et al., 2000).

1.6 Barriers to educational collaboration between teachers and scientists

Although the need for collaboration between teachers and scientists is clear, barriers exist that often make such collaboration difficult. Barriers to the practice of interprofessional collaboration can foil the best intentions and efforts of participants. According to Walsh, Bradeck & Howard (1999), barriers to interprofessional collaboration exist at both conceptual and practical levels. As for conceptual barriers, the current *understanding of profession* in an expert model often inhibits collaborative relations. Issues of *status* may influence an individual's willingness to work collaboratively with professionals from other disciplines. As for practical barriers, many work environments present professionals with *structural constraints* to engaging in interprofessional collaboration, including financial arrangements, staffing patterns, and work-day responsibilities. The subtle but significant differences in the *cultures of professions* may also serve to discourage collaboration. *Professional preparation* programs have typically focused on isolated non-collaborative models of practice (Walsh et al., 1999).

Based upon an intensive literature review, Mattessich et al. (2001) identified a comprehensive set of twenty factors that influence the success of collaboration in six categories: factors related to the environment (e.g., history of collaboration in the community), membership characteristics (e.g., mutual respect, understanding, and trust), process and structure (e.g., multiple layers of participation), communication (e.g., open and frequent communication), purpose (e.g., shared vision), and resources (e.g., sufficient funds, staff, materials, and time) (p. 7-10). Deficiencies in or absence of these success factors can be interpreted as barriers to collaboration.

What determines whether teachers and/or scientists develop collaborative relationships with each other that serve to enhance both professions? The Center for Ocean Sciences Education Excellence once used the work of Mattessich et al. as a basis for asserting the need to formulate a systematic strategy for collaboration among educational institutions to promote ocean science curriculum development. In the teacher-scientist collaboration context, detailed knowledge of mechanisms to facilitate, support, and sustain such relationships is lacking. A limited number of studies identified factors that may impede *scientists*' participation in EPO opportunities: lack of time, lack of information about outreach opportunities, absence of reward systems for participation in outreach, and lack of training for scientists doing outreach (Andrews, Weaver, Shamatha & Melton, 2005; Dolan *et al.*, 2004).

Such institutional supports as budget constraints, limited time, and reward system also comprise difficulties for *teachers* who want to collaborate with scientists for improved science teaching. Recently, based on a cultural model – hierarchy model, Carlone and Webb (2006) argued that deficit-based explanations (e.g., blaming individuals or organizational structures) can not explain the complexities of collaboration. Several studies have described cultural barriers to teacher-scientist collaboration. Although Tanner et al. (2003) argued that the different professional cultures of scientists and K–12 educators can impede collaboration when allowed to go unacknowledged, there are few studies on how such cultural factors play roles in teacher-scientist collaboration.

1.7 Conclusion

The research that is presented in the following chapters consists of three published or submitted manuscripts on professional development and interprofessional collaboration of K-12 teachers. They are based upon three areas of teacher-scientist collaboration literature as introduced here. The first (published) manuscript in Chapter 2 investigates primary and secondary teachers' views of collaboration with scientists and incorporates the findings of the teacher surveys from eight Great Lakes states into discussions about professional development programs for educators. The second (accepted) manuscript in Chapter 3 is an attempt to reveal interactions in education by scientists whose research is focused on the Great Lakes, and incorporates the findings into discussions about scientists' potential for the role of education partner. The third (submitted) manuscript in Chapter 4 elaborates on the results and discussions in Chapters 2 and 3 by comparing the two groups and by identifying implications of the findings for teacher-scientist collaboration. Chapter 5 concludes the dissertation by summarizing the various findings and identifying the underlying implications for the professions of scientists and K-12 teachers as well as natural resources professionals and environmental educators. The goal of all of the research reported in Chapter 2 through 4 is to increase our understanding of educational collaboration in teacher-scientist partnership contexts. The results of these studies may provide insights into facilitating dynamic collaborative relationships between research scientists and educators.

CHAPTER 2

EDUCATORS' VIEWS OF COLLABORATION WITH SCIENTISTS[1]

2.1 Introduction

For four decades and more, the National Science Foundation, the U.S. Department of Education, NOAA and others have provided support for numerous programs designed to enhance the capabilities of science teachers and informal science educators, with the ultimate goal of increasing science literacy for students and the public at large. Many of the programs have focused on putting teachers in science laboratories (such as NSF's Research Experiences for Teachers), providing sustained and intensive science content instruction for teachers (as in State Systemic Initiatives - SSI), or bringing scientists into closer communication with classrooms (such as GK-12 programs). All such programs assume that interactions of scientists and educators will result in better, more, or more current science instruction.

In fact the National Science Education Standards (NRC, 1996) promote science learning as the first Professional Development Standard for teachers, and programs addressing this standard are expected to have teachers involved in inquiry, not a common mode of learning science in traditional college courses! Thus, programs under the

[1] Published as Kim, C and Fortner, R.W. 2006. "Educators' views of collaboration with scientists." American Secondary Education, 35(3): 29-53.

sponsorship of NSF Teacher Enhancement (currently Teacher Professional Continuum) funding, the Eisenhower Math and Science Education Act, and other sources, have labored long to reach those goals of enhanced science learning.

2.2 Educators' collaboration with scientists

K-12 teachers become involved in collaboration with scientists in a variety of ways. Perhaps the most common practice involving scientists in K-12 education is to bring a scientist to the classroom or alternatively to take students to field trips or lab visits hosted by a scientist. Such involvement is important, but represents only one of the five general approaches to engaging scientists in science education in the literature. Others are to involve a scientist as a key member of a curriculum development effort, a deliverer of content in teacher enhancement, a partner in scientist-student-teacher partnerships, or a teacher mentor, providing a teacher with the opportunity to work on a research project (Drayton & Falk, 2006; Morrow & Dusenbery, 2004).

The role of scientists as partners in science education, and especially in teacher professional development, has grown in importance (Kim & Fortner, accepted; Drayton & Falk, 2006). Scientists can make an important contribution to the professional development of science teachers: they represent a special source of insight about science content and process, the structure of their field of knowledge, and key approaches to curriculum and pedagogy in their area of expertise (Drayton & Falk, 2006). A growing body of research suggests that collaboration with scientists can be a powerful way to affect teachers' understanding of science, science learning and teaching, and eventually may lead to improved student achievement (Dresner & Worley, 2006; Fortner, Corney &

Mayer, 2005; Kahle & Kronebusch, 2003; Caton, Brewer & Brown, 2000; Von Secker & Lissitz, 1999). Illustrating long-term values of a professional development program with ecologists, Dresner and Worley (2006) conclude that engaging teachers in real-world field science research with scientists is an effective way for teachers, and consequently, their students, to learn ecological knowledge and skills. Therefore, Loucks-Horsley et al. (2003) suggest that one of the principles for quality professional development experiences is to provide opportunities for teachers to work with other experts (scientists) in learning communities to improve their practice (p.47).

Currently, K-12 educators have little chance for such opportunities to interact with scientists in enhancing their science instruction. Describing an ideal state in the continuum of science teacher education phases, (preparation, induction and professionalization) Kahle and Kronebusch (2003) report that within any given phase there are few connections among scientists, educators, and K–12 teachers. What determines whether teachers develop collaborative relationships with scientists that serve to enhance both the science and education professions?

Unfortunately, detailed knowledge of mechanisms to facilitate, support, and sustain such relationships is lacking. Tanner et al. (2003) highlighted three issues that, when allowed to go unacknowledged, can impede collaboration: (1) the importance of mutual learning in partnerships, (2) the professional cultures of scientists and K–12 educators, and (3) barriers of language in partnerships. Challenges in facilitating educational collaboration include breaking down the hierarchies that often exist between the two professions, fostering learning within both groups for true mutual learning in partnerships. Caton, Brewer & Brown (2000) reported that stressing equal status for teachers and research scientists and facilitating two-way exchange of expertise increased the satisfaction of participants in a partnership.

Barriers of language in two professions can also be important challenges (Kim & Fortner, accepted; Tanner et al., 2003). Examining a program focused on improving teachers' understanding and ability with inquiry by providing the collaboration of graduate level scientists, Thompson (2003) found that *none* of the languages of inquiry were consistent with those used by scientists or classroom teachers. Even in a teacher-scientist collaboration project that was successful in increasing the use of inquiry by participating teachers, several teachers suggested that facilitating communication with scientists was essential to continued collaboration and use of inquiry (Caton, Brewer & Brown, 2000).

The research reported here began as a study of professional cultures. As people from different cultural groups take on the challenge of working together, cultural values sometimes conflict. In pursuit of a supposed common goal, we risk misunderstanding and acting in ways that hinder promising partnerships. When K-12 teachers collaborate with scientists both groups need to understand the distinct academic cultures and recognize obstacles such as differing perspectives on teaching and learning (Carr, 2002; Duggan-Haas et al., 2000). Teachers' views about the nature of science, their science teaching, and the science learning of their students can be different from those of scientists (Lunn, 2002; Pomeroy, 1993). Differences between these cultures also include differences in the level of resources available, the level of autonomy, and the nature of peer relations as well as scientists' unfamiliarity with issues of classroom management and logistics (Kim & Fortner, accepted; Drayton & Falk, 2006). K-12 teachers may have a very different level of understanding in scientific research, compared with a scientist (Herwitz & Guerra, 1996).

2.3 COSEE Great Lakes and educational collaboration

The Centers for Ocean Sciences Education Excellence (COSEE), supported by the National Science Foundation, promote the development of effective partnerships between research scientists and educators with that often-sought goal of increasing science literacy. As a member of the national network, COSEE Great Lakes pursues the goal through standards-based science curricula and programs that bridge the ocean and freshwater sciences.

The purpose of this study was to investigate educators' views of collaboration with scientists, a baseline for COSEE Great Lakes efforts in facilitating dynamic collaborative relationships between Great Lakes researchers and educators. Three research questions guided the study: 1) how are educators in the Great Lakes region involved in collaboration with scientists, 2) what barriers may deter their involvement and 3) which factors are related to educators' potential in educational collaboration**.**

2.4. Methods

To characterize the population of educators in the Great Lakes region targeted as a potential audience for teacher enhancement activities of COSEE Great Lakes, we developed a baseline study of "Perceptions of Cultural Differences and Collaboration among Scientists and Educators." We expect to repeat the study in 2010 to gauge the overall COSEE program outcomes related to increasing collaborations among scientists and educators. “Education” connotes for us the domain and personnel of classroom education in U.S. grades kindergarten to twelve (K-12). In terms of scientists’ involvement with teacher professional development, we define “educational outreach” or “outreach” as efforts to make scientific information available to the public and schools.

2.4.1. Survey instrument

Quantitative data were collected for this study through the use of written surveys. A survey instrument composed of 66 statements plus demographic items was developed based on literature review. Sections of the survey invited response to items on how science is conducted, taught and learned (views of science and science education, 14 items), attitudes toward educational collaboration (12), professional preparation and experience (11), familiarity with 10 terms in science and education, barriers to educational collaboration with scientists (12), and seven items related to factors or opportunities that would assist educators in collaboration (Table 2.1). Most sections were worded to be parallel to a concurrent survey being conducted among Great Lakes scientists (Kim & Fortner, accepted).

For views of science and science education, Pomeroy’s (1993) items were used to represent traditional views (empiricist views) and contemporary views (constructivist views) after modification. A panel of 15 experts in science education, communication or collaboration examined the instrument to establish content validity. In May 2006, surveys were mailed to 180 schools randomly selected from 5757 public schools in the eight Great Lakes states. The number of schools selected per state was determined proportionally by the number of schools in the shoreline counties.

Survey component	Items	Cronbach's alpha
Views of science and science education:		
Traditional views / Contemporary views	7 / 7	0.524 / 0.568
Attitudes toward:		
Scientists' involvement / Collaboration with scientists	7 / 5	0.886 / 0.512
Professional preparation:		
Science competencies / Collaborative cultures	3 / 3	0.616 / 0.659
Experiences in collaborating with scientists	5	0.831
Familiarity with terms/concepts in Science*	5	0.661
Barriers to collaboration:		
Institutional supports / Difficulties (others)	4 / 8	0.695 / 0.561
Facilitating assistances for collaboration	7	0.897

* Teachers' responses to five terms/concepts in education were collected in this study but not used as a construct because of low reliability.

Table 2.1: Structure of survey instrument administered to Great Lakes teachers, with reliability of components.

Mailings were done under a cover letter from the Sea Grant Educator in each state, establishing a "local" connection for project credibility. Three copies of the survey were mailed to each school with cover letters asking the principal to give the surveys to three teachers in the 4th and 5th grades in the school (elementary), or three science teachers for 7th and 8th grades (middle), or 9th and 10th grades (high school). Teachers returned their completed surveys to the principal, who forwarded them to the researchers. If they wished to receive teaching materials about the Great Lakes and be entered into a prize drawing for additional instructional materials, teacher respondents returned separate postcards with their name and contact information.

2.4.2 Survey participants – Teachers

Most respondents returned their surveys by the selected deadlines in May or June 2006, but 19 returned them later. We sent one follow-up reminder letter to principals as well as thank-you cards for school responses. The late surveys did not show any difference in terms of age, gender, or years of teaching experience, and most responses in the survey compared with the on time surveys. We can therefore assume that late responders are from the same population.

We received a total of 194 survey responses (36% response rate) (Table 2.2). Considering all responses were voluntary and self-selected, the possibility of bias arises from those who elected to take the time to respond to the survey in that they may have been: (1) more interested in educational collaboration; (2) more interested in the incentive, or (3) more confident in working with scientists.

State	N of public schools in shoreline counties	Schools sampled	Survey received / Survey distributed	State teacher response rate
Illinois / Indiana*	1677	51	35/153	22.9%
Michigan	1581	45	44/135	32.6%
Minnesota	80	9	11/27	40.7%
New York	671	21	40/63	63.5%
Ohio	800	24	25/72	34.7%
Pennsylvania	82	9	10/27	37.0%
Wisconsin	735	21	29/63	46.0%
Total	**5757**	**180**	**194/540**	**35.9%**

* Illinois and Indiana share one Sea Grant program. Schools were selected by separate state but combined for anonymous response returns.

Table 2.2: Sample frames, selected number of schools, and response rates by region.

Of the 194 educator respondents, 80 (42%) were male while 109 (58%) were female. Their average age was 41 (range = 23-62), and they reported an average of 13.7 years in teaching experience (range = 1-38). Their teaching levels were approximately equally represented, with 62 elementary (4–5th, 32%); 65 middle school (7-8th, 34%) and 67 high school (10-11th; 35%). Among the respondents, secondary teachers mainly teach ‘General/Integrated science’ or ‘Science subjects’ such as Life science, Physics, Earth science or Environmental science (83.1% for 7-8th and 89.6% for 10-11th) while elementary teachers teach science with other subjects (88.0%) (Table 2.3). Only five respondents did not report any science subjects as subjects taught. Therefore we can assume that the respondents represent a potential audience for science teacher enhancement activities of COSEE Great Lakes.

	4-5th	**7-8th**	**10-11th**	**Total**
All Subjects	28 (48.3%)	-	-	28 (14.7%)
General/Integrated Science	4 (6.9%)	29 (44.6%)	3 (4.5%)	36 (18.9%)
Science Subjects[1)]	-	25 (38.5%)	57 (85.1%)	87 (45.8%)
Science and Other subjects[2)]	23 (39.7%)	10 (15.4%)	1 (1.5%)	34 (17.9%)
Other subjects only[2)]	3 (5.2%)	1 (1.5%)	1 (1.5%)	5 (2.6%)
Total	58 (100.0%)[3)]	65 (100.0%)	67 (100.0%)	190 (100.0%)

1) Science Subjects include Life science (biology), Physics, Chemistry, Earth/Space science (geology), Environmental science (ecology).

2) Other subjects include Language arts, Physical education, Special education, Math and Reading.

3) Out of 62 elementary teachers, four did not report their teaching subjects.

Table 2.3: Frequency and percentage of principal teaching subjects reported by educators (By teaching levels).

2.5 Analyses and discussion

Underlying themes occurring in groups of survey statements were identified and described by clustering statements. A correlation matrix was used to identify those statements showing significant correlation with each other. Eleven clusters appeared that exhibited relatively strong internal consistency indicated by Cronbach's alpha greater than 0.5 (Table 2.1). Finally, the memberships of the clusters generated were examined to assure identification of all significant clusters. Analyses were conducted on the full sample of respondents for the purpose of characterizing educator responses in general. Post hoc analyses examined results for differences between elementary ($4\text{-}5^{th}$) and secondary teachers ($7\text{-}8^{th}$ or $10\text{-}11^{th}$), since addressing the needs identified by the research would likely take different forms for the different grade levels.

2.5.1 Views of science and science education

Teachers responded to items describing how scientific research is conducted and how science is taught and learned in classrooms (Table 2.4). Analyses clustered the items into two sets determined to represent approaches to scientific research and science teaching/learning: traditional views and contemporary views (Pomeroy, 1993). The latter views are more oriented to constructivist views in the continuum from empiricist to constructivist perspectives (Tsai, 2000). Such views are also related to the five components of inquiry Thompson (2003) identified: the existence and steps of the scientific method, the subjective nature of knowledge creation in science, the empirical basis of scientific inquiry, the tentative nature of scientific knowledge and the role of creativity in inquiry. Items regarding views of science education also describe classroom culture and perceptions about how students learn. Perhaps these views represent when or in what university setting (education or science department) teachers received their initial development as professionals.

The statements emerging in the clusters ‘traditional views’ and ‘contemporary views’ are in Table 2.4. The internal consistency scores reported by Cronbach’s alpha were moderate for both clusters (See Table 2.1). The teachers’ responses to traditional views were approximately normally distributed (mean = 2.72, SD = 0.38) about the midpoint of the scale, indicating generally neutral, or balanced, beliefs as expressed in this set of statements. The responses to contemporary views tended toward agreement with this cluster (mean = 3.20, SD = 0.37) with an approximately normal distribution. Teachers in this study showed that they are more favorable to contemporary views than traditional views, consistent with Pomeroy’s noting of a growing awareness of and commitment to constructivism among educators (1993). The mean scores of traditional views were significantly different among three groups by grades ($F=9.73$, $p < .001$). The elementary teachers ($4\text{-}5^{th}$) scored significantly lower in traditional views (mean = 2.58) than middle school teachers ($7\text{-}8^{th}$, 2.72) or high school teachers ($10\text{-}11^{th}$, 2.86) while there was no difference in contemporary views among the groups.

Statements: Traditional views of Science education	% Agree, Mean (SD)
Science is performed by a specific community of qualified scientists.	34.2%, 2.19 (0.88)
Science is based on experiments which other scientists should be able to replicate.	91.6%, 3.48 (0.70)
The acquisition of new scientific knowledge moves from observation to formation of hypotheses, then testing, and finally generalizing to theory.	93.6%, 3.45 (0.66)
When students are presented with a clear explanation of a concept, most are able to learn the concept.	80.6%, 3.02 (0.66)
Students learn best during laboratory experiments when they work individually.	27.4%, 2.20 (0.74)
Listening to lectures is a good way for students to learn scientific concepts.	34.9%, 2.17 (0.80)
When students ask questions, teachers should provide the answers.	52.5%, 2.57 (0.70)
Statements: Contemporary views of Science education	**% Agree, Mean (SD)**
The process of scientific discovery often involves a high degree of creativity.	83.9%, 3.19 (0.79)
Intuition plays an important role in scientific discovery.	84.3%, 3.10 (0.67)
Cultural groups differ in their processes of gaining valid knowledge about natural phenomena.	60.1%, 2.60 (0.86)
Students often learn science best through hands-on activities.	98.5%, 3.70 (0.51)
Student-led discussion is a good way for students to learn science.	88.5%, 3.27 (0.65)
It is important for students to be involved in group projects.	92.2%, 3.43 (0.65)
If there must be a choice between learning concepts thoroughly and learning the processes of discovery, the teacher should emphasize the processes of discovery.	79.6%, 3.07 (0.72)

Ratings were on a 4-point Likert scale (1=strongly disagree; 4=strongly agree).

% Agree = combined percentage of respondents who either agreed (3) or strongly agreed (4) with each statement.

Table 2 4: Percentage, means and standard deviations of educators' responses to views of science and science teaching/learning.

2.5.2 Attitudes toward educational collaboration

This section of the survey measured how educators view scientists' involvement with classrooms and teachers, and their working with scientists in education collaboration (Table 2.5). Seven statements were used to measure educators' attitudes toward scientists' roles in education and outreach. The internal consistency (Cronbach's alpha = 0.886) was strong for these statements. The responses tended toward agreement with this cluster (mean = 3.42, SD = 0.50) with an approximate normal distribution. More than 90% of respondents either agreed or strongly agreed that it is important for research scientists to get involved in educational outreach projects (94.8%) and to support K-12 education (90.1%) (Table 2.5). Educators also perceived that it is important for research scientists to work directly with K-12 teachers (86.9%). Educators' responses to the statements measuring their attitudes toward collaboration with scientists also tended toward agreement (mean = 3.05, SD = 0.47). The internal consistency for the statements was moderate (See Table 2.1). About 80% of educators reported that partnerships with scientists may extend the impact of their teachings (79.8%).

Statements: Attitudes toward scientists' involvement	% Agree, Mean (SD)
Scientists' involvement in educational outreach projects motivates students to be interested in scientific careers.	96.3%, 3.54(.60)
Scientists' involvement in educational outreach increases public understanding of scientific research.	95.8%, 3.54 (.60)
It is important for research scientists to get involved in educational outreach projects.	94.8%, 3.49 (.61)
Research scientists should include educational outreach plans in their funding proposals.	91.6%, 3.42 (.68)
By getting involved in educational outreach, scientists can develop the educational foundations for informed decision-making in public policy.	91.6%, 3.37 (.65)
It is important that research scientists support K-12 education.	90.1%, 3.43 (.71)
It is important for research scientists to work directly with K-12 teachers.	86.9%, 3.17 (.72)
Statements: Attitudes toward collaboration with scientists	**% Agree, Mean (SD)**
I am comfortable working with scientists.	80.6%, 3.19 (0.80)
Partnership with scientists extends the impact of my teaching.	79.8%, 3.10 (0.90)
K-12 teachers are interested in educational collaboration with scientists.	79.4%, 3.02 (0.72)
Students are interested in learning directly from scientists.	88.8%, 3.14 (0.67)
K-12 teachers need scientists' assistance in creating resources for students.	70.2%, 2.82 (0.85)

Ratings were on a 4-point Likert scale (1=strongly disagree; 4=strongly agree).

% Agree = combined percentage of respondents who either agreed (3) or strongly agreed (4) with each statement.

Table 2.5: Percentage, means and standard deviations of educators' responses to attitudes statements regarding educational collaboration.

2.5.3 Experiences in collaborating with scientists

This study examined the ways in which educators collaborate with scientists. The educators responded that among the activities described they most frequently take their students on field trips or lab visits hosted by a scientist (55.7%). About half of the respondents reported that they have brought a scientist to their classroom (51.3%). However, less than one third consulted with scientists on curriculum development (25.0%) or referred to scientists for scientific research (32.1%). The summary of responses confirms that the most common "use" of scientists in science education is to bring a scientist to the classroom or alternatively to take students to field trips or lab visits hosted by a scientist (Drayton & Falk, 2006) while only a small portion of educators have experience working closely with scientists in curriculum development or scientific research. On average, the combined group of secondary teachers (mean = 2.32, SD = 0.85) reported significantly ($p < 0.001$) more experience in collaborating with scientists than did the elementary teachers (mean = 1.85, SD = 0.72).

Statements	% Agree, mean (SD)
I have experience in bringing a scientist to my classroom.	51.3%, 2.45 (1.12)
I have taken my students to field trips or lab visits hosted by a scientist.	55.7%, 2.59 (1.15)
I have conducted collaborative research with a scientist.	29.2%, 1.94 (1.07)
I have consulted with scientists on curriculum development.	25.0%, 1.81 (1.01)
I have experience in referring to scientists for their knowledge of scientific research.	32.1%, 2.06 (1.04)

Items were rated on a 4-point Likert scale (1=strongly disagree; 4=strongly agree).

Table 2.6: Percentage, means and standard deviations of educators' reported experience in collaborating with scientists.

2.5.4 Professional preparation for science teaching

Using two clusters with relatively strong internal consistency, we categorized six statements about professional preparation for educators into two groups, herein called "Professional preparation I – science competencies" and "Professional preparation II - collaborative cultures." The summary of responses is shown in Table 2.7.

Regarding the science competencies, about 70% of respondents reported that their professional preparation as a teacher equipped them with enough knowledge in science (72.8%). More of the secondary teachers (82.9%) agreed to the statement than did elementary teachers (51.6%). Averaging responses to the three statements on competencies, the combined group of secondary educators (7-8th or 10-11th) reported that they have obtained significantly higher ‘science competencies’ through the professional preparation period than did the elementary teachers (4-5th) ($p<.001$) (See Table 2.11).

Compared to a group of scientists in a parallel study (Kim & Fortner, 2007), more educators reported that they were trained in collaborative cultures. This finding is in line with what Duggan-Haas (1998) described in his ethnographic research regarding the different professional training cultures for scientists and educators. More than 90% of educators indicated that they had been trained in institutions using cooperative learning. This classroom methodology is seen as key to student growth in teamwork that simulates how scientists work (Fortner, 2001). At the same time it can be an important component of acceptance of partners in educational collaboration.

2.5.5 Barriers to / facilitating assistances for collaboration with scientists

Using twelve survey statements, we examined educators’ perceived barriers to collaborating with scientists: institutional supports and other difficulties. Barrier statements in Table 2.8 are in descending order from primary to less important barriers. Institutional supports such as funding, time, and professional acknowledgement are among top barriers. Most respondents agreed that lack of time (94.4%) and funding (96.9%) may deter their collaborating with scientists, and about three-fourths reported that K-12 teachers do not receive adequate professional acknowledgement for educational collaboration with scientists (78.8%).

Statements: Professional Preparation I – Science competencies	% Agree, mean (SD)
My professional training as a teacher has equipped me with enough	
knowledge in science.	72.8%, 2.93 (0.91)
I took more than one course in science during my professional	94.7%, 3.58 (0.65)
training.	96.3%, 3.58 (0.58)
I believe that I am equipped with the ability to help students gain a	
better understanding of science.	
Statements: Professional Preparation II - Collaborative cultures	**% Agree, mean (SD)**
During my professional training I often worked often in collaborative	
groups.	84.8%, 3.34 (0.80)
At least one college I attended encouraged the use of cooperative	94.3%, 3.59 (0.60)
learning.	94.8%, 3.59 (0.61)
The teacher-student relationships in at least one college I attended	
were warm and supportive.	

Items were rated on a 4-point Likert scale (1=strongly disagree; 4=strongly agree).

Table 2.7: Percentage, means and standard deviations of professional preparation reported by educators.

Table 2.8 also shows how educators perceive other barriers than institutional supports. More than 90% of educators in this study claim it is not clear to them *how* to get involved in educational collaboration. Differing perspectives on education between scientists and educators is also an important barrier (75.0% agreed) as Duggan-Haas et al. (2000) suggested. About half of the educators reported there are difficulties in communicating with scientists (49.7%).

The respondents also reported how seven types of assistance will facilitate their participation in educational collaboration with scientists (Table 2.9). Among them, the respondents reported that "help in identifying specific opportunities" to collaborate with scientists will most facilitate their collaboration with scientists (94.3% agreed).

Statements: Institutional supports	% Agree
K-12 teachers do not have sufficient funding to work with scientists.	96.9%*
K-12 teachers do not have sufficient time to work with scientists.	94.4%*
K-12 schools do not place much importance on continuing involvement with scientists.	93.2%*
K-12 teachers do not receive adequate professional acknowledgement for educational collaboration with scientists.	78.8%*
Statements: Difficulties (others)	**% Agree**
It is not clear to K-12 teachers how to get involved in educational collaboration with scientists.	94.3%*
I want to increase my understanding of how scientists conduct research.	75.9%
K-12 teachers have different perspectives on education from scientists.	75.0%
I need to have a better understanding of the profession of scientists.	52.6%
K-12 teachers have difficulty in communicating with scientists.	49.7%
It is difficult to communicate with scientists about their research.	44.4%
It is difficult to present scientific concepts in a manner that is comprehensible by K-12 students.	26.0%
I am afraid that I don't understand science well.	11.0%

Statements with asterisks (*) were originally stated in reverse terms. For such items, percentage of Disagree and Strongly disagree are reported.

Table 2.8: Percent agreement of educators regarding barriers to collaboration with scientists.

Facilitating Assistances for Collaboration	% Agree
Help in identifying specific opportunities I could become involved in	**94.3%**
Incentives (e.g., promotion, stipend, course credit, or classroom materials)	92.2%
Workshop or course providing cutting-edge science from research scientists	91.2%
Assistance in carrying out collaborative efforts with scientists	89.1%
Assistance in justifying how collaborative efforts with scientists fulfills "standards"	81.8%
Assistance in developing budgets for collaboration with research scientists	78.0%
Institutional appreciation of my involvement in collaboration with scientists	78.0%

Table 2.9: Percent agreement of educators regarding facilitating assistances for collaboration with scientists.

2.5.6 Familiarity with terms in science: Barriers of language in collaboration

To examine barriers of language in collaboration, we asked educators to indicate their familiarity with terms/concepts in science (Table 2.10). We can assume that the terms are common to scientists since most scientists in a parallel study reported that they have used such terms *in practice*: Experimental design (88%), Statistical analysis (95%), Empirical studies (77%), Problem-solving approaches (79%), Hypothesis testing (96%) (Kim & Fortner, accepted). Many educators in this study indicated their familiarity with the selected terms in scientific research. Regarding "empirical studies", however, about

40 % of respondents were either not familiar with the concept or not sure what it means (39.1%). On average, the secondary teachers (mean = 3.55) reported that they are more familiar with the five selected terms in science than did elementary teachers (3.20) (See Table 2.11).

It is as expected that most educators have used the selected education terms *in practice*: classroom management (98%), "hands-on" activities (98%), National Science Education Standards (78%), constructivist learning theory (46%), inquiry-based learning (87%). On the other hand, the scientists in the parallel study (Kim & Fortner, accepted) were less familiar with the education terms that the teachers use. Scientists have at best a minimal understanding of what the National Science Education Standards are, for example.

2.5.7 Comparison of elementary and secondary teachers

Post hoc analyses examined results for differences between elementary (4-5th) and secondary teachers (7-8th or 10-11th), since addressing the needs identified by the research would likely take different forms for the three groups. In most sections of this study, middle school teachers (7-8th) responded similarly to high school teachers (10-11th). The only exception is the traditional views of science/science education. The high school teachers (mean = 2.97, SD = 0.32) scored significantly ($t=3.256$, $p = 0.001$) higher in traditional views than the middle school teachers (mean = 2.85, SD = 0.29). Otherwise there was no significant difference among secondary groups at 0.05 levels.

Terms/concepts in science	Not familiar	Not sure	I know, but	I've used
Experimental design	13 (6.8%)	17 (8.8%)	37 (19.4%)	124 (64.9%)
Statistical analysis	2 (1.0%)	21 (11.0%)	66 (34.6%)	102 (53.4%)
Empirical studies	28 (14.8%)	46 (24.3%)	64 (33.9%)	51 (27.0%)
Problem-solving approaches	1 (0.5%)	3 (1.6%)	17 (8.9%)	170 (89.0%)
Hypothesis testing	4 (2.1%)	6 (3.2%)	22 (11.6%)	158 (83.2%)

Items were rated on a 4-point Likert scale (1 = I am NOT familiar with the concept at all. 2 = I've heard of the term, but I'm not sure what it means. 3 = I know what this is, but I've never used it in practice. 4 = I know what this is and I've used it in practice).

Table 2.10: Frequency and percentage of educators' perceived familiarity with terms/concepts in science.

On the contrary, the combined group of secondary teachers showed statistically significant differences in several clusters. The combined group of secondary teachers (mean = 2.79, SD = 0.35) showed significantly ($p < 0.001$) stronger agreement with traditional views of science education than did the elementary teachers (mean = 2.58, SD = 0.41). The secondary teachers also reported that they have obtained significantly higher 'science competencies' through professional preparation period than did the elementary teachers ($p < .001$) (Table 2.11). There was no statistical difference between the elementary and the combined secondary teachers in responses to attitudes toward educational collaboration, perceived institutional supports, and facilitating factors.

	Elementary	**Secondary**	
	4-5th	**7-8th or 10-11th**	**t / Sig.**
	mean (SD)	mean (SD)	
Views of Science Teaching & Learning			
- Traditional views	2.58 (0.41)	2.79 (0.35)	-3.759 / .000
- Contemporary views	3.22 (0.31)	3.19 (0.40)	0.617 / .538
Experiences in collaborating with scientists	1.85 (0.72)	2.32 (0.85)	-3.781 / .000
Familiarity with terms/concepts in science	3.20 (0.55)	3.55 (0.44)	-4.717 / .000
Professional Preparation			
- Science competencies	3.01 (0.61)	3.61 (0.39)	-7.222 /.000
- Collaborative cultures	3.40 (0.57)	3.56 (0.49)	-2.045 /.042
Barriers to collaboration with scientists			
- Institutional supports	1.51 (0.44)	1.61 (0.50)	-1.366 / .174
- Difficulties (others)	2.30 (0.43)	2.17 (0.39)	2.587 /.010

Ratings were on a 4-point Likert scale (1=strongly disagree; 4=strongly agree).

Table 2.11: Mean responses and standard deviations of elementary (n = 62) and secondary teachers (n=130) to the survey on scientist/educator collaboration.

Variable	Attitudes toward scientists' involvement	Experience in collaboration
Views of Science and Science Teaching/Learning		
- Traditional views / Contemporary views	.075 / .455**	.123 / .215**
Attitudes toward		
- Scientists' involvement / Collaboration with scientists	n.a. / .485**	.102 / .350**
Familiarity with terms/concepts in Science	.126	.234**
Professional Preparation		
- Science competencies / Collaborative cultures	.050 / .318**	.320** / .188**
Barriers to collaboration		
- Institutional supports / Difficulties (others)	-.011 / .049	.270** / -.142*
Facilitating assistances for collaboration	.467**	.082
Teaching experience in years	-.191**	.201**

A single asterisk (*) indicates significance at the 0.05 level; double asterisk (**) indicates significance at the 0.01 level.

Table 2.12. Two-tailed correlations between educators' experience with scientists in educational collaboration and explaining variables (n=194).

2.5.8 Factors related to educators' potential for science education partnership

To investigate factors related to the educators' potential role in collaboration with scientists, we studied the correlations between educators' experience with scientists and the following indices: views of science and science teaching/learning, attitudes toward collaboration, familiarity with terms in science, professional preparation, barriers to collaboration, and teaching experience in years (Table 2.12). When comparing the characteristics of individual respondents, an educator who had a positive attitude toward collaboration with scientists tended to have more experience in educational collaboration ($r = 0.350$, $p < 0.001$). Educators' experience in collaboration and their perceived professional preparation were significantly correlated (with PP I - Science competencies, $r = 0.320$; with PP II - Collaborative cultures, $r = 0.188$). The educator's experience in educational collaboration also showed significant correlations with institutional supports positively ($r = 0.270$) and with other barriers negatively (-0.224). An educator who reported higher familiarity with terms in science tended to have more experience in educational collaboration, as well.

Interestingly, educators who have taught longer tended to have less positive attitudes toward scientists' involvement in education, although they reported more experience in educational collaboration. A positive correlation between educators' contemporary view of science / science education and their attitudes toward scientists' involvement in education was also shown ($r = 0.414$).

Finally, we examined the relative contribution of variables in predicting the educators' experience in collaboration with scientists, with the idea that maximizing predictor variables might increase collaboration. Responses to the survey items on experience with scientists served as the dependent variable. The sociodemographic factors, examined as predictors of educators' experience in collaboration, include age in years, teaching experience in years, gender, and level of formal educational attainment (degrees). The indicators used to assess the respondents' experience in collaboration include a self-reported measure of views of science and science teaching/learning, attitudes toward educational collaboration, familiarity with terms in science, professional preparation and perceived barriers to collaboration. Regression analyses were used to determine the performance of each predictor variable and to ascertain the most parsimonious set of variables that predicts collaborating experience. The analyses show that five predictor variables account for a majority of the variance in explaining educators' experience in collaboration with scientists (a combined predictive ability of 32%): attitudes toward collaboration with scientists, professional preparation (science competencies), teaching experience in years, contemporary views of science/science education and perceived institutional support (Table 2.13).

2.6 Discussion

The results reported here provide valuable insights for teachers and scientists engaged in educational collaborations, and for those designing teacher professional development programs to improve their capacity as collaborators in the efforts for science literacy.

Variables	R^2	R^2 change	t / Significance
Attitudes toward collaboration (X1)	.129	.129	3.903 / .000
PP I – Science competencies (X2)	.218	.089	4.713 / .000
Teaching Years (X3)	.270	.052	3.698 / .000
Contemporary views (X4)	.298	.028	2.678 / .008
Institutional supports (X5)	.324	.026	2.577 / .011

Std. Error of the Estimate 0.70, Adjusted $R^2 = 0.304$, For model: $F = 16.476$; $p < 0.001$

Table 2.13: Stepwise regression of educators' experience in collaboration on selected variables.

2.6.1 Barriers and facilitating assistance

Although a growing body of research suggests that collaboration with scientists can be a powerful way to affect teachers' understanding of science, science learning and teaching, and eventually student achievement, only a small portion of educators in this study have experience in working closely with scientists in curriculum development or scientific research. Budget constraints and limited time comprise difficulties for teachers who want to collaborate with scientists for improved science teaching. Other barriers include the lack of a reward system as educators in this study reported.

One positive sign is that teachers in this study consider "help in identifying specific opportunities" as the assistance that *most* facilitates their participation in educational collaboration with scientists. This aligns with their responses indicating they are uncertain about *how* to get involved in educational collaboration with scientists. Institutional supports help, but teachers may need to know more about how to engage scientists in science education (Drayton & Falk, 2006). The results support the argument of Kahle & Kronebusch (2003) that within any given phase of science teacher education there are few connections among scientists and K–12 teachers. Teachers often express interest in working with scientists but are unsure who to contact at their neighboring university or research institute (Dolan et al., 2004). As a means of addressing this issue, educators need professional development opportunities to interact with scientists.

As for professional language as a barrier, the educators in this study showed functional familiarity with the selected science terms. However, the communication barriers may still come from the scientists who do not understand most education terms (Kim & Fortner, accepted; Bell & Buccino, 1997, p.37; Thompson, 2003).

2.6.2 Professional development and collaboration with scientists

We have good evidence that educational collaboration with scientists improves teachers' science teaching and learning. Therefore it is important to develop a collaborative environment/cultures and connections to scientists through the continuum of teacher education: preparation-induction-professionalization. At the front end, participation in science research needs to be an important component of teacher preparation. Providing all prospective teachers chances to participate in research opportunities with scientists, through undergraduate research projects for example, can expose them to the process of scientific inquiry. To foster professionalization for inservice teachers, school systems should strengthen reward systems that support scholarly work in teaching. Considering the educators' years of teaching showed negative correlations with their attitudes toward scientists' involvement in education and collaborative cultures in professional preparation, such research opportunities should also be offered for in-service teachers. Teachers with more years in the classroom might have received their initial development as professionals when or where working with scientists was not highly appreciated. Through these efforts across the teacher education continuum, then, our educators can extend their ability to engage scientists not only as visitors to the classroom but in more substantial collegial ways (Drayton & Falk, 2006).

The correlation analysis shows the connection between educators' experience in collaboration and their perceived professional preparation (Science competencies and Collaborative cultures). The regression analysis implies that for educators' collaboration with scientists the major predictors need to be addressed; attitudes toward collaboration, professional preparation (science competencies), contemporary views of science/science education, and institutional supports. Interestingly, in the parallel study for scientists both collaborative cultures and educational competencies were included in the regression model in explaining scientists' experience with educators (Kim & Fortner, accepted). In this current study for educators, however, the variable of "Collaborative cultures" in professional preparation was not included in the regression model explaining educators' experience with scientists (Table 2.13). Given that the cultures of professional preparation for teachers are much more collaborative than those for scientists (Duggan-Haas, 1998), consideration must be given to increasing educators' science competencies (content knowledge of science or process of inquiry) in thinking how to provide educators opportunities to work with scientists. Fostering mutual learning in essence will require raising scientists' collaborative attributes and teachers' science competencies.

2.6.3 **Professional cultures and COSEE efforts for collaboration**

The results show that most educators have little chance to understand the profession of scientists during their professional preparation. The lack of opportunities to gain science competencies is one manifestation of the different professional cultures of scientists and educators. As Duggan-Haas (1998) described in his article *Two programs, two cultures: The dichotomy of science teacher preparation,* the culture of science departments where most research scientists are trained is different from that of teacher education programs with regard to teaching and learning. Science training culture has been described as typically teacher centered, lecture based and competitive. In contrast, teacher education culture promotes classrooms which are student-centered, discussion-based and cooperative. Every instructional characteristic [use of lecture, cooperative learning, textbook use, methods of assessment] of one program is reversed in the other (Duggan-Haas, 1998, p. 3). As Tanner et al. (2003) argue, the different professional cultures of scientists and K–12 educators can impede collaboration when allowed to go unacknowledged. Understanding the different professional cultures increases the ease of collaboration at the same time.

Many educators in this study wanted to have a better understanding of how scientists conduct research (75.9%) and of the profession of scientists (52.6%). An understanding of different professions and perspectives is critically important in engaging educators in a successful teacher-scientist collaboration. Such differences are not always a barrier: They can lead to collaborations based on strengths and mutual benefits. Compared to the responses of scientists in the parallel study (Kim & Fortner, accepted), educators have more traditional views (empiricist views) on the nature of *science* and more contemporary ones (constructivist views) on *science teaching and learning*. Given that teachers have a good understanding of how they construct their knowledge about students and their teaching and that scientists know how the scientific knowledge is constructed, the interactions among teachers and scientists may lead them into mutual learning. By showing teachers how their own learning is not unlike the processes of science, teachers may develop beliefs about the nature about science that are more in keeping with modern views and are surely less foreign to them (Pomeroy, 1993).

As Caton, Brewer & Brown (2000) insist, collaboration between teachers and scientists can be one promising strategy to "demystify science for teachers who are uncomfortable with this subject." When teachers work on investigations with scientists, they can develop understandings of scientific processes and have greater confidence in their ability to teach science using inquiry methods. Collaboration for educational aims takes many forms, but any of these should pursue a shared vision and mutual benefits based on understanding of the professional cultures of partners.

Among many forms of educational collaboration, resident institutes or intensive summer workshops are reported to be successful in increasing educators' understanding of science and inquiry (Jeanpierre, Oberhauser & Freeman, 2005; Lord & Peard, 1995). Such intensive institutes can also increase constructivist views of science/science education which is one factor in the regression model explaining teachers' experience with scientists (Table 2.13). COSEE Great Lakes summer workshops focus on several mechanisms to foster mutual learning and teacher inquiry development. In these workshops, scientists are not invited to lecture. Instead, teachers read a professional article about a scientist's research and develop questions they would like the scientist to address: explanations, applications, implications, and classroom infusion are generally the topics of the questions. In discussing the science, then, the researcher is making the topic relevant to teachers' needs, and perhaps more importantly, learning about those needs. At the same time, each scientist reads an educational research article as background for the teacher workshop. The scientist is expected to ask questions of the educators about the content and implications of the article.

In week-long shipboard workshops, COSEE Great Lakes educator participants discuss on Day 1 what science data can be collected by the research vessel. In discussions with the scientist participants the educator groups develop hypotheses about relationships among the variables that can be studied. As they learn the aquatic sampling techniques and analyze data alongside the scientists, the educators are living an inquiry experience. Most report this as a new way of "doing science," and their take-home projects reflect its value as they determine how to offer their students such an enriching and relevant science experience in their classrooms. As Caton, Brewer, and Brown (2000) suggest, in developing effective collaborations between scientists and teachers, it is necessary to foster interaction between scientists and educators through experiences focused on a shared vision, inquiry instruction, and learning related to the science content of interests. This research is reinforcing COSEE best practices.

2.7 Summary and conclusions

Engaging teachers in working with scientists for educational aims will likely enhance efforts of COSEE and others to increase the science literacy of students. However, the results reported in this study suggest that while the teachers have positive attitudes toward their collaboration with scientists, their professional preparation has not equipped them with enough understanding of the process of science and the professions of scientists. Some educators have experience in bringing a scientist to their classroom or alternatively taking their students on field trips or lab visits hosted by a scientist. But most do not have experience in working closely with scientists in curriculum development or scientific research. Educators perceive that institutional supports such as funding, time and professional rewards are the primary barriers to their involvement in educational collaboration. At the same time, such barriers as different perspectives on education, different professional cultures and communication gaps can also be factors that deter educators from working with scientists. It is not clear to most of the educators in this study *how* to get involved in educational collaboration with scientists. Thus, the efforts of COSEE to provide them opportunities with scientists can facilitate educational collaboration for science literacy.

Well-designed on-going professional development programs to raise the level of scientific competencies (or scientific knowledge) of teachers and those who will enter the teaching profession are required to achieve the goal of increasing science literacy. Given the general lack of connections between educators and scientists, bringing together educators and scientists involved in scientific research and education to develop a common vision for instruction and collaboration are the first steps.

CHAPTER 3

GREAT LAKES SCIENTISTS' PERSPECTIVES ON K-12 EDUCATION COLLABORATON[2]

3.1 Introduction

3.1.1 Rationale for scientists in public education

In a recent editorial in *Science* magazine, CEO Alan Leshner of the American Association for the Advancement of Science focused attention on a growing concern for all of science: "There is a growing consensus that …scientists must engage more fully with the public about scientific issues and the concerns that society has about them. Efforts that focus simply on increasing public understanding of science are not enough" (Leshner 2007). Most science agencies and institutions that deal with the Great Lakes and other marine/aquatic resources have as part of their mission a charge to increase public knowledge about their science, based on the notion that public support for the science enterprise and, in the case of the Great Lakes, resource protection, is enhanced by awareness of complex concepts and issues. Indeed, measures of public knowledge of Great Lakes science and resource issues demonstrate fairly low levels of science awareness. The public of the 1990s scored about 45% on an interdisciplinary test of Great

---

[2] Accepted for publication as Kim, C and Fortner, R.W. 2008. "Great Lakes scientists' perspectives on K-12 education collaboration." Journal of Great Lakes Research.

Lakes knowledge (Brothers *et al.* 1991), while recreationists with their expanded lake opportunities still scored only 56% (Fortner *et al.* 1991). In 2003 a survey of 1,539 residents of the eight Great Lakes states showed that despite a lack of some knowledge, "residents place much importance on the Great Lakes as a resource to use and protect. At the same time, residents lack awareness about a number of threats to the quality and quantity of water in the Lakes" (Belden Russonello & Stewart 2003).

The response of science agencies and their research colleagues in universities to the need for public information has been to develop programs of education and public outreach (EPO), targeting key groups with information campaigns and media. While most EPO focuses on the adult public and decision makers, scientists have also been encouraged by the National Science Foundation and other sponsors of research to develop outreach directly into K-12 classrooms, an approach that not only fosters continued attention to science as people mature, but also introduces the excitement of learning that can lead to students selecting careers in science.

Thanks to efforts of science agencies, institutions and programs, increasing amounts of Great Lakes information has been available to students and the public in recent years, and with classroom emphases on standards for learning science, there are now greater incentives for inclusion of regional information in classrooms. The science of the lakes provides excellent examples of the range of topics expected from the curriculum to meet National Science Education Standards (NRC 1996), as well as standards in geography (NCGE 1994) and mathematics (NCTM 1989), and all states have their own standards roughly mirroring national ones. Ocean and freshwater sciences provide opportunities to enrich the total curriculum as well as demonstrate its relevance to student lives.

One of the programs seeking to enhance public understanding of Great Lakes and ocean sciences is COSEE (Centers for Ocean Sciences Education Excellence). The ten COSEEs, supported by the National Science Foundation (NSF) and National Oceanic and Atmospheric Administration (NOAA), collaborate to create dynamic national linkages between marine and aquatic research and education with the goal of enhancing scientific literacy and environmental stewardship. COSEE Great Lakes is an eight-state collaborative of the Great Lakes Sea Grant Network education programs. With science partners in NOAA's Great Lakes Environmental Research Laboratory (GLERL), the Cooperative Institute for Limnology and Ecosystem Research (CILER) and the USEPA's Great Lakes National Program Office [GLNPO], COSEE Great Lakes works with educators and scientists from the eight Great Lakes states on ocean/aquatic science literacy efforts.

3.2 Scientists' collaboration in education

Scientists become involved in K-12 education and outreach for a variety of reasons. Sometimes they see a need to provide scientific expertise in their own children's classrooms, and some universities expect faculty to provide service to the community. Clearly, scientists have resources and expertise to offer to the K–12 community. At the same time, scientists themselves can accrue benefits from engaging in educational outreach, such as improvement of teaching skills, communication with a broader audience about research, and learning about education theory (Dolan *et al.* 2004).

In recent years, another compelling reason has emerged for scientists' involvement in K–12 education and public outreach programs. To encourage meaningful involvement in outreach, funding agencies have begun to enforce a stipulation that their grantees participate in public education (Dolan *et al.* 2004). It is sometimes not enough to propose excellent science; it is now necessary to add a strong education outreach component to science research proposals seeking public research funds (Smith 2002). For example, in January 2000, the National Science Foundation (NSF) revised its Grant Proposal Guide to specify that Principal Investigators must address not only the intellectual merit of their proposed activities, but also their benefits to society, the broader impacts. The broader impacts of a research effort can manifest themselves in many ways, including the promotion of teaching, training, and learning, as well as the enhancement of public understanding of science and technology. Such a mandate has prompted an unprecedented number of scientists to seek opportunities to participate in precollege education and outreach (Dolan *et al.* 2004).

Traditionally, many scientists have made school visits and taught single lessons for education and outreach. Such involvement is important, but represents only a small sample of the spectrum of roles scientists can play (Morrow and Dusenbery 2004, Bainer *et al.* 1998). There are much broader and deeper ways that the expertise of scientists may contribute to improving science education. Morrow (2000) suggests a framework to describe the different levels of involvement in a variety of activities that contribute to improving K-12 science education. Scientists' level of involvement can include *advocacy*, acting as a *resource*, or *partnership*. Advocating does not require as much time and commitment as does becoming a full partner and joining in the work of teaching or developing instructional materials. An advocate generally empowers others in their educational outreach efforts, for example by speaking out in support of science education. Acting as a resource, such as making presentations, judging a science fair, or serving on an advisory board for a science education project is a good intermediate level of involvement. Partnership between scientists and educators might take the form of mentoring teachers or students, implementing curriculum with teachers, or other intensive involvement. Such partnership activities can be mutually beneficial both to scientists and educators, but they come with their own challenges that may deter widespread application of the models.

Factors that serve as barriers inhibiting scientists' involvement in education and outreach have been described in some studies. Surveying 73 scientists (before public funding agencies had begun to require that research have a "broader impact"), Andrews *et al.* (2005) reported that scientists identified "lack of time" and "lack of information about outreach opportunities" as top barriers to participation in outreach while "lack of interest" and "funding" were less important barriers. Dolan *et al.* (2004) pointed out that challenges such as absence of reward systems for participation in outreach and lack of training for scientists doing outreach may impede scientists' participation in educational outreach. Interviewing leaders of educational partnerships, Bainer (2001) suggested strong predictors of a partnership's demise include "lack of commitment by resource professional (such as scientists)" and "lack of relationships among partners", experienced as lack of communication or lack of mutual support, etc.

A strong collaboration between scientists and educators also requires a careful negotiation of the boundaries between distinct academic cultures (Carr 2002). As

Duggan-Haas *et al.* (2000) suggest, “differing perspectives on the knowledge base for teaching and learning” and “lack of understanding of the disciplines, workings, and goals” of collaborators can be another type of barrier. There are few studies on such barriers to teacher-scientist collaboration, though the subject is critically important.

3.2.1 This study

This study examines the ways in which scientists are involved in educational outreach and the barriers that deter their participation. In particular, we look at the experience and attitudes of research scientists whose foci are on the Great Lakes. Our goal is to gain insight that will inform research scientists who seek collaboration with educators to more effectively deliver education outreach programs, particularly for K-12 teachers and students. As a baseline, such information will be of particular value to programs such as COSEE Great Lakes, whose focus is on facilitating scientist-educator interactions and improving scientists’ educational outreach capacity. We used three research questions for the study reported here: 1) how are Great Lakes scientists involved in K-12 education, 2) what barriers may deter their participation in educational outreach and 3) which factors are related to scientists’ potential for the role of education partner.

3.3 Methods

To characterize the population of Great Lakes scientists targeted as a potential audience for activities of COSEE Great Lakes, we developed a baseline study of “Perceptions of Cultural Differences and Collaboration among Scientists and Educators.” We expect to repeat the study in 2010 to gauge the overall COSEE program outcomes related to increasing collaborations among scientists and educators. In the study we defined “educational outreach” or “outreach” as scientists’ efforts to make scientific information available to the public and schools. “Education” connotes for us the domain and personnel of classroom education in U.S. grades kindergarten to twelve (K-12).

3.3.1 Survey instrument and participants

Quantitative data were collected for this study through the use of written surveys. A survey instrument composed of 75 statements plus demographic items was developed based on literature review. Sections of the survey invited response to items on characteristics of science (9 items), how science is taught and learned (8 items), familiarity with 10 terms in science and education, role of scientists in education and outreach (6), professional preparation and experience (11), roles of scientists and educators (12), barriers to educational outreach (12), and seven items related to factors or opportunities that would assist scientists in educational outreach. Most sections were worded to be parallel to a concurrent survey being conducted among secondary science teachers in the Great Lakes states. For views of science and science education, Pomeroy’s (1993) items were modified to represent traditional views (empiricist views) and contemporary views (constructivist views). Items in the other sections were based on unpublished COSEE surveys. A panel of 15 experts in environmental/science education, communication or collaboration examined the instrument to establish content validity.

Marine and aquatic scientists were recruited at a conference on Great Lakes research to participate in the study. We chose the conference since it represented the largest gathering of Great Lakes scientists, and the group that might be most interested in the results of such research. The National Science Foundation, aware of the prominence of the International Association for Great Lakes Research (IAGLR), approved support for a COSEE workshop in the organization's conference, and the structure of that "School for Scientists" could be based on the research results.

Six hundred copies of the survey were distributed to all conference participants in the registration packet, and a prize drawing was offered as incentive to participate. Most respondents returned their surveys during the conference period but six returned them by mail after the conference. We followed up with an additional recruitment through scientist networks and received additional responses. The additional recruitment group did not show any difference in terms of age, gender, working years and most responses in the survey compared with the conference group; in fact some of them used the survey form they received at the conference. We can therefore assume that late responders are from the same population.

3.3.2 Data Analysis

The Statistical Package for the Social Sciences (SPSS) was used for data analysis. The coded responses from the survey were transferred to an SPSS data file. Descriptive information on scientists' attitudes toward, and their experience in, and perceived barriers to participating in education and outreach were examined. To investigate factors related to the scientists' potential role of education partner, we studied the correlations between scientists' experience in education (partner role and resource role) and three indices: attitude toward scientists' involvement, familiarity with terms in education, and professional training. The Pearson product-moment correlation coefficients (r) were reported.

Then, we examined the relative contribution of variables in predicting scientists' experience in collaboration with teachers, with the idea that maximizing predictor variables might increase collaboration. Responses to the survey items on partner role experience with teachers served as the dependent variable. The sociodemographic factors, examined as predictors of scientists' partner role experience, include age in years, gender, and level of formal educational attainment (degrees). The indicators used to assess the partner role experience of respondents include a self-reported measure of familiarity with terms in education, attitudes towards involvement, professional training, and perceived barriers to educational outreach. Multilinear regression analyses were used to determine the performance of each predictor variable and to ascertain the most parsimonious set of variables that predicts collaborating experience.

3.4 Results

We received a total of 94 survey responses (16% response rate) after follow-up. Considering all responses were voluntary and self-selected, the possibility of bias arises from those who elected to take the time to respond to the survey in that they may have been: (1) more interested in science education and outreach; and/or (2) more confident in working with educators. Of the 94 scientist respondents, 52 (57%) were men while 39 (43%) were women. Their principal areas of investigation were aquatic ecology, 34%; aquatic biology, 17%; environmental engineering, 13%; limnology/oceanography, 12%;

environmental chemistry, 12% (Table 3.1). Their average age was 42 (range = 20-74), and they reported an average of 15.5 years of research experience (range = 1-40).

When asked to check all categories that described their main job functions, 70% of the respondents reported that research was their primary job responsibility, 25% identified postsecondary teaching, and 19% reported that they were graduate students. Therefore, we will refer to all respondents as “Great Lakes researchers” with current or potential for research. Twelve respondents (13%) reported outreach/extension education as one of their main jobs. As suggested in the discussion of bias, the reported experience and interest in educational outreach may be higher than one would normally expect from the population of the Great Lakes researchers due to self-selection of respondents in this study.

Regarding their current conditions of funding, 62 respondents (69%) reported they are required to demonstrate the “broader impact” of research either most of the time (25, 28%) or some of the time (37, 41%), while 18 respondents (20%) reported that they are not required to demonstrate the “broader impact” at all. Only 7 (8%) were not sure what is meant by "broader impact." When asked whether including an educational outreach component in research proposals enhances their chances of receiving research funding, 34 scientists (38%) reported yes, 26 (29%) no, and 27 (30%) were not sure or didn’t know.

Areas of Investigation	Frequency (Percent, %)
Ecology (aquatic, fisheries)	32 (34.0%)
Biology (aquatic, conservation)	16 (17.0%)
Environmental/civil engineering	12 (12.8%)
Limnology/Oceanography	11 (11.7%)
Bio/environmental chemistry	11 (11.7%)
Policy / Management	8 (8.5%)
Others	4 (4.3%)
Total	94 (100.0%)

Table 3.1: Frequency and percentage of principal areas of investigation reported by scientists responding to the survey of perceptions of collaboration.

3.4.1 Scientists' attitudes toward involvement in education and outreach

Seven statements were used to measure scientists’ attitudes toward their roles in education and outreach. More than 90% of respondents either agreed or strongly agreed that it is important for research scientists to get involved in educational outreach projects (91.5%) and to support K-12 education (91.2%) (Table 3.2). Despite these expressions of value, the scientists perceived that it was less important to work directly with K-12 teachers (72.4%) and to include educational outreach plans in their research proposals (66.0%).

Statements	% Agree*	Mean (SD)
Scientists' involvement in educational outreach increases public understanding of scientific research.	94.7%	3.63 (.53)
It is important for research scientists to get involved in educational outreach projects.	91.5%	3.48 (.62)
It is important that research scientists support K-12 education.	91.2%	3.47 (.66)
Scientists' involvement in educational outreach projects motivates students to be interested in scientific careers.	91.5%	3.41(.60)
By getting involved in educational outreach, scientists can develop the educational foundations for informed decision-making in public policy.	86.1%	3.23 (.69)
It is important for research scientists to work directly with K-12 teachers.	72.4%	2.93 (.76)
Research scientists should include educational outreach plans in their funding proposals.	66.0%	2.93 (.90)

Ratings were on a 4-point Likert scale (1=strongly disagree; 4=strongly agree).
Asterisks (*) indicate percentage of respondents who either agreed (3) or strongly agreed (4) with each statement.

Table 3.2: Percentage, means and standard deviations of scientists' responses to attitude statements regarding their involvement in education and outreach.

3.4.2 Experiences in education and outreach

This study examined the ways in which scientists are involved in educational outreach. The scientists responded that among the activities described they most frequently give presentations about their research to the public (83.5%). About sixty percent of scientists reported that they have presented their research to K-12 students and hosted students to research sites. However, only one third of the scientists reported direct collaborations with teachers. Factor analysis categorized six statements about scientists' experience in educational outreach into two groups, hereafter called "Resource role experience" and "Partner role experience" in Morrow's (2000) framework (Table 3.3). The summary of responses confirms that most scientists do not play the role of "partners."

3.4.3 Professional training for scientists

Factor analysis categorized six statements about professional training for scientists into two groups, herein called "Professional training I – educational competencies" and "Professional training II - collaborative cultures." Regarding the educational competencies, only 27% of scientists reported that their professional training as a scientist equipped them with enough knowledge in education. In addition, only 20% (primarily those who identified education/outreach as one of their main jobs) reported that they took more than one course in education during their professional training (Table 3.4). Compared to a group of educators in a parallel study (Kim and Fortner 2007), fewer scientists reported that they were trained in collaborative cultures. About half of the scientists (56%) indicated they had been trained in institutions using cooperative learning in contrast to 94% of respondents in the parallel study for educators. This classroom methodology is seen as key to student growth in teamwork that simulates how scientists work (Fortner, 2001) and an important component of acceptance of partners. This finding is in line with what Duggan-Haas (1998) described in his ethnographic research regarding the different professional training cultures for scientists and educators.

Role	Statements	% Agree	mean (SD)
Resource	I have made numerous presentations about my research to the public.	83.5%	3.40 (0.92)
	I have hosted field trips or lab visits for K-12 students.	61.1%	2.68 (1.31)
	I have experience in making presentations about my research to K-12 students.	58.9%	2.64 (1.17)
Partner	I have consulted with science educators on curriculum development.	33.3%	2.01 (1.12)
	I have conducted collaborative research with teachers.	33.0%	2.02 (1.15)
	I have experience in calling on teachers for their pedagogical knowledge.	24.4%	1.84 (1.10)

Items were rated on a 4-point Likert scale (1=strongly disagree; 4=strongly agree).

Table 3.3: Percentage, means and standard deviations of scientists' reported experience in education and outreach.

Statements: Professional Training I Educational competencies	% Agree	mean (SD)
My professional training as a scientist has equipped me with enough knowledge in teaching.	27.1%	2.08 (0.83)
I took more than one course in education during my professional training.	20.2%	1.63 (1.11)
I believe that I am equipped with the ability to help students gain a better understanding of science	87.7%	3.31 (0.68)
Statements: Professional Training II Collaborative cultures	**% Agree**	**mean (SD)**
During my professional training I often worked often in collaborative groups.	78.3%	3.09 (0.83)
At least one college I attended encouraged the use of cooperative learning.	55.6%	2.67 (1.09)
The teacher-student relationships in at least one college I attended were warm and supportive.	83.3%	3.31 (0.77)

Items were rated on a 4-point Likert scale (1=strongly disagree; 4=strongly agree).

Table 3.4: Percentage, means and standard deviations of professional training reported by scientists.

3.4.4 Barriers to participating in educational outreach

Using twelve survey statements, we examined scientists' perceived barriers to participating in educational outreach. Barrier statements in Table 3.5 are in descending order from primary to less important barriers. External barriers such as funding, time and professional rewards are among top barriers. About 90% of scientists agreed that lack of time and absence of reward systems may deter their participation, and most respondents reported that research scientists do not have enough funding for outreach activities (95.7%). Table 3.5 also shows that differing perspectives on education between scientists and educators is an important barrier (87.7% agreed) as Duggan-Haas *et al.* (2000) suggested in their qualitative study. Almost 90% of scientists in this study claim it is not clear to them how to get involved in education outreach.

Statements	% Agree
Research scientists do not have sufficient funding for outreach activities.	95.7%*
Research scientists need assistance in creating resources for K-12 students.	91.3%
Research scientists do not have sufficient time for outreach activities.	89.3%*
It is not clear to research scientists how to get involved in educational outreach.	88.2%*
K-12 teachers have different perspectives on education from scientists.	87.7%
Research scientists do not receive adequate professional rewards for engaging in outreach activities.	86.0%*
Funding agencies do not place much importance on educational outreach.	71.8%*
Research scientists are unaware of what K-12 students need to learn.	71.1%
Institutions do not support research scientists' educational outreach.	67.8%
Research scientists have difficulty in communicating with K-12 teachers.	58.5%
Research scientists are not interested in education and outreach activities.	52.3%*
The public is not interested in learning about my research.	16.5%*

Statements with asterisks (*) were originally stated in reverse terms. For such items, percentage of Disagree and Strongly disagree are reported

Table 3.5: Percent agreement of scientists regarding barriers to participating in educational outreach.

3.4.5 Familiarity with terms in education: Barriers of language in collaboration

To examine barriers of language in collaboration, we asked scientists to indicate their familiarity with terms/concepts in education (Table 3.6). We can assume that the terms are common to educators since most educators in a parallel study reported that they have used such terms *in practice*: classroom management (98%), "hands-on" activities (98%), National Science Education Standards (78%), constructivist learning theory (46%), inquiry-based learning (87%) (Kim and Fortner 2007). Scientists in this study were especially not familiar with such education terms/concepts as constructivist learning theory and National Science Education Standards. Constructivist learning theory refers to the idea that each learner individually and socially constructs knowledge as he or she learns, building it on a scaffold of prior knowledge and experience. The National Science Education Standards are guidelines for the science education in primary and secondary schools in the United States. (There were several Canadian respondents in this study and one commented that the term does not represent Canadian standards.) The standards have influenced teachers and administrators in offering a vision of what it means to be scientifically literate and how best to achieve such literacy at different grade levels (Morrow 2003). Fewer than 10% of scientists reported that they incorporated these concepts into their practice and more than half of them were unaware or not sure of the concepts.

Terms/concepts in education	Not familiar	Not sure	I know, but	I've used
Classroom management	15 (16.7%)	26 (28.9%)	24 (26.7%)	25 (27.8%)
"Hands-on" activities	1 (1.1%)	1 (1.1%)	8 (6.7%)	82 (89.1%)
National Science Education Standards	25 (27.5%)	37 (40.7%)	21 (23.1%)	8 (8.8%)
Constructivist learning theory	47 (51.1%)	24 (26.1%)	16 (17.4%)	5 (5.4%)
Inquiry-based learning	9 (9.8%)	16 (17.4%)	28 (30.4%)	39 (42.4%)

Items were rated on a 4-point Likert scale (1 = I am NOT familiar with the concept at all. 2 = I've heard of the term, but I'm not sure what it means. 3 = I know what this is, but I've never used it in practice. 4 = I know what this is and I've used it in practice).

Table 3.6: Frequency and percentage of scientists' perceived familiarity with terms/concepts in education.

3.5.6 Factors related to scientists' potential for education partnership

To investigate factors related to the scientists' potential role of education partner, we studied the correlations between scientists' experience in education (partner role and resource role) and three indices: attitude toward scientists' involvement, familiarity with terms in education, and professional training. When comparing the characteristics of individual scientists, a person who had a positive attitude toward scientists' involvement also tended to have more experience in educational outreach (with resource role experience r = 0.395, $p < 0.001$; with partner role experience r = 0.291, $p < 0.01$). A scientist with more experience in educational outreach tended to show higher familiarity with terms in education. Professional training of scientists and partner role experience were significantly correlated (with Professional training I – Educational competencies, r = 0.468; with Professional training II – Collaborative cultures, r = 0.381). Interestingly, the connection between collaborative cultures in professional training (Professional training II) and resource role experience was not as obvious (Table 3.7).

Variable	**Resource Role Experience**	**Partner Role Experience**
Attitude towards scientists' involvement	.395(**)	.291(**)
Familiarity with terms in education	.529(**)	.506(**)
Familiarity with terms in science	.027	.006
Professional training I – Educational competencies	.349(**)	.468(**)
Professional training II - Collaborative cultures	.191	.381(**)

A single asterisk (*) indicates significance at the 0.05 level; double asterisk (**) indicates significance at the 0.01 level.

Table 3.7: Two-tailed correlations between scientists' experience in educational outreach and explaining variables (n=94).

Finally, we examined the relative contribution of variables in predicting scientists' experience in collaboration with teachers, with the idea that maximizing predictor variables might increase collaboration. On the basis of the data analyses for the entire sample there are four predictor variables which account for a majority of the variance in explaining partner role experience and serve as the most parsimonious predictor set: 1) familiarity with terms in education, 2) professional training II - collaborative cultures, 3) age and 4) professional training I – educational competencies. Other variables such as gender, degrees, attitudes and perceived barriers were excluded by the regression model. The four predictors have a combined predictive ability to explain 42% of the variance in partner role experience of scientists (Table 3.8).

Variables	**Regression Coeff.** B	**S.E.**	**Regression Coeff.** β	R^2	R^2 **change**
Education terms	.485	.166	.303 **	.256	.256
Professional training II	.462	.121	.358 ***	.333	.078
Age	.018	.007	.236 *	.374	.041
Professional training I	.380	.151	.260 *	.419	.045
(constant)	-2.408	.645			

(Adjusted R^2 = 0.391). A single asterisk (*) indicates significance at the 0.05 level; double asterisk (**) at the 0.01 level; triple asterisk (***) at 0.001 level.

Table 3.8: Stepwise regression of partner role experience on model-selected variables.

3.6 Discussion

3.6.1 Barriers to educational outreach

Barriers to Great Lakes scientists' involvement in education outreach identified in this study are mainly in line with the previous studies (Andrews *et al.* 2005; Dolan *et al.* 2004). External barriers such as funding, time and professional rewards are among top barriers. It is interesting to see that most of the respondents in the present study reported that research scientists do not have enough funding for outreach activities, while Andrews *et al.* (2005) reported the scientists in their study identified "funding" as one of the less important barriers. Their study was conducted in 1999-2000, however, before public funding agencies began to require a "broader impact." Since funds for education and public outreach can now be requested from sponsors, we expected that funding would not be an issue. Perhaps the EPO requirement has become a source of proposal development stress, with scientists uncertain how to justify funds for broader impact.

As can be seen in Table 3.5, to most scientists (88%) it is not clear *how* to get involved in education outreach. The result supports earlier findings that challenges such as lack of training for scientists doing outreach may impede scientists' participation in educational outreach (Dolan et al., 2004). Just as teachers often express interest in working with scientists but are unsure about whom to contact at their neighboring university or research institute, scientists are not aware how and where to start interactions with education. Scientists who are parents of school-age children may find and exploit opportunities and contacts made in their children's schools. However, for scientists who lack these informal contacts, finding a partner teacher or school can be daunting (Tanner *et al.* 2003) as *all* scientists in the study of Andrews *et al.* (2005) stated that they lacked information about outreach opportunities. These results suggest that scientists may need training/assistance in working closely with teachers for educational partnership.

3.6.2 Professional training and language barriers

Scientists in this study were involved in educational outreach more frequently as a "resource" than a "partner" in Morrow's framework (2000). Professional training of scientists and their lack of knowledge in education may explain the ways in which scientists are involved in educational outreach. Scientists' lack of knowledge in education was demonstrated by their unfamiliarity with the terms/concepts in education (Table 3.6). The results also show that most scientists had little chance to obtain knowledge in professional *education* during their professional *science* training. The lack of opportunities to gain educational competencies is one manifestation of the different professional cultures of scientists and educators.

As Duggan-Haas (1998) described in his article *Two programs, two cultures: The dichotomy of science teacher preparation,* the culture of science departments where most research scientists are trained is different from that of teacher education programs with regard to teaching and learning. "It seems that every instructional characteristic [use of lecture, cooperative learning, textbook use, methods of assessment] of one program is reversed in the other" (p. 3). Science training culture has been described as typically teacher centered, lecture based and competitive. In contrast, teacher education culture promotes classrooms which are student-centered, discussion-based and cooperative (Duggan-Haas 1998). Over the last decade, the National Science Foundation has addressed these issues through support of GK-12 programs, in which graduate students in the sciences are introduced to service in K-12 science classrooms. While they bring current science to the students, the scientists-in-training learn how to communicate effectively with non-scientists and how to use effective instructional strategies that are learner-centered. Such programs may help to blur the differences between science and education training cultures in the coming generation of scientists.

When professionals come together across the professional cultural boundaries of their disciplines, language can also become a barrier. In addition to the more cautious communication styles of scientists and the more open communication styles of teachers, even phrases and single words can present challenges in partnership communication (Tanner *et al.* 2003). Scientists in this study were unfamiliar with education terms (Table 3.6). Moreover, scientists may also have misconceptions about education terms. From the experiences in scientist-educator partnerships, for example, "Standards-based activities" were seen as equivalent to "hands-on activities," though the basis of these terms is quite different (Morrow 2003). This study did not explore for misconceptions, but next steps in research should examine such a possibility among Great Lakes researchers.

Interestingly enough, about 90% of scientists reported that they have used "hands-on" activities *in practice*. However, the meaning of "hands-on" may differ from teachers' understanding of the term. In analyzing the language barrier in scientist-teacher partnerships, Tanner *et al.* (2003) explained that when noneducators (scientists) attempt to derive the meaning of education terms composed of common words, they interpret them simply as the sum of the conjoined terms. Tanner *et al.* (2003) also showed that a seemingly simple word such as *activity* can have different multiple meanings when definitions are compared among teachers and scientists. Similarly, the scientists in this study might interpret "*hands-on" activity* differently from teachers.

Such unfamiliarity with education terms, lack of knowledge in education theory and practice, and different professional cultures can be factors that deter scientists' involvement in educational outreach. These barriers become more important when a scientist intends to play a role of "partner" in educational outreach which requires a closer working relationship with educators.

3.6.3 Scientists' role as education partners

The correlation analysis shows the connection between professional training of scientists and their role in educational outreach is more obvious when they play a role of education partners than when they act as a resource. A scientist who has been trained in a collaborative culture tends to be more experienced in the partner role in educational outreach, as opposed to the resource role. Considering the science training culture is traditionally less collaborative (Duggan-Haas 1998), such correlations explain why scientists in this study are involved in educational outreach more frequently as Morrow's "resource" role than "partner" role.

The regression analysis implies that for scientists' collaboration with teachers in educational outreach two major predictors need to be addressed; familiarity with terms in education, and professional training (collaborative cultures and educational competencies). As Tanner *et al.* (2003) suggest, a workshop to introduce scientists to educational theory and practice, and the "culture of educators" will be helpful for scientists. Such a program addressing cultural similarities and differences between scientists and educators may improve scientists' capacity in educational outreach and facilitate development of teacher-scientist partnerships.

3.7 Summary and conclusion

Engaging Great Lakes research scientists in educational outreach will likely enhance efforts of COSEE and others to increase ocean and Great Lakes science literacy. However, the results reported in this study suggest that while the scientists have positive attitudes towards their involvement in educational outreach, their training has not included knowledge of education systems. Some of the Great Lakes researchers have "resource role experience" in educational outreach, but most of them do not have "partner role experience" to directly collaborate with teachers.

Scientists perceive that funding, time and professional rewards are the primary barriers to their involvement in educational outreach. At the same time, such barriers as different perspectives on education, different professional cultures and communication gaps can also be factors that deter scientists' involvement in educational outreach. These barriers become more important when a scientist intends to play a role of education partner which requires a closer working with educators.

The regression analysis implies that scientists' partner role experience can be explained by their professional training and familiarity with terms in education. Considering that current professional training for scientists lacks training opportunities for scientists in education theory and practice, it seems to be critically important provide those opportunities to improve scientists' capacity in educational outreach and to ensure their participation as partners. In Leshner's (2007) words, "university science departments should design specific programs to train graduate students and postdoctoral fellows in public communication. …We need to add media and communications training to the scientific training agenda." To equip scientists with skills for closely working in partnership with teachers, then, COSEE Great Lakes "schools for scientists" should include fundamentals of educational theory and practice, and recognition of the "culture of educators."

Given that "the public throughout the Great Lakes region holds a strong sense of responsibility for taking care of the Lakes" but lacks awareness of issues (Belden Russonello & Stewart 2003), greater efforts are required for public education and outreach of science. The low response rate on this survey may indicate that indeed only a small percentage of scientists are interested in public education. The respondents have nevertheless given an insight into why greater levels of outreach and education are not being sought or achieved. COSEE Great Lakes planning includes a number of opportunities for scientists to learn about education and to engage in education interactions through 2010. Following those efforts, we expect to repeat the survey for two groups of scientists. Those who are actually COSEE program participants will represent a "treatment" group, and self-selected attendees at the IAGLR conference (excluding COSEE participants) will again give a measure of perceptions within the general scientist population of the region. That follow-up study will gauge program effectiveness and help identify the need for future directions.

Science teachers represent an audience that is receptive to interaction and has its own outreach into today's and tomorrow's public. To work with the education audience effectively, it is also necessary to see scientists themselves as an audience. "If science is going to fully serve its societal mission in the future, we need to both encourage and equip the next generation of scientists to effectively engage with the broader society in which we work and live" (Leshner 2007).

CHAPTER 4

FACTORS ASSOCIATED WITH COLLABORATION EXPERIENCE OF K-12 TEACHERS AND SCIENTISTS[3]

4.1 Introduction

Based on a growing concern for all of science, CEO Alan Leshner of the American Association for the Advancement of Science stressed importance of scientists' roles in society in an editorial in *Science*: "There is a growing consensus that …scientists must engage more fully with the public about scientific issues and the concerns that society has about them. Efforts that focus simply on increasing public understanding of science are not enough" (Leshner, 2007). There has been a significant growth of interest in facilitating educational collaboration between teachers and scientists to ultimately improve students' science literacy (e.g., Kim & Fortner, 2007; Drayton & Falk, 2006; Dresner & Worley, 2006; Dolan, Soots, Lemaux, Rhee & Reiser, 2004; Morrow & Dusenbery, 2004; Tanner, Chatman & Allen, 2003). To encourage scientists' meaningful involvement in K-12 education and public outreach (EPO) programs, many funding agencies have begun to enforce a stipulation that their grantees participate in educational arenas. Such a mandate has prompted an unprecedented number of scientists to seek or

[3] Submitted for publication as Kim, C and Fortner, R.W. In review. "Factors associated with collaboration experience of K-12 teachers and scientists." Journal of Research in Science Teaching.

develop opportunities for EPO (Dolan et al., 2004), many of which involve interactions with schools, teachers or curriculum. Unfortunately, detailed knowledge of mechanisms to facilitate, support, and sustain collaborative relationships between scientists and educators is lacking.

This study is informed by three related clusters of scholarship: (1) the literature that reported teacher-scientist collaboration initiatives (projects); (2) differences in professional cultures of teachers and scientists; and (3) barriers to teacher-scientist collaboration.

4.1.1 Collaboration between teachers and scientists: How are they involved?

Scientists become involved in K-12 education in a variety ways. Perhaps the most common practice involving scientists in education is to bring a scientist to the classroom or alternatively to take students to a scientist (e.g., field trips or lab visits). Such involvement is important, but represents only a small sample of the spectrum of roles scientists can play in science education (Morrow & Dusenbery, 2004). Other general approaches to engaging scientists are to involve a scientist as a key member of a curriculum development effort, a deliverer of content in teacher enhancement, a partner in scientist-student(-teacher) partnerships, or a teacher mentor, providing a teacher with the opportunity to work on a research project (Drayton & Falk, 2006).

Morrow (2000) suggests a framework to describe the different levels of scientists' involvement for K-12 science education: Scientists can serve in K-12 education as *advocates*, *resources*, or *partners*. An advocate generally empowers others in their educational outreach efforts, for example by speaking out in support of science education.

Acting as a resource, such as making presentations, judging a science fair, or serving on an advisory board for a science education project is a good intermediate level of involvement. Partnership between scientists and educators might take the form of mentoring teachers or students, implementing curriculum with teachers, or other intensive involvement. Such partnership activities can be mutually beneficial both to scientists and educators. Clearly, scientists have resources and expertise to offer to the K–12 community. At the same time, scientists themselves can accrue benefits from engaging in educational outreach, such as improvement of teaching skills, communication with a broader audience about research, and learning about education theory (Dolan et al. 2004).

The role of scientists as partners in science education, and especially in teacher professional development, has grown in importance (Kim & Fortner, 2007; Drayton & Falk, 2006). Scientists can make an important contribution to the professional development of science teachers: they represent a special source of insight about science content and process, the structure of their field of knowledge, and key approaches to curriculum and pedagogy in their area of expertise (Drayton & Falk, 2006). A growing body of research suggests that collaboration with scientists can be a powerful way to affect teachers' understanding of science, science learning and teaching, and eventually may lead to improved student achievement (Dresner & Worley, 2006; Fortner, Corney & Mayer, 2005; Kahle & Kronebusch, 2003; Caton, Brewer & Brown, 2000; Von Secker & Lissitz, 1999). Therefore, Loucks-Horsley, Love, Stiles, Mundry & Hewson (2003) suggest that one of principles in quality professional development experiences is to provide opportunities for teachers to work with other experts (scientists) in learning communities to improve their practice (p.47).

Collaboration is generally defined as a mutually beneficial relationship between individuals, groups, and organizations in which they work together to achieve common goals (Uchida, 2005; Mattessich, Murray-Close & Monsey, 2004). In *Shared Minds*, Schrage (1990) defines collaboration as "the process of shared creation: two or more individuals with complementary skills interacting to create a shared understanding that none had previously possessed or could have come to on their own" (p.40). In *Interaction*, Friend and Cook (2007) define collaboration as "a style for direct interaction between at least two co-equal parties voluntarily engaged in shared decision making as they work toward a common goal" (p.7). In this study, we functionally defined "educational collaboration," often part of "education and public outreach" (EPO) from the scientists' side, as efforts among K-12 teachers and scientists to improve students' science literacy. This includes the full spectrum of lower to higher levels of involvement of teachers and scientists (e.g., resource role to partner role of scientists).

4.1.2 Differences in professional cultures: K-12 teachers and scientists

Several studies have investigated different cultures in the profession of K-12 teachers and scientists (Tanner et al., 2003; Carr, 2002; Turner, Miller & Mitchell-Kernan C., 2002; Duggan-Haas et al., 2000). Culture is a complex concept, with many different definitions. But, simply put, "culture" refers to a group or community with which we share common experiences that shape the way we understand the world (DuPraw & Axner, 1997). In this study, we use a functional definition: When groups of people develop their own sets of beliefs about themselves and others, such groups constitute, functionally, a "culture" (Carr, 2002).

As Duggan-Haas (1998) described in his article *Two programs, two cultures: The dichotomy of science teacher preparation,* the culture of science departments where most research scientists are trained is different from that of teacher education programs with regard to teaching and learning. Science training culture has been described as typically teacher centered, lecture based and competitive. In contrast, teacher education culture promotes classrooms which are student-centered, discussion-based and cooperative. Every instructional characteristic [use of lecture, cooperative learning, textbook use, methods of assessment] of one program is reversed in the other (Duggan-Haas, 1998, p. 3). With a cultural difference model, Carr (2002) analyzed a collaborative, interdepartmental project between scientists and teachers, and found several notable differences, including different approaches to learning and knowing. For example, Carr (2002) summarized that in a teacher education department, everybody is seen as a co-learner, and knowledge is gained through not only individual effort but as a result of relationships and dialogue. In a science department, on the other hand, learning is the assimilation of knowledge delivered by experts. In other words, teachers are prepared in more *collaborative* disciplinary cultures while scientists are prepared in more *lone-scholar* disciplinary cultures (Turner et al., 2002).

Such different cultures in professional preparation may directly contribute to cultural tendencies and differences between scientists and K-12 teachers in services. Based on their experience over eight years of 4-day workshops on education and public outreach, Morrow & Dusenbery (2004) reported the cultural differences observed with over 400 scientists, engineers and education managers. While scientists are seen as intellectually confident, competitive, critical and less socially adept, teachers are often less intellectually confident, collaborative, appreciative, and have good social skills. These compressions into two categories could be an oversimplication, and by no means all distinctions apply to all teachers and scientists. Nevertheless, they can suggest a lens for considering professional cultures of teachers and scientists for educational collaboration of both professions (Turner et al., 2002). When K-12 teachers collaborate with scientists, both groups need to understand the distinct academic cultures and recognize obstacles such as differing perspectives on teaching and learning (Carr, 2002; Duggan-Haas et al., 2000).

4.1.3 Barriers to interprofessional collaboration

Although the need for collaboration between teachers and scientists is clear, barriers exist that often make such collaboration difficult. Barriers to the practice of interprofessional collaboration can foil the best intentions and efforts of participants. According to Walsh, Bradeck & Howard (1999), barriers to interprofessional collaboration exist at both conceptual and practical levels. As for conceptual barriers, the current *understanding of profession* in an expert model often inhibits collaborative relations. Issues of *status* may influence an individual's willingness to work collaboratively with professionals from other disciplines. As for practical barriers, many work environments present professionals with *structural constraints* to engaging in interprofessional collaboration, including financial arrangements, staffing patterns, and work-day responsibilities. The subtle but significant differences in the *cultures of professions* may also serve to discourage collaboration. *Professional preparation* programs have typically focused on isolated non-collaborative models of practice (Walsh et al., 1999).

What determines whether teachers and/or scientists develop collaborative relationships with each other that serve to enhance both professions? In the teacher-scientist collaboration context, unfortunately, detailed knowledge of mechanisms to facilitate, support, and sustain such relationships is lacking. Factors that serve as barriers inhibiting scientists' involvement in educational collaboration have been described in a limited number of studies (Andrews, Weaver, Shamatha & Melton, 2005; Dolan *et al.*, 2004). Surveying 73 scientists, Andrews *et al.* (2005) reported that scientists identified "lack of time" and "lack of information about outreach opportunities" as top barriers to participation in outreach while "lack of interest" and "funding" were less important barriers. Dolan *et al.* (2004) pointed out that challenges such as absence of reward systems for participation in outreach and lack of training for scientists doing outreach may impede scientists' participation in EPO opportunities.

Although collaboration with scientists can be a powerful way to affect teachers' capacity for student achievement, only a small portion of K-12 teachers have chances to work closely with scientists (Kim & Fortner, 2007). Budget constraints, limited time, and reward system comprise difficulties for teachers who want to collaborate with scientists for improved science teaching. Such institutional supports are always desirable, but their absence is no reason not to pursue the benefits of educational collaborations. Teachers need to know more about how to engage scientists in science education (Drayton & Falk, 2006): They often express interest in working with scientists but are unsure about whom to contact at their neighboring university or research institute (Dolan et al., 2004).

Recently, Carlone and Webb (2006) explained the complexities of collaboration between teachers and university-based educators with a cultural model – hierarchy model, and argued that deficit-based explanations (e.g., blaming individuals or organizational structures) mask the ways meaning is made in interaction with others. Several studies have described cultural differences, but though the subject is critically important, there are few studies on how such cultural factors play roles in teacher-scientist collaboration.

Teachers' views about the nature of science, their science teaching, and the science learning of their students can be different from those of scientists (Lunn, 2002; Pomeroy, 1993). Differences between these cultures also include differences in the level of professional autonomy, and the nature of peer relations as well as scientists' unfamiliarity with issues of classroom management and logistics (Kim & Fortner, 2007; Drayton & Falk, 2006). K-12 teachers may have a very different level of understanding in scientific research, compared with a scientist (Herwitz & Guerra, 1996).

Tanner et al. (2003) highlighted three issues that, when allowed to go unacknowledged, can impede collaboration: (1) the importance of mutual learning in partnerships, (2) the professional cultures of scientists and K–12 educators, and (3) barriers of language in partnerships. Barriers of language in two professions can be important challenges (Kim & Fortner, 2007; Tanner et al., 2003). Examining a program focused on improving teachers' understanding and ability with inquiry by providing the collaboration of graduate level scientists, Thompson (2003) found that *none* of the languages of inquiry were consistent with those used by scientists or classroom teachers. Even in a teacher-scientist collaboration project that was successful in increasing the use of inquiry by participating teachers, several teachers suggested that facilitating communication with scientists was essential to continued collaboration and use of inquiry (Caton, Brewer & Brown, 2000). As Carlone and Webb (2006) argued with a cultural model – hierarchy model, one of the critical challenges in facilitating educational collaboration is to break down the hierarchies that often exist between the two professions, fostering learning within both groups for true mutual learning in partnerships. Caton et al. (2000) reported that stressing equal status for teacher and research scientists and facilitating two-way exchange of expertise increased the satisfaction of participants in a partnership.

4.2 Contextual Background

4.2.1 COSEE Great Lakes and educational collaboration

The Centers for Ocean Sciences Education Excellence (COSEE), supported by the National Science Foundation (NSF) and to some extent the National Oceanic and Atmospheric Administration (NOAA), promote the development of effective partnerships between research scientists and educators with that often-sought goal of increasing science literacy. As a member of the national network, COSEE Great Lakes pursues the goal through standards-based science curricula and programs that bridge the ocean and freshwater sciences.

4.2.2 This study

This study examines the ways in which K-12 teachers and scientists are involved in educational collaboration, and barriers that deter their participation. In particular, we look at the collaboration experience of teachers and scientists in Great Lakes region. Our goal is to gain insight that will inform scientists who seek collaboration with educators to more effectively deliver EPO programs, and teachers who want to collaborate with scientists for their educational purposes. As a baseline, such information will be of particular value to programs such as COSEE Great Lakes, whose focus is on facilitating teacher-scientist interactions and/or improving scientists' educational outreach capacity. We used three research questions for the study reported here: 1) how are K-12 teachers and scientists involved in educational collaboration, 2) what barriers may deter their involvement, and 3) which factors are related to their potential for partners in education collaboration.

4.3 Methods

4.3.1 Survey instruments

This study is based upon the survey data collected from teachers and scientists in 2006 as a part of the evaluation for COSEE Great Lakes. To characterize the population of teachers and scientists targeted as a potential audience for COSEE Great Lakes, Kim and Fortner (2007) developed a pair of surveys, "Perceptions of cultural differences and collaboration among scientists and educators," worded parallel for the two groups. We expect to repeat the study in 2010 to gauge the overall COSEE program outcomes related to increasing collaborations among scientists and educators. The surveys invited teachers and scientists to respond to items on how science is conducted, taught and learned (views of science and science education, 14 items), attitudes towards educational collaboration (14 items), professional preparation and collaboration experience (12), familiarity with ten terms in science and education, barriers to educational collaboration (11), and seven items related to factors or opportunities that would facilitate collaboration (Table 4.1), as well as personal demographic information. For views of science and science education, Pomeroy's (1993) items were modified to represent traditional views (empiricist views) and contemporary views (constructivist views). Items in the other sections were based on unpublished COSEE surveys. A panel of 15 experts in science education, communication or collaboration examined the instrument to establish content validity. Internal consistency reliability was determined through Cronbach's alpha coefficients.

4.3.2 Survey implementation

In May 2006, teacher surveys were mailed to 180 schools randomly selected from 5757 public schools in the eight Great Lakes states. The number of schools selected per state was determined proportionally by the number of schools in the shoreline counties. Mailings were done under a cover letter from the Sea Grant Educator in each state, establishing a "local" connection for project credibility. Three copies of the survey were mailed to each school with a cover letter asking the principal to give the surveys to three teachers in the 4-5th grades in the school, or three science teachers for 7- 8th or 9-10th grades. Teachers returned their completed surveys to the principal, who forwarded them to the researchers. If they wished to receive teaching materials about the Great Lakes and be entered into a prize drawing for additional instructional materials, teacher respondents returned separate postcards with their name and contact information. We sent one follow-up reminder letter to principals as well as thank-you cards for school responses. Most respondents returned their surveys by the selected deadlines in May or June 2006, but 19 returned them later. The late surveys did not show any difference in terms of age, gender, or years of teaching experience, and most responses in the survey compared with the on-time surveys. We can therefore assume that late responders are from the same population.

Marine and aquatic scientists were recruited at a conference on Great Lakes research in May 2006. We chose the conference since it represented the largest gathering of Great Lakes scientists, and the National Science Foundation had approved support for a COSEE workshop for scientists in the following year's conference. The structure of that "School for Scientists" could be based on the research results. Six hundred copies of the survey were distributed to all conference participants in the registration packet, and a prize drawing was offered as incentive to participate. Most respondents returned their surveys during the conference period but six returned them by mail after the conference. We followed up with an additional recruitment through scientist networks and received additional responses. The additional recruitment group did not show any difference in terms of age, gender, or working years, and most responses in the survey compared with the conference group; in fact some of them used the survey form they received at the conference. We can therefore assume that late responders are from the same population.

4.3.3 Data analysis

Descriptive information on views of science and science education, professional preparation, collaboration experience, and barriers to collaboration of both groups were examined. To investigate factors related to the teachers' and scientists' experience in educational collaboration, we studied the correlations (Pearson's r) between their experience in educational collaboration and other explaining variables.

Survey component	Items	Cronbach's alpha	
		Teachers	**Scientists**
Views of science and science education			
Traditional views	7	0.524	0.470
Contemporary views	7	0.568	0.445 2)
Attitudes towards:			
Scientists' involvement	7	0.886	0.823
Collaboration with scientists (educators)	7	0.562	0.452 2)
Professional Preparation			
Science (Educational) competencies	3	0.616	0.519
Collaborative cultures	3	0.659	0.738
Experiences in collaborating with scientists	6	0.818	0.818
Familiarity with terms or concepts			
in Science	5	0.661	0.522
in Education 1)	5	0.342 1)	0.681
Barriers to collaboration:			
Institutional supports	4	0.695	0.568
Cultural or personal barriers	7	0.620	0.539
Facilitating assistances for collaboration	7	0.897	0.809

1) Teachers' responses to five terms/concepts in education were collected in this study but not used as a construct because of low reliability.

2) We caution the reader that a few constructs for the scientists group showed Cronbach's alpha coefficients at borderline level of acceptability (0.5).

Table 4.1: Structure of survey instrument administered to Great Lakes teachers and scientists, with reliability of components.

Then, we examined the relative contribution of variables in predicting experience in collaboration of both groups, with the idea that maximizing predictor variables might increase collaboration. Responses to the survey items on experience in collaboration served as the dependent variable. The indicators used to assess the collaboration experience of respondents include a self-reported measure of familiarity with terms in the other area [i.e. scientists' familiarity with education terms and vice-versa], attitudes towards educational collaboration, professional preparation, and perceived barriers to collaboration. The sociodemographic factors, examined as predictors of experience in collaboration, include age, years in the job field, gender, and level of formal educational attainment (degrees). Multilinear regression analyses were used to determine the performance of each predictor variable and to ascertain the most parsimonious set of variables that predicts collaborating experience.

4.4 Results

4.4.1 Survey participants – Teachers

We received a total of 194 survey responses (36% response rate). Of the 194 educator respondents, 80 (42%) were male while 109 (58%) were female. Their average age was 41 (range = 23-62), and they reported an average of 13.7 years in teaching experience (range = 1-38). Their teaching levels were approximately equally represented, with 62 elementary (4–5th, 32%); 65 middle school (7-8th, 34%) and 67 high school (10-11th; 35%). Among the respondents, secondary teachers mainly teach 'General/Integrated science' or 'Science subjects' such as Life science, Physics, Earth science or Environmental science (83.1% for 7-8th and 89.6% for 10-11th) while elementary teachers teach science with other subjects (88.0%). Only five respondents did not report any science subjects as subjects taught. Therefore we can assume that the respondents represent a potential audience for science teacher enhancement activities of COSEE Great Lakes.

4.4.2 Survey participants – Scientists

We received a total of 94 survey responses (16% response rate) after follow-up. Of the 94 scientist respondents, 52 (57%) were men while 39 (43%) were women. When asked to check all categories that described their main job functions, 70% of the respondents reported that research was their primary job responsibility, 25% identified postsecondary teaching, and 19% reported that they were graduate students. Therefore, we will refer to all respondents as "Great Lakes scientists" with current or potential for research. Twelve respondents (13%) reported outreach/extension education as one of their main jobs.

Considering all responses were voluntary and self-selected, the possibility of bias arises from those who elected to take the time to respond to the survey in that they may have been: (1) more interested in educational collaboration or educational outreach; (2) more interested in the incentive; and/or (3) more confident in working with educators. Therefore the reported experience and interest in educational outreach may be higher than one would normally expect from the population of the Great Lakes researchers.

4.4.3 Views of science and science education

Teachers and scientists responded to the same items describing how scientific research is conducted and how science is taught and learned in classroom (Table 4.2). Analyses clustered the items into two sets determined to represent approaches to scientific research and science teaching/learning: traditional views and contemporary views (Pomeroy, 1993). The latter views are more oriented to constructivist views in the continuum from empiricist to constructivist perspectives (Tsai, 2000). Such views are also related to the five components of inquiry Thompson (2003) identified: the existence and steps of the scientific method, the subjective nature of knowledge creation in science, the empirical basis of scientific inquiry, the tentative nature of scientific knowledge and the role of creativity in inquiry. Items regarding views of science education also describe classroom culture and perceptions about how students learn. Perhaps these views represent when or in what university setting (education or science department) the respondents received their initial development as professionals.

The internal consistency scores reported by Cronbach's alpha were moderate for both clusters (Table 4.1). Teachers showed that they are more favorable to contemporary views (mean = 3.20) than traditional views (mean = 2.72), consistent with Pomeroy's noting a growing awareness of and commitment to constructivism among educators (1993). Scientists also showed that they are more favorable to contemporary views (mean = 3.29) than traditional views (mean = 2.84).

When we divided the views into science and science teaching/learning groupings, some interesting differences between teachers and scientists surfaced. Among 14 statements in views of science and science education, teachers and scientists showed statistical differences in the mean responses of four (4) statements (t-test, $p < 0.05$). Compared to the responses of scientists, educators have more traditional views (empiricist views) on the nature of *science* and more contemporary ones (constructivist views) on *science teaching and learning* (Table 4.2).

Statements: Views of science and science education	**Teachers**		**Scientists**	
	% Agree	**Mean (SD)**	**% Agree**	**Mean (SD)**
Contemporary views of science				
A. The process of scientific discovery often involves a high degree of creativity.	83.9%	3.19 (0.79)	92.4%	3.45 (0.67)
B. Cultural groups differ in their processes of gaining valid knowledge about natural phenomena.	60.1%	2.60 (0.86)	73.9%	3.03 (0.94)
Traditional views of science education				
C. Listening to lectures is a good way for students to learn scientific concepts.	34.9%	2.17 (0.80)	57.3%	2.53 (0.76)
D. When students ask questions, teachers should provide the answers.	52.5%	2.57 (0.70)	67.1%	2.80 (0.78)

Ratings were on a 4-point Likert scale (1=strongly disagree; 4=strongly agree).

% Agree = combined percentage of respondents who either agreed (3) or strongly agreed (4) with each statement.

Table 4.2: "Views of science and science teaching/learning" statements showing statistical differences between teachers and scientists.

4.4.4 Professional preparation for science/education

Using two clusters with relatively strong internal consistency, we categorized six statements about professional preparation for educators and scientists into two groups, herein called "Professional preparation I – science competencies (for teachers) or educational competencies (for scientists)" and "Professional preparation II - collaborative cultures."

Regarding the science or educational competencies, about 70% of teachers in this study reported that their professional preparation as a teacher equipped them with enough knowledge in science (72.8%) while only 27% of scientists reported that their professional training as a scientist equipped them with enough knowledge in education. In addition, only 20% (primarily those who identified education/outreach as one of their main jobs) of scientists reported that they took more than one course in education during their professional training (Table 4.3).

Compared to the teachers, fewer scientists reported that they were trained in collaborative cultures. More of the teachers (94%) indicated that they had been trained in institutions using cooperative learning than did scientists (56%). This classroom methodology is seen as key to student growth in teamwork that simulates how scientists work (Fortner, 2001) and is an important component of acceptance of partners. This finding is in line with what Duggan-Haas (1998) described in his ethnographic research regarding the different professional training cultures for scientists and educators.

Statements: Professional preparation	Teachers		Scientists	
	% Agree	**Mean (SD)**	**% Agree**	**Mean (SD)**
Science (Educational) competencies				
My professional training as a teacher (scientist) has quipped me with enough knowledge in science (teaching).	72.8%	2.93 (0.91)	27.1%	2.08 (0.83)
I took more than one course in science (education) during my professional training.	94.7%	3.58 (0.65)	20.2%	1.63 (1.11)
I believe that I am equipped with the ability to help students gain a better understanding of science	96.3%	3.58 (0.58)	87.7%	3.31 (0.68)
Collaborative cultures				
During my professional training I often worked in collaborative groups.	84.8%	3.34 (0.80)	78.3%	3.09 (0.83)
At least one college I attended encouraged the use of cooperative learning.	94.3%	3.59 (0.60)	55.6%	2.67 (1.09)
The teacher-student relationships in at least one college I attended were warm and supportive.	94.8%	3.59 (0.61)	83.3%	3.31 (0.77)

Ratings were on a 4-point Likert scale (1=strongly disagree; 4=strongly agree).

% Agree = combined percentage of respondents who either agreed (3) or strongly agreed (4) with each statement.

Table 4.3: Percentage, means and standard deviations of responses to items about professional preparation by teachers and scientists.

4.4.5 Experiences in educational collaboration

Six statements examined the ways in which teachers and scientists are involved in educational collaboration. Although the statements ranged from lower level to higher level in educational collaboration, the experience in collaboration measured by the statements showed relatively strong internal consistency (Cronbach's alpha 0.818 for both groups).

The educators responded that among the activities described they most frequently take their students on field trips or lab visits hosted by a scientist (56%). About half of the respondents reported that they have brought a scientist to their classroom (51%). However, less than one third consulted with scientists on curriculum development (25%) or referred to scientists for scientific research (32%). The summary of responses confirms that the most common "use" of scientists in science education is to focus on the scientist as an expert for a student group (Drayton & Falk, 2006) while only a small portion of educators have personally worked closely with a scientist (Table 4.4).

The scientists responded that among the activities described they most frequently give presentations about their research to the public (84%). About sixty percent of scientists reported that they have presented their research to K-12 students (61%) and hosted students to research sites (59%). However, only one third of the scientists reported direct collaborations with teachers. The summary of responses confirms that more scientists play the role of "resource" than "partners" (Morrow 2000; Kim & Fortner, accepted).

Statements: Type of professional contact *(I have experienced in …)*	**Teachers** **% Agree**	**Scientists** **% Agree**
Scientist as Resource		
Bringing a scientist to my classroom (Making presentations about my research to students)	51.3%	58.9%
Taking my students to (hosting) field trips or lab visits hosted by a scientist (for students)	55.7%	61.1%
Making presentations to non-school groups (about my research to the public)	34.7%	83.5%
Scientist as Partner		
Consulting with scientists (science educators) on curriculum development	25.0%	33.3%
Conducting collaborative research with a scientist (teachers)	29.2%	33.0%
Referring to scientists for their knowledge of scientific research (Calling on teachers for their pedagogical knowledge)	32.1%	24.4%

Ratings were on a 4-point Likert scale (1=strongly disagree; 4=strongly agree).
% Agree = combined percentage of respondents who either agreed (3) or strongly agreed (4) with each statement.

Table 4.4: Percentage of educators and scientists reporting experience in collaboration

4.4.6 Barriers to educational collaboration

Using eleven statements, we examined perceived barriers to educational collaboration between teachers and scientists: institutional barriers and cultural/personal barriers. Most teachers and scientists agreed that lack of institutional supports such as funding, time, and professional rewards may deter their involvement in educational collaboration. Table 4.5 also shows how teachers and scientists perceive other barriers. Many teachers and scientists in this study agreed that cultural barriers such as different perspectives on education (75% for teachers, 88% for scientists), understanding of profession of partners (53%, 58%), and difficulty in communication (50%, 59%) can be important challenges, while they agreed less with barriers related to individual capacity.

4.4.7 Factors related to potential for science education partnership

We investigated the relations between experiences in educational collaboration of both groups and the following indices: views of science and science education, attitudes towards collaboration, familiarity with terms in science and education, professional preparation, barriers to collaboration, and teaching/research experience in years. Correlations between the experience in collaboration and these variables were calculated (Table 4.6).

Barriers to educational collaboration	Teachers % Agree	Scientists % Agree
Institutional barriers		
Funding for educational collaboration	96.9%	95.7%
Time for educational collaboration	94.4%	89.3%
K-12 schools (Funding agencies) not placing importance on educational collaboration	93.2%	71.8%
Professional acknowledgement or rewards for educational collaboration	78.8%	86.0%
Cultural barriers		
Understanding of how scientists conduct research (how students learn).	75.9%	84.6%
Different perspectives on education	75.0%	87.7%
Understanding of the profession of scientists (teachers)	52.6%	57.6%
Difficulty in communicating with scientists (K-12 teachers).	49.7%	58.5%
Personal barriers		
Difficulty in communicating scientific research	44.4%	23.1%
Difficulty in presenting scientific concepts for K-12 students	26.0%	25.3%
Teachers' understanding of science	11.0%	60.7%

Ratings were on a 4-point Likert scale (1=strongly disagree; 4=strongly agree).

% Agree = combined percentage of respondents who either agreed (3) or strongly agreed (4) with each statement.

Table 4.5: Percent agreement of educators of scientists regarding barriers to collaboration

Variable	Experience in collaboration	
	Teachers	**Scientists**
Views of science and science education:		
Traditional views	.140	-.099
Contemporary views	.248**	.215*
Attitudes towards:		
Scientists' involvement	.109	.372***
Collaboration with scientists (educators)	.353***	.303**
Professional Preparation:		
Science (Educational) competencies	.323***	.457***
Collaborative cultures	.208**	.318**
Familiarity with terms or concepts		
in Science	.237**	.019
in Education	.118	.588***
Barriers to collaboration		
Institutional supports	.269***	.034
Cultural or personal barriers	-.245**	-.079
Teaching (Research) experience in years	.195**	.136
Age	.162*	.068

* $p < .05$

** $p < .01$

*** $p < .001$

Table 4.6: Two-tailed correlations between educators' (n=194) and scientists' (n=94) experience in educational collaboration and explaining variables

When comparing the characteristics of individual respondents, a teacher or a scientist who had more contemporary views tended to have more experience in education collaboration (for teachers $r = .248$, $p < .01$; for scientists $r = .215$, $p < .05$) while traditional views of science and science education did not show any significant relations with experience in collaboration. In both groups, attitude toward collaboration with scientists or teachers showed moderate positive relations with experience in educational collaboration (for teachers $r = .353$, $p < .001$; for scientists $r = .303$, $p < .01$).

For teachers and scientists in this study, their experience in collaboration was significantly correlated with two categories of professional training: Professional preparation I – science (educational) competencies and Professional preparation II - collaborative cultures. Educational competencies of scientists ($r = .457$) and science competencies of teachers ($r = .323$) showed moderate positive correlations with their experience in collaboration. The scientists group ($r = .318$) appeared to show a stronger relationship between "Professional preparation II - collaborative culture" and experience in collaboration than did teachers group ($r = .208$). A scientist who has been trained in a more collaborative culture tends to be more experienced in educational collaboration.

As for vocabulary associated with the cultures, it is not surprising that teachers' experience in collaboration was not significantly correlated with their familiarity in *education* terms as scientists' experience was not correlated with their familiarity in *science* terms. Regarding familiarity with terms in other areas, however, scientists' collaboration experience showed a substantial positive relation with their familiarity with *education* terms ($r = .588$). The strength of the relationships in the scientists group was more than twice that of the teachers group ($r = .237$).

The teachers' experience in educational collaboration also showed a significant positive correlation with institutional supports (r = .269) and a negative correlation with other barriers such as different perspectives (r = -.245). Interestingly, however, scientists' experience was not significantly correlated with their perceived barriers. Among background variables, only teaching years and age of teachers were significantly correlated with their experience in collaboration. Teachers who were older and had more teaching experience reported more experience in working with scientists.

On the basis of the data analyses for teachers there are six predictor variables which account for a majority of the variance in explaining their experience in collaboration and serve as the most parsimonious predictor set: 1) attitudes towards collaboration with scientists, 2) professional preparation I - science competencies, 3) teaching experience in years, 4) contemporary views of science and science education, 5) perceived level of cultural/personal barriers and 6) institutional support. Other variables such as gender and degrees were excluded by the regression model. The six predictors have a combined predictive ability to explain 36% of the variance in experience of teachers (Table 4.7).

Variables	**B**	***SE* B**	**β**	**R^2**	**ΔR^2**
Attitudes towards collaboration (X1)	.455***	.120	.253	.130	.130***
Professional training I - Science competencies (X2)	.378***	.091	.266	.226	.097***
Teaching Years (X3)	.020***	.005	.253	.284	.057***
Contemporary views (X4)	.479**	.138	.223	.320	.036**
Cultural/personal barriers (X5)	-.255*	.106	-.156	.345	.025*
Institutional supports (X6)	.234*	.104	.142	.364	.019*
(constant)	-1.908**	.644			

$R^2 = 0.364$; Adjusted $R^2 = 0.341$

* $p < .05$

** $p < .01$

*** $p < .001$

Table 4.7: Stepwise regression of teachers' experience in collaboration on selected variables

The regression analyses also show that four predictor variables account for a majority of the variance in explaining scientists' experience in collaboration with teachers (a combined predictive ability of 50%): 1) familiarity with terms in education, 2) attitudes towards collaboration, 3) research experience in years, and 4) professional preparation II - collaborative cultures (Table 4.8).

Variables	B	*SE* B	β	R^2	ΔR^2
Familiarity with terms in education (X1)	.725***	.110	.552	.371	.371***
Attitudes towards collaboration (X2)	.497*	.194	.211	.412	.041*
Research Years (X3)	.018**	.006	.262	.455	.043*
Professional training II - Collaborative Cultures (X4)	.234*	.093	.216	.496	.041*
(constant)	-1.900**	.622			

$R^2 = 0.496$; Adjusted $R^2 = 0.470$

* $p < .05$

** $p < .01$

*** $p < .001$

Table 4.8: Stepwise regression of scientists' experience in collaboration on selected variables

4.5 Discussion

The results reported here provide valuable insights for teachers and scientists engaged in educational collaborations, and for those designing professional development programs to improve their capacity as collaborators in the efforts for science literacy.

First, the study results suggest that the frequencies of participation in various educational collaboration activities differ to a large extent: while some teachers in this study reported a lower level of collaboration with scientists (e.g., field trips or classroom visits), only a small portion of them have experience in working closely with scientists in curriculum development or scientific research. Scientists in this study also reported that they were involved in educational outreach more frequently as a “resource” than a “partner” in Morrow’s framework (2000). Professional preparation of teachers and scientists may explain the ways in which teachers and scientists are involved in educational collaboration. The results show that most scientists had little chance to obtain knowledge in professional *education* during their professional *science* training. Scientists’ lack of knowledge in education was also demonstrated by their unfamiliarity with the terms in education (Kim &Fortner, accepted). As Kahle and Kronebusch (2003) reported, in the continuum of science teacher education phases (preparation, induction and professionalization) there are few connections among scientists, educators, and K–12 teachers.

Second, the study provides empirical evidence for a number of factors that predict collaboration experience of teachers and scientists. Note that the purpose of the analyses is not to identify and interpret these factors singly but identify factors that show significant associations with collaboration experience and then to collectively consider the factors in an interpretation. The correlation analysis showed the connection between teachers’ and scientists’ experience in collaboration and their professional preparation. On the basis of the correlation coefficients, it was reasonable to conclude that two categories of professional preparation (science/educational competencies, collaborative cultures) appeared to affect collaboration experience of teachers and scientists.

The regression analysis implies that for educators' collaboration with scientists the major predictors that need to be addressed are attitudes toward collaboration, professional preparation (science competencies), contemporary views of science/science education, cultural/personal barriers, and institutional supports. Interestingly, for scientists, the factor of collaborative cultures during their professional preparation was included in the regression model with their familiarity with education terms and attitudes toward collaboration, in explaining their collaboration experience with educators. For teachers, however, the factor of "collaborative cultures" was not included in the regression model. Given that the cultures of professional preparation for teachers are much more collaborative than those for scientists (Duggan-Haas, 1998), consideration must be given to increasing educators' science competencies (content knowledge of science or process of inquiry) in thinking how to provide educators opportunities to work with scientists. Fostering mutual learning in essence will require raising scientists' collaborative attributes and teachers' science competencies. These findings of the study were reflected in conducting COSEE Great Lakes' "School for Scientists" which included fundamentals of educational theory and practice, and recognition of the "culture of educators."

The results of this study also suggest that the complexities of collaboration go beyond deficit-based explanations (e.g., blaming individuals or organizational structures) as Carlone and Webb (2006) argued. The cultural barriers seem to be important as well institutional supports in the regression model for teachers. Many educators in this study agreed that such cultural barriers as different perspectives on education (75%), understanding of profession of scientists (53%), and difficulty in communication (50%)

can be important challenges. In the regression model for scientists, the language barrier (familiarity with terms in education) seems to be an important challenge: this factor alone accounted for 38% of the variance in explaining scientists' collaboration experience. Most K-12 educators have little chance to interact with scientists in enhancing their science instruction and most scientists have little chance to understand the profession of *education* during their professional preparation. The teachers' lack of opportunities to gain science competencies and scientists' lack of understanding in terms/concepts in education could be manifestations of the divided/different professional cultures during their professional preparation. As Tanner et al. (2003) argue, the different professional cultures of scientists and K–12 educators can impede collaboration when allowed to go unacknowledged. Understanding the different professional cultures increases the ease of collaboration at the same time and could contribute to successful teacher-scientist collaboration. Therefore, such differences found in this study are not always a barrier; they can be a chance to build collaborative relations based on strengths and mutual benefits.

Third, this study suggests possibilities of mutual benefits through educational collaboration between teachers and scientists. Inherent in the concept of educational collaboration between scientists and educators is that both benefit from such relationship. Compared to the responses of scientists, educators have more traditional views (empiricist views) on the nature of *science* and more contemporary ones (constructivist views) on *science teaching and learning*. Given that teachers have a good understanding of how they construct their knowledge about students and their teaching and that scientists know how the scientific knowledge is constructed, the interactions among teachers and scientists may lead them into mutual learning. By showing teachers how their own learning is not unlike the processes of science, teachers may develop beliefs about the nature of science that are more in keeping with modern views and are surely less foreign to them (Pomeroy, 1993). As Caton et al. (2000) insist, collaboration between teachers and scientists can be one promising strategy to "demystify science for teachers who are uncomfortable with this subject." When teachers work on investigations with scientists, they can develop understanding of scientific processes and have greater confidence in their ability to teach science using inquiry methods. Collaboration for educational aims takes many forms, but any of these should pursue a shared vision and mutual benefits based on understanding of professional cultures of partners.

Finally, several points raised in this article call for further study. This study reveals the importance of cultural difference as a concern in teacher-scientist collaboration and points to a need for further study on how cultural factors play roles in teacher-scientist collaboration. Further study on possibilities of mutual benefits/learning through educational collaboration both for teachers and scientists is also in need. Inherent in the concept of educational collaboration between scientists and educators is that both benefit from such relationship. Compared to benefits for teachers, possible benefits for scientists in educational collaboration have less been investigated. In other areas of interprofessional collaboration, for example, Bainer et al. (2000) found that school-based partnerships between natural resources professionals and teachers could bring great professional growth of natural resources professionals as well as school teachers. The interpersonal competencies, for example, obtained from interaction with and observation of teachers and their students, can benefit natural resources not only as "informal educator" but also as "content experts." Further study on how working with educators can bring professional growth of "scientists" is in need to encourage scientists with many other priorities to be involved in educational collaboration. Analyses of GK-12 programs may offer such insight.

4.6 Conclusion

Various formats of teacher-scientists collaboration have been implemented in science education settings and often to be found successful in increasing educators' understanding of science and inquiry, and eventually student achievement. Such partnerships can be beneficial to scientists, too. However, challenges identified in this study may deter widespread application of teacher-scientist collaboration as a model for professional development for both professions. Collaboration for educational aims takes many forms, but any of these should pursue a shared vision and mutual benefits based on understanding of professional cultures of partners.

The results of this study also provide a suggestion for future implementation of teacher-scientist collaboration projects. Among many other efforts for educational collaboration, COSEE Great Lakes summer workshops focus on several mechanisms to foster mutual learning and teacher inquiry development. In these workshops, scientists are not invited to lecture. Instead, teachers read a professional article about a scientist's research and develop questions they would like the scientist to address. In discussing the science, then, the researcher is making the topic relevant to teachers' real needs, and perhaps more importantly, learning about those needs. At the same time, each scientist reads an educational research article as background for the teacher workshop. The scientist is expected to ask questions of the educators about the content and implications of the article. Often, however, we found that both teachers and scientists revert to the traditional postures of lecture and learner! As Carlone and Webb (2006) discussed, this kinds of unintended features of collaboration are not typically published, but take place behind closed doors. Given that further consideration must be given to increasing educators' science competencies and scientists' collaborative attributes, we may foster mutual learning among them by allowing teachers to have initiatives/controls in knowledge interactions in teacher-scientist collaboration (Nelson, 2005). Otherwise, as in traditional settings of contacts between teachers and scientists, (university-based) scientists often determine main dimensions of collaboration: 'whose question is being investigated?' "Is this collaboration based on scientists' expertise or teachers' interest?' or 'who is the collaborative research for?' (Drayton and Falk, 2006).

CHAPTER 5

SUMMARY AND CONCLUSION

5.1 Overview

The research that is presented in the preceding chapters consists of three published or submitted manuscripts on professional development and interprofessional collaboration of K-12 teachers. The first (published) manuscript in Chapter 2 investigates primary and secondary teachers' views of collaboration with scientists and incorporates the findings of the teacher surveys from eight Great Lakes states into discussions about professional development programs for educators. The second (accepted) manuscript in Chapter 3 is an attempt to reveal interactions in education by scientists whose research is focused on the Great Lakes, and incorporates the findings into discussions about scientists' potential for the role of education partner. The third (submitted) manuscript in Chapter 4 elaborates on the results and discussions in Chapters 2 and 3 by comparing the two groups and by identifying implications of the findings for teacher-scientist collaboration. The goal of all of the research reported in Chapter 2 through 4 is to increase our understanding of educational collaboration in teacher-scientist partnership contexts. The results of these studies may provide insights into facilitating dynamic collaborative relationships between research scientists and educators.

5.2 Summary of three research reports

This research generated important findings with underlying implications for the professions of scientists and K-12 teachers as well as natural resources professionals and environmental educators. The findings summarized below could provide insights into facilitating dynamic collaborative relationships between research scientists and educators and contribute to our understanding of educational collaboration in teacher-scientist partnership contexts.

First, only a small portion of K-12 teachers have chances for higher level collaboration experience with scientists while more teachers have less intensive interactions (e.g., field trips). The results also show the impact on current teachers of the fact that there are few connections among K-12 teachers and scientists in any the phases of the science teacher training (preparation, induction and professionalization).

Second, scientists were involved in educational outreach more frequently as a “resource” than a “partner.” The disciplinary culture of scientist preparation (lone-scholar culture) and their lack of knowledge in education explain why most scientists are not ready for collaboration as an education partner.

Third, to most scientists it is not clear *how* to get involved in education collaboration. To overcome scientists’ lack of knowledge in professional *education*, such programs as COSEE Great Lakes “schools for scientists” which focus on fundamentals in education and the “culture of educators” are required.

Fourth, on the basis of the correlation coefficients, it was reasonable to conclude that two categories of professional preparation (science/educational competencies, collaborative cultures) have major effects on collaboration experience of teachers and scientists. Regression analyses suggest specifics for the focus of remediation: further consideration must be given to increasing educators' science competencies and scientists' collaborative attributes when we develop professional development programs for educators and scientists.

Fifth, the cultural barriers are important as well as institutional supports. Many educators agreed that such cultural barriers as different perspectives on education, understanding of the profession of scientists, and difficulty in communication can be important challenges. The language barrier (familiarity with terms in education) alone accounted for 38% of the variance in scientists' collaboration experience.

Sixth, recognition of the very different professional cultures of scientists and K–12 educators can be a chance to build collaborative relations based on strengths and mutual benefits. For example, given that teachers have a good understanding of how they construct their knowledge about students and their teaching, and scientists know how scientific knowledge is constructed, the interactions among teachers and scientists may lead them into mutual learning.

Finally, the survey instruments used for this research are not content-specific: although they were implemented for Great Lakes scientists and teachers in the region, the items of the instruments can be applied to scientist groups which have other subject focuses and/or teacher groups which have different local heritages.

5.3. Implications for professional development of environmental educators: Teachers and natural resources professionals

This research on educational collaboration also has implications for professional development of environmental educators: teachers in formal settings and natural resources professions in nonformal settings. As Great Lakes scientists are, natural resources professionals are generally oriented toward the production and management of tangible resources, such as trees and water, rather than the nonformal environmental education and management of people. They are more inclined toward identifiable responsibilities, such as protecting and conserving natural resources, than they are toward abstract responsibilities, such as educating people about complex issues and stewardship of resources (Bainer et al., 2000)

Millions of people call upon natural resource professionals to enable their demands on natural services, including recreation, land use, wildlife management, and water use. These professionals are an important link between resources and the public in their role as "occasional teachers." Bainer et al. (2000) found that school-based partnerships between natural resources professionals and teachers could bring great professional growth of natural resources professionals as well as school teachers. The interpersonal competencies, for example, obtained from interaction with and observation of teachers and their students, can benefit natural resources not only as "informal educator" but also as "content experts."

Collaboration between the two professions, teachers and natural resource professionals, can help teachers to be equipped to teach environmental education effectively. At the same time, working with teachers for young and/or adult audiences can provide natural resources professionals with opportunities of professional development in communication skills and basic educational practices. The experiences and insights obtained through teacher-scientist collaboration can be applied to further develop the vehicles for the professional development of *environmental educators* - both teachers in formal settings and natural resource professionals in nonformal settings.

"In the canoe, the Indian smiled. Once he paused in a stroke, and rested his blade. For that instant he looked like his own Paddle. There was a song in his heart. It crept to his lips, but only the water and the wind could hear.

'You, Little Traveler! You made the journey, the Long Journey. You now know the things I have yet to know. You, Little Traveler! You were given a name, a true name in my father's lodge. Good Medicine, Little Traveler! You are truly a Paddle Person, a Paddle-to-the-Sea!'"

- Holling Clancy Holling (1941), Chapter 27

BIBLIOGRAPHY

American Association for the Advancement of Science (1993). *Benchmarks for science literacy: Project 2061*. New York, NY: Oxford University Press.

Andrews, E., Weaver, A., Shamatha J. & Melton G. (2005). Scientists and public outreach: participation, motivations, and impediments. *Journal of Geoscience Education, 53*(3), 281-293.

Bainer, J.D. (2001). Characteristics of enduring partnerships, Paper presented at the annual meeting of the Mid-Western Educational Research Association, Chicago, IL. ERIC ED 457 038.

Bainer, J.D., Cantrell, D. & Barron, P. (2001). Professional development of nonformal environmental educators through school-based partnerships. *Journal of Environmental Education, 32*(1), 36-45.

Bainer, D.L., Barron, P. & Cantrell, D. (1998). SWEEP: Sciencing with watersheds, environmental education and partnerships. Instructor's guide to implementation and Summer institute participant notebook. ERIC ED 429 807.

Bell, J. A. & Buccino, A. (Eds.). (1997). *Seizing opportunities: Collaborating for excellence in teacher preparation*. Washington DC: American Association for the Advancement of Science.

Belden Russonello & Stewart (2003). Great Lakes: Responsibility and awareness about a vital resource. Summary analysis of public opinion in Great Lakes states. Survey conducted for the Biodiversity Project and the Joyce Foundation. Washington DC: Author. On-line at http://www.biodiversityproject.org/resourcespublicopinion.htm

Brothers, C.D., Fortner, R.W. and Mayer, V.J. (1991). The impact of television news on public environmental knowledge, *The Journal of Environmental Education, 22*, 22-29.

Bruner, J. (1996). *The Culture of Education*. Cambridge, Mass.: Harvard University Press

Carr, K. (2002). Building bridges and crossing borders: Using service learning to overcome cultural barriers to collaboration between science and education departments. *School Science & Mathematics, 102*(6), 285-298.

Caton, E., Brewer, C. & Brown, F. (2000). Building teacher-scientist partnerships: Teaching about energy through inquiry. *School Science & Mathematics, 100*(1), 7-15.

Carlone H.B. & Webb S.M. (2006) On (not) overcoming our history of hierarchy: complexities of university/school collaboration, *Science Education, 90*, 544-568.

Cobb, T.B. (1998). On the miscibility of science and environmental education, *Journal of Environmental Education, 29*(4), 5-11.

Dolan, E. L., Soots, B. E., Lemaux, P. G., Rhee, S. Y. & Reiser, L. (2004). Strategies for avoiding reinventing the precollege education and outreach wheel, *Genetics, 166*, 1601–1609.

Drayton, B. & Falk, J. (2006). Dimensions that shape teacher-scientist collaborations for teacher enhancement. *Science Education*, *90*(4), 734– 761.

Dresner, M. & Worley, E. (2006). Teacher research experiences, partnerships with scientists, and teacher networks sustaining factors from professional development. *Journal of Science Teacher Education, 17*(1), 1–14.

Duggan-Haas, D. (1998). Two programs, two cultures: The dichotomy of science teacher preparation. Paper presented at the annual meeting of the American Educational Research Association, San Diego, CA. ERIC ED 418 848.

Duggan-Haas, D., Roettger, E.E., Foster, G., Truedson, J.R., Yeotis, C., Schwartz, R.S., Lederman, N.G., Rowe, F. & Adams, P. (2000). Science and science education collaboratives: Where we are, how we got there, and where we are going. Paper presented at the annual meeting of the Association for the Education of Teachers in Science, Akron, OH. ERIC ED 437 272.

DuPraw, M.E., & Axner, M. (1997). Working on common cross-cultural communication challenges [Online]. Available from http://www.pbs.org/ampu/crosscult.html. (Accessed 9/20/07).

Fortner, R. W. (2001). Cooperative learning: A basic instructional methodology for global science literacy. In: V. J. Mayer (Ed.), *Global Science Literacy (*pp. 79-92). Dordrecht, Netherlands: Kluwer.

Fortner, R.W. and Corney, J.R. (2001). Great Lakes educational needs assessment: Teachers' priorities for topics, material & training. *Journal of Great Lakes Research, 28*, 3-14.

Fortner, R.W., Corney, J.R. & Mayer, V.J. (2005). Growth in student achievement as an outcome of inservice education using Standards-based infusion materials. *NAAEE Monograph 2: Preparing effective environmental educators* (pp. 73-90).

Fortner, R.W., Mayer, V.J., Brothers, C.C. and Lichtkoppler, F.R. (1991). Knowledge about the Great Lakes environment: A comparison of publics. *Journal of Great Lakes Research, 17*, 394-402.

Herwitz, S. R. & Guerra, M. (1996). Perspectives, partnerships, and values in science education: A university and public elementary school collaboration. *Science Education, 80*(1), 21-34.

Hollings, C. H. (1941). *Paddle-to-the-Sea*. Boston, MA: Houghton Mifflin.

Jeanpierre, B., Oberhauser, K. & Freeman, C. (2005). Characteristics of professional development that effect change in secondary science teachers' classroom practices. *Journal of Research in Science Teaching, 42*(6), 668-690.

Kagan, S. L. (1991). *United we stand: Collaboration for child care and early education services*. New York, NY: Teachers College Press.

Kahle, J. B. & Kronebusch, M. (2003). Science teacher education: from a fractured system to a seamless continuum. *Review of Policy Research, 20*(4), 585–602.

Kim, C. & Fortner, R.W. (2007). Educators' views of collaboration with scientists. *American Secondary Education, 35*, 29-53.

Kim, C. & Fortner, R.W. (accepted). Great Lakes scientists' perspectives on K-12 education collaboration. *Journal of Great Lakes Research.*

Kuh, G. D. & Hall, J. E. (1993). Using cultural perspectives in student affairs. In G.D. Kuh (Ed.), *Cultural perspectives in student affairs work* (pp. 1-20). Latham, MD: University Press of America.

Leshner, A. (2007, January 12). Outreach training needed (Editorial). *Science, 315*, 161.

Lord, T. R. & Peard, T. L. (1995). Scientist-teacher summer workshops can enhance constructivist views about science and science. *Education, 115*(3), 445-447.

Loucks-Horsley, S., Love, N., Stiles, K.E., Mundry, S. E. & Hewson, P.W. (2003). *Designing professional development for teachers of science and mathematics (2nd ed.)*. Thousand Oaks, CA: Corwin Press.

Lunn, S. (2002). What we think we can safely say …': Primary teachers' views of the nature of science. *British Educational Research Journal, 28*(5), 649-672.

Morrow, C. A. (2000). The diversity of roles for scientists in k-14 education and public outreach, white paper, Retrieved January 15, 2007, from http://www.spacescience.org/education/papers/Roles_M.pdf

Morrow, C.A. (2003). Misconceptions scientists often have about the K-12 National Science Education Standards. *The Astronomy Education Review, 2*, 85-94.

Morrow, C. A. & Dusenbery, P. B. (2004). Workshops for scientists and engineers on education and public outreach. *Advances in Space Research, 34*, 2153-2158.

Mattessich, P.W., Murray-Close, M. & Monsey, B. R. (2001) *Collaboration: what makes it work* (2nd ed.) MN: Amherst H. Wilder Foundation.

National Council for Geographic Education (NCGE) (1994). *Geography for Life, National Geography Standards*. Jacksonville, AL: Author.

National Council of Teachers of Mathematics (NCTM) (1989). *Curriculum and evaluation standards for School Mathematics*. Reston, VA: Author.

National Research Council. (1996). *National Science Education Standards*. Washington, DC: National Academy of Sciences.

National Research Council. (1996b). *The role of scientists in the professional development of science teachers.* Washington, DC: National Academy Press.

National Research Council. (1998). *Agriculture 's role in K-12 education: Proceedings of a forum on the national science education standards.* Washington, DC: National Academy of Sciences. ERIC ED 425 933.

Nelson, T.H. (2005). Knowledge interactions in teacher-scientist partnerships: negotiation, consultation, and rejection, *Journal of Teacher Education, 56*(4), 382-395.

Pomeroy, D. (1993). Implications of teachers' beliefs about the nature of science: Comparison of the beliefs of scientists, secondary science teachers, and elementary teachers. *Science Education, 77*(3), 261-278.

Smith, L. (2002) Getting started in education outreach, Retrieved January 15, 2007, from the American Society for Limnology and Oceanography, http://aslo.org/education/outreach/smith_outreach.pdf

Schrage, M. (1990). *Shared Minds: The New Technologies of Collaboration,* New York, NY: Random House

Supovitz, J. A. & Turner H. M. (2000). The effects of professional development on science teaching practices and classroom culture. *Journal of Research in Science Teaching, 37*(9), 963-980.

Tanner, K. D., Chatman L. & Allen, D. (2003). Approaches to biology teaching and learning: Science teaching and learning across the school-university divide - Cultivating conversations through scientist-teacher partnerships. *Cell Biology Education*, *2*, 195-201.

Thompson, S. L. (2003). Development of a framework to measure science teachers' inquiry perceptions and practices. Paper presented at the annual meeting of the Association of the Education of Teachers of Science, St. Louis. ERIC ED 472 970.

Tsai, C. (2000). Relationships between student scientific epistemological beliefs and perceptions of constructivist learning environments. *Educational Research, 42*(2), 193–205.

Turner J.L., Miller M. and Mitchell-Kernan Claudia, 2002, Disciplinary cultures and graduate education, *Emergences, 12*(1), 47-70.

Uchida, C (2005). *Making possibilities visible: the process of collaboration between general and special education teachers in an inclusive early childhood education program*, Unpublished Ph.D. Dissertation of The Ohio State University.

Von Secker, C. E. & Lissitz, R. W. (1999). Estimating the impact of instructional practices on student achievement in science. *Journal of Research in Science Teaching*, *36*(10), 1110–1126.

Walsh, M., Brabeck, M. & Howard, K. (1999) Interprofessional collaboration in children's services: Toward a theoretical framework, *Children's Services, 2*(4), 183-208.

Yore, Larry. (2003). Examining the literacy component of science literacy: 25 years of language arts and science research, *International Journal of Science Education, 25*(6), 689-725.

APPENDIX A

PERCEPTIONS OF CULTURAL DIFFERENCES AND COLLABORATION AMONG SCIENTISTS AND EDUCATORS – TEACHER VERSION

Perceptions of Cultural Differences and Collaboration

Among Scientists and Educators

COSEE Great Lakes Baseline Study

School of Environment and Natural Resources

The Ohio State University

2021 Coffey Rd, 210 Kottman Hall

Columbus, OH 43210-1085

As a teacher in the Great Lakes region, your perceptions can help us understand how scientists and educators may collaborate to develop science literacy. Please respond to the following questions with your expert opinions and **return your survey to your principal by May 15**. When we analyze the results, we will not identify any specifics about your individual responses. We are only interested in understanding the views of the participants as members of groups. No one besides the researchers will have access to the survey data. Your participation in this study is completely voluntary. We do hope that you will provide your expert opinions in a timely manner.

In return for your assistance we will send you a poster about the Great Lakes. Mail the stamped postcard with your address so we can send you this gift. We will also enter the card in a drawing for $100 worth of teaching materials! Thank you for assisting in this COSEE Great Lakes baseline study. If you have questions about this study, please contact:

Rosanne W. Fortner Phone: (910) 278-6754 E-mail: fortner.2@osu.edu

Chankook Kim Phone: (614) 292-1078 E-mail: kim.1744@osu.edu

♠ **Please indicate the extent to which you agree or disagree with each of the following statements about science: Use the scale described and circle the appropriate number.**

1 = strongly disagree, 2 = somewhat disagree, 3 = somewhat agree, 4 = strongly agree

1. Science provides objective knowledge about the world.	1	2	3	4
2. Unbiased science has never been achieved.	1	2	3	4
3. Science is performed by a specific community of qualified scientists.	1	2	3	4
4. The process of scientific discovery often involves a high degree of creativity.	1	2	3	4
5. Science is based on experiments which other scientists should be able to replicate.	1	2	3	4
6. Some scientific studies that do not involve experimentation are valid.	1	2	3	4
7. The acquisition of new scientific knowledge moves from observation to formation of hypotheses, then testing, and finally generalizing to theory.	1	2	3	4
8. Intuition plays an important role in scientific discovery.	1	2	3	4
9. Cultural groups differ in their processes of gaining valid knowledge about natural phenomena.	1	2	3	4

♠ **Teaching and learning science: Use the scale described and circle the appropriate number.**

1 = strongly disagree, 2 = somewhat disagree, 3 = somewhat agree, 4 = strongly agree

10. Students often learn science best through hands-on activities.	1	2	3	4
11. Student-led discussion is a good way for students to learn science.	1	2	3	4
12. When students are presented with a clear explanation of a concept, most are able to learn the concept.	1	2	3	4
13. It is important for students to be involved in group projects.	1	2	3	4
14. Students learn best during laboratory experiments when they work individually.	1	2	3	4
15. Listening to lectures is a good way for students to learn scientific concepts.	1	2	3	4
16. If there must be a choice between learning concepts thoroughly and learning the processes of discovery, the teacher should emphasize the processes of discovery.	1	2	3	4
17. When students ask questions, teachers should provide the answers.	1	2	3	4

♠ **Familiarity with concepts: Use the scale described and circle the appropriate number.**

1 = I am NOT familiar with the concept at all. 2 = I've heard of the term, but I'm not sure what it means. 3 = I know what this is, but I've never used it in practice. 4 = I know what this is and I've used it in practice.

18. Classroom management	1	2	3	4
19. Experimental design	1	2	3	4
20. “Hands-on” activities	1	2	3	4
21. Statistical analysis	1	2	3	4
22. National Science Education Standards	1	2	3	4
23. Empirical studies	1	2	3	4
24. Constructivist learning theory	1	2	3	4
25. Problem-solving approaches	1	2	3	4
26. Inquiry-based learning	1	2	3	4
27. Hypothesis testing	1	2	3	4

♠ **Role of scientists in education and outreach: Use the scale described and circle the appropriate number. “Educational outreach” or “outreach” is defined as scientists’ efforts to make scientific information available to the public and schools.**

1 = strongly disagree, 2 = somewhat disagree, 3 = somewhat agree, 4 = strongly agree

28. It is important for research scientists to get involved in educational outreach projects.	1	2	3	4
29. Scientists' involvement in educational outreach increases public understanding of scientific research.	1	2	3	4
30. It is important for research scientists to work directly with K-12 teachers.	1	2	3	4
31. Scientists' involvement in educational outreach projects motivates students to be interested in scientific careers.	1	2	3	4
32. Research scientists should include educational outreach plans in their funding proposals.	1	2	3	4
33. By getting involved in educational outreach, scientists can develop the educational foundations for informed decision-making in public policy.	1	2	3	4

♠ **Professional preparation and experiences: Use the scale described and circle the appropriate number.**

1 = strongly disagree, 2 = somewhat disagree, 3 = somewhat agree, 4 = strongly agree

34. My professional training as a teacher has equipped me with enough knowledge in science.	1	2	3	4
35. I took more than one course in science during my professional training.	1	2	3	4
36. During my professional training I often worked often in collaborative groups.	1	2	3	4
37. At least one college I attended encouraged the use of cooperative learning.	1	2	3	4
38. The teacher-student relationships in at least one college I attended were warm and supportive.	1	2	3	4
39. I have made numerous presentations to non-school groups.	1	2	3	4
40. I have experience in bringing a scientist to my classroom.	1	2	3	4
41. I have taken my students to field trips or lab visits hosted by a scientist.	1	2	3	4
42. I have conducted collaborative research with a scientist.	1	2	3	4
43. I have consulted with scientists on curriculum development.	1	2	3	4
44. I have experience in referring to scientists for their knowledge of scientific research.	1	2	3	4

♠ **Educator/Scientist roles: Use the scale described and circle the appropriate number.**

1 = strongly disagree, 2 = somewhat disagree, 3 = somewhat agree, 4 = strongly agree

45. It is difficult to present scientific concepts in a manner that is comprehensible by K-12 students.	1	2	3	4
46. It is difficult to communicate with scientists about their research.	1	2	3	4
47. I need to have a better understanding of the profession of scientists.	1	2	3	4
48. I want to increase my understanding of how scientists conduct research.	1	2	3	4
49. It is important that research scientists support K-12 education.	1	2	3	4
50. I believe that I am equipped with the ability to help students gain a better understanding of science.	1	2	3	4
51. I am afraid that I don't understand science well.	1	2	3	4
52. I have been involved in interdisciplinary collaboration.	1	2	3	4
53. I am comfortable working with scientists.	1	2	3	4
54. Partnership with scientists extends the impact of my teaching.	1	2	3	4
55. Research scientists can teach K-12 students new discoveries better than teachers can.	1	2	3	4
56. In our society, scientists have a higher status than educators.	1	2	3	4

♠ **Barriers to educational collaboration: Use the scale described and circle the appropriate number.**

1 = strongly disagree, 2 = somewhat disagree, 3 = somewhat agree, 4 = strongly agree

57. K-12 teachers have sufficient time to work with scientists.	1	2	3	4
58. K-12 teachers have sufficient funding to work with scientists.	1	2	3	4
59. K-12 teachers are interested in educational collaboration with scientists.	1	2	3	4
60. Students are interested in learning directly from scientists.	1	2	3	4
61. K-12 teachers need scientists' assistance in creating resources for students.	1	2	3	4
62. K-12 teachers receive adequate professional acknowledgement for educational collaboration with scientists.	1	2	3	4
63. School systems do not support educational collaboration with scientists	1	2	3	4
64. K-12 schools place much importance on continuing involvement with scientists.	1	2	3	4
65. It is clear to K-12 teachers how to get involved in educational collaboration with scientists.	1	2	3	4
66. Scientists are unaware of what K-12 students need to learn.	1	2	3	4
67. K-12 teachers have difficulty in communicating with scientists	1	2	3	4
68. K-12 teachers have different perspectives on education from scientists.	1	2	3	4

♠ **How would each of the following facilitate your participation in educational collaboration with scientists? Use the scale described and circle the appropriate number.**

1 = strongly disagree, 2 = somewhat disagree, 3 = somewhat agree, 4 = strongly agree

69. Help in identifying specific opportunities I could become involved in	1	2	3	4
70. Assistance in justifying how collaborative efforts with scientists fulfills "standards"	1	2	3	4
71. Assistance in developing budgets for collaboration with research scientists	1	2	3	4
72. Assistance in carrying out collaborative efforts with scientists1	1	2	3	4
73. Institutional appreciation of my involvement in collaboration with scientists	1	2	3	4
74. Workshop or course providing cutting-edge science from research scientists	1	2	3	4
75. Incentives (e.g., promotion, stipend, course credit, or classroom materials)	1	2	3	4

FINALLY, A LITTLE BIT ABOUT YOURSELF:

♠ **Please indicate the main SUBJECT(s) and GRADE LEVEL(s) you teach.**

Subject(s) taught __________________ Grade level(s) ________

Subject(s) taught __________________ Grade level(s) ________

Subject(s) taught __________________ Grade level(s) ________

♠ **Please fill in following blanks with your GENDER, AGE and RACE.**

Gender: ______ Age: _______ Race: ____________________

♠ **Please identify your number of YEARS of full-time K-12 teaching experience.**

I have taught in K-12 school settings for _____ years.

♠ **Please check your highest degree earned and fill in the subject area of the highest degree.**

a. Highest Degree: Bachelor's _____ Master's _____ Doctoral _____

b. Subject area of your highest degree: ________________

♠ **Please check the best description of your school community.**

Urban ____ Suburban ____ Rural ____ Tribal ____

♠ **Please estimate the percentage of students you teach who belong to "under-represented" groups [tribal, minority].** _____%

Thank you for your efforts and for helping us understand the perceptions of collaboration among scientists and educators.

*Please return the completed survey to your principal by **May 15, 2006**, for your school's return of materials to the research office.*

Chankook Kim / Rosanne W. Fortner
School of Environment and Natural Resources
The Ohio State University
2021 Coffey Road
210 Kottman Hall
Columbus, OH 43210-1085

APPENDIX B

PERCEPTIONS OF CULTURAL DIFFERENCES AND COLLABORATION AMONG SCIENTISTS AND EDUCATORS – SCIENTIST VERSION

Perceptions of Cultural Differences and Collaboration

Among Scientists and Educators

COSEE Great Lakes Baseline Study
School of Environment and Natural Resources
The Ohio State University
2021 Coffey Road
210 Kottman Hall
Columbus, OH 43210-1085

Perceptions of Cultural Differences and Collaboration Among Scientists and Educators

(For Scientists)

As a Great Lakes scientist, your perceptions can help us understand how scientists and educators may collaborate to develop science literacy. Please respond to the following questions with your expert opinions and submit your response to the registration desk before you leave IAGLR's 49th Annual Conference on Great Lakes Research. If you prefer, you may want to mail it to the researchers by June 1 using the address at the end. When we analyze the results, we will not identify any specifics about your individual responses. We are only interested in understanding the views of the participants as members of groups. No one besides the researchers will have access to the survey data. Your participation in this study is completely voluntary. Thank you for assisting in this COSEE Great Lakes baseline study.

If you have questions about this study, please contact:

Rosanne W. Fortner Phone: (910) 278-6754, E-mail: fortner.2@osu.edu

Chankook Kim Phone: (614) 292-1078, E-mail: kim.1744@osu.edu

♠ **Please indicate the extent to which you agree or disagree with each of the following statements about science: Use the scale described and circle the appropriate number.**

1 = strongly disagree, 2 = somewhat disagree, 3 = somewhat agree, 4 = strongly agree

1. Science provides objective knowledge about the world.	1	2	3	4
2. Unbiased science has never been achieved.	1	2	3	4
3. Science is performed by a specific community of qualified scientists.	1	2	3	4
4. The process of scientific discovery often involves a high degree of creativity.	1	2	3	4
5. Science is based on experiments which other scientists should be able to replicate.	1	2	3	4
6. Some scientific studies that do not involve experimentation are valid.	1	2	3	4
7. The acquisition of new scientific knowledge moves from observation to formation of hypotheses, then testing, and finally generalizing to theory.	1	2	3	4
8. Intuition plays an important role in scientific discovery.	1	2	3	4
9. Cultural groups differ in their processes of gaining valid knowledge about natural phenomena.	1	2	3	4

♠ **Teaching and learning science: Use the scale described and circle the appropriate number.**

1 = strongly disagree, 2 = somewhat disagree, 3 = somewhat agree, 4 = strongly agree

10. Students often learn science best through hands-on activities.	1	2	3	4
11. Student-led discussion is a good way for students to learn science.	1	2	3	4
12. When students are presented with a clear explanation of a concept, most are able to learn the concept.	1	2	3	4
13. It is important for students to be involved in group projects.	1	2	3	4
14. Students learn best during laboratory experiments when they work individually.	1	2	3	4
15. Listening to lectures is a good way for students to learn scientific concepts.	1	2	3	4
16. If there must be a choice between learning concepts thoroughly and learning the processes of discovery, the teacher should emphasize the processes of discovery.	1	2	3	4
17. When students ask questions, teachers should provide the answers.	1	2	3	4

♠ Familiarity with concepts: Use the scale described and circle the appropriate number.

1 = I am NOT familiar with the concept at all. 2 = I've heard of the term, but I'm not sure what it means. 3 = I know what this is, but I've never used it in practice. 4 = I know what this is and I've used it in practice.

18. Classroom management	1	2	3	4
19. Experimental design	1	2	3	4
20. “Hands-on” activities	1	2	3	4
21. Statistical analysis	1	2	3	4
22. National Science Education Standards	1	2	3	4
23. Empirical studies	1	2	3	4
24. Constructivist learning theory	1	2	3	4
25. Problem-solving approaches	1	2	3	4
26. Inquiry-based learning	1	2	3	4
27. Hypothesis testing	1	2	3	4

♠ Role of scientists in education and outreach: Use the scale described and circle the appropriate number. “Educational outreach” or “outreach” is defined as scientists’ efforts to make scientific information available to the public and schools.

1 = strongly disagree, 2 = somewhat disagree, 3 = somewhat agree, 4 = strongly agree

28. It is important for research scientists to get involved in educational outreach projects.	1	2	3	4
29. Scientists' involvement in educational outreach increases public understanding of scientific research.	1	2	3	4
30. It is important for research scientists to work directly with K-12 teachers.	1	2	3	4
31. Scientists' involvement in educational outreach projects motivates students to be interested in scientific careers.	1	2	3	4
32. Research scientists should include educational outreach plans in their funding proposals.	1	2	3	4
33. By getting involved in educational outreach, scientists can develop the educational foundations for informed decision-making in public policy.	1	2	3	4

♠ **Professional preparation and experiences: Use the scale described and circle the appropriate number.**

1 = strongly disagree, 2 = somewhat disagree, 3 = somewhat agree, 4 = strongly agree

34. My professional training as a scientist has equipped me with enough knowledge in teaching.	1	2	3	4
35. I took more than one course in education during my professional training.	1	2	3	4
36. During my professional training I often worked often in collaborative groups.	1	2	3	4
37. At least one college I attended encouraged the use of cooperative learning.	1	2	3	4
38. The teacher-student relationships in at least one college I attended were warm and supportive.	1	2	3	4
39. I have made numerous presentations about my research to the public.	1	2	3	4
40. I have experience in making presentations about my research to K-12 students.	1	2	3	4
41. I have hosted field trips or lab visits for K-12 students.	1	2	3	4
42. I have conducted collaborative research with teachers.	1	2	3	4
43. I have consulted with science educators on curriculum development.	1	2	3	4
44. I have experience in calling on teachers for their pedagogical knowledge.	1	2	3	4

♠ **Scientist/educator roles: Use the scale described and circle the appropriate number.**

1 = strongly disagree, 2 = somewhat disagree, 3 = somewhat agree, 4 = strongly agree

45. It is difficult to present scientific concepts in a manner that is comprehensible by K-12 students.	1	2	3	4
46. It is difficult to communicate with teachers about my research field.	1	2	3	4
47. I need to have a better understanding of the profession of teachers.	1	2	3	4
48. I want to increase my understanding of how students learn.	1	2	3	4
49. It is important that research scientists support K-12 education.	1	2	3	4
50. I believe that I am equipped with the ability to help students gain a better understanding of science.	1	2	3	4
51. Teachers, on average, are afraid that they don't know enough science.	1	2	3	4
52. I have been involved in interdisciplinary collaboration.	1	2	3	4
53. I am comfortable working with teachers.	1	2	3	4
54. Partnership with educators extends the impact of my research results.	1	2	3	4
55. Research scientists can teach K-12 students new discoveries better than teachers can.	1	2	3	4
56. In our society, scientists have a higher status than educators.	1	2	3	4

♠ **Barriers to educational outreach: Use the scale described and circle the appropriate number.**

1 = strongly disagree, 2 = somewhat disagree, 3 = somewhat agree, 4 = strongly agree

57. Research scientists have sufficient time for outreach activities.	1	2	3	4
58. Research scientists have sufficient funding for outreach activities.	1	2	3	4
59. Research scientists are interested in education and outreach activities.	1	2	3	4
60. The public is interested in learning about my research.	1	2	3	4
61. Research scientists need assistance in creating resources for K-12 students.	1	2	3	4
62. Research scientists receive adequate professional rewards for engaging in outreach activities.	1	2	3	4
63. Institutions do not support research scientists' educational outreach.	1	2	3	4
64. Funding agencies place much importance on educational outreach.	1	2	3	4
65. It is clear to research scientists how to get involved in educational outreach.	1	2	3	4
66. Research scientists are unaware of what K-12 students need to learn.	1	2	3	4
67. Research scientists have difficulty in communicating with K-12 teachers.	1	2	3	4
68. K-12 teachers have different perspectives on education from scientists.	1	2	3	4

♠ **How would each of the following facilitate your participation in educational outreach? Use the scale described and circle the appropriate number.**

1 = strongly disagree, 2 = somewhat disagree, 3 = somewhat agree, 4 = strongly agree

69. Help in identifying specific opportunities I could become involved in	1	2	3	4
70. Assistance in developing the "broader impact" component of research proposals	1	2	3	4
71. Assistance in justifying budgets for "broader impact" components of research proposals	1	2	3	4
72. Assistance in carrying out educational outreach activities	1	2	3	4
73. Institutional appreciation of my involvement in educational outreach projects	1	2	3	4
74. Workshop or course providing pedagogical knowledge (how to teach science) from teachers	1	2	3	4
75. Professional incentives (e.g. promotion, stipend, or raise)	1	2	3	4

FINALLY, A LITTLE BIT ABOUT YOURSELF:

♠ **Please indicate which of the following best describes your MAIN JOB FUNCTION: Check all that apply.**

Teaching ______ Research ______
Outreach/Extension education ______ Student ______
Other (please specify) ____

♠ **Please complete following blank with your PRIMARY DISCIPLINARY FOCUS.**
(Open-ended: e.g. biological oceanography)

____

♠ **Please fill in following blanks with your GENDER, AGE and RACE.**
Gender: ______ Age: _______ Race: ___________________

♠ **Please identify the number of YEARS of full-time experience in your current field.**
I have worked in my research field for _____ years.

♠ **Please check your highest degree earned and fill in the area of the highest degree.**
a. Highest Degree: Bachelor's _____ Master's _____ Doctoral _____ Other ______
b. Subject area of your highest degree: _______________

♠ **Please check one response per statement best describing your situation.**
a. As a condition of my funding, I am required to demonstrate the "broader impact" of my research.
Most of the time ___ Some of the time ___ Not at all ___
I am not sure what is meant by "broader impact." ___

b. Including some form of educational outreach in my research proposals enhances my chances of receiving research funding.
Yes ___ No ___ I am not sure / I do not know ___

***Thank you for your efforts and for helping us understand the perceptions of collaboration among scientists and educators*.**

Please return the completed form to the registration desk by the end of the IAGLR's 49th Annual Conference on Great Lakes Research (May 26, 2006). You can also mail it to the researchers by June 1.

Chankook Kim / Rosanne Fortner
School of Environment and Natural Resources
The Ohio State University
2021 Coffey Road
210 Kottman Hall
Columbus, OH 43210-1085

To be included in a drawing for a $100 Amazon.com gift certificate and other valuable prizes, put your name and address on the bottom section of the survey and turn it in separately when you submit your responses.

………

Name ______________________________ *E-mail* ________________

Address ______________________________

____