Appendix D: Literature Review

A literature review of watershed education-related research to inform NOAA B-WET's evaluation system

Completed September 2011 for NOAA B-WET by:

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Executive Summary

NOAA B-WET funds and supports Meaningful Watershed Education Experiences (MWEEs) to increase students' and teachers' knowledge, attitudes, and skills so that they will act in ways to protect watersheds and related ocean, coastal, and Great Lakes ecosystems.

This literature review of watershed education and related research was conducted primarily to inform B-WET's evaluation system. More specifically, we sought to learn how constructs of interest have been measured in reliable and valid ways. However, in light of B-WET's desire to learn what research suggests about the potential effectiveness of MWEEs, the review also addresses this question.

Research supports that B-WET's focus on watershed education is very much warranted. There is a great need for enhancing individuals' watershed literacy and this need is unlikely to be sufficiently met through formal education and other national environmental education programs.

- U.S. adults and children are not "watershed literate," they lack the knowledge necessary to understand issues related to water quality, point and non-point source pollution, as well as the impact of land use practices and personal actions on watersheds. They are therefore also unlikely to recognize the need for a watershed-based management approach.
- Watershed education concepts have limited representation in K-12 national and state standards and the few instructional resources that teachers can choose from tend to be national in scope; i.e., they tend not to be place-specific, locally-relevant, or linked to relevant education standards.

"Literacy" initiatives and watershed education research provide insight into the understanding individuals need to be considered scientifically "watershed literate."

- Based on our review, we propose that a watershed literate individual should be able to 1) define the term "watershed", 2) identify their local watershed(s), 3) identify how watersheds are connected to the ocean via streams, rivers, and human-made structures, 4) identify the functions that occur in a watershed (transport, store, and cycle water), 5) recognize that both natural processes and human activities affect water flow and water quality in watersheds, 6) identify connections between human welfare and water flow and quality, 7) identify possible point and non-point sources of water pollution, 8) identify actions individuals can engage in to protect/restore water quality in watersheds, and 9) identify how humans seek to manage watersheds

It is important to note, however, that while scientific literacy may be necessary for individuals to act to protect watersheds and related ocean, coastal, and Great Lakes ecosystems (B-WET's desired longer-term outcome), it is unlikely to be sufficient.

- Research suggests that environmental education programs need to have the following characteristics, if they are to have behavioral outcomes:
  - explicit behavioral outcome objectives,

- driven by behavior theories/models,[2]
- consider participants' needs, context and background,
- incorporate experiential learning and
- be longer[3] in duration.

Studies confirm that watershed education can have the types of benefits B-WET expects its funded projects to have for both students and teachers – to the extent that they incorporate certain instructional and professional practices.

- Potential benefits consist of improved students and teachers understanding of watersheds (as defined above and consistent with national science standards) and enhanced environmental attitudes, sense of environmental stewardship, and responsible environmental behaviors.
- Instructional practices leading to these outcomes include 1) place-based authentic hands-on science inquiry with sufficient opportunities to examine and discuss data, 2) outdoor learning experiences that include preparation and reflection phases as well as the nature of the experience itself (e.g., appropriate amount of structure, opportunities to directly interact with environment, facilitating and role modeling by educators), 3) demonstrations/models that make invisible parts of watershed systems visible, 4) use of instructional technologies, and 5) service learning. To achieve behavioral outcomes, in addition to learning outcomes, programs should also have the characteristics outlined earlier. Finally, programs that are longer tend to be more effective than shorter programs.
- Professional development needs to provide teachers with the knowledge and skills they perceive as necessary to conduct outdoor field investigations with their students, including involving them in experiences similar to those they are expected to engage in with their students (e.g., collecting and analyzing watershed data). Effective subsequent implementation is likely to depend on teachers' perceptions about how well aligned the proposed activities are with their own goals and the goals they have for their students, the extent to which they had time, as part of the professional development, to plan for implementation, as well as on a number of other characteristics. Finally, 30 or more contact hours have been associated with perceived increases in teachers' knowledge and skills.

Altogether these findings support the effectiveness of the practices that B-WET advocates for through its MWEEs for students, such as the inclusion of outdoor, inquiry based field work or engaging in restoration activities[4] as well as of preparation and reflection phases to support student learning. The above findings, however, also offer additional ways MWEEs could be strengthened to further contribute to student learning and result in behavioral outcomes (e.g.,

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[2] An excellent review of relevant models is provided by Heimlich & Ardoin (2008). The majority of these models include predictors other than scientific literacy.

[3] Syntheses of environmental education research and evaluations suggest that programs which last only a few hours are less likely to change behaviors than ones that last 1-2 years. However, whether or not this goal is reached also very likely depends on other program characteristics.

[4] Under the assumption that these are part of a service learning experience.

longer duration, building on behavior theories). With regard to teacher professional development, MWEEs encourage a minimum length of 3 days which, comes close to the 30 hours that teachers have reported as necessary for changing their own knowledge and skills. Other professional development practices, including but not limited to those suggested by B-WET, are also likely to play an important role in determining to what extent teachers will adopt the desired MWEE practices.

There is a relatively limited number of studies that can inform the B-WET evaluation system given that the system will be based primarily on quantitative data whereas most watershed education studies have relied on qualitative data. At the same time, two national studies have included multiple choice and true/false questions that can be used to test aspects of students' understanding of watersheds, as well as a few other studies which include questions that can be modified to provide quantitative response options. In terms of assessing to what extent students may change their environmentally responsible behaviors as a result of the watershed education they receive through B-WET funded programs, the B-WET Chesapeake evaluation conducted by the authors in 2007 still seems to provide some of the most relevant measures to adapt for the purpose of the national evaluation. Finally, two studies of teacher watershed education programs provide some insight into constructs to measure that may explain differences in teacher outcomes and syntheses of professional development research provide a foundation for the development of list of best professional development practices to measure.

Introduction

As suggested by its mission and logic model, B-WET seeks to increase its funded projects' participants' knowledge, attitudes, and skills so that they will act in ways to protect watersheds and related ocean, coastal, and Great Lakes ecosystems. B-WET does so by funding and supporting its grantees to adopt Meaningful Watershed Education Experiences (MWEEs).

Purposes of Literature Review

The purposes of this literature review were to identify research to help assess the potential effectiveness of the features of Meaningful Watershed Education Experiences (MWEEs) and, importantly, as a result of this process find measures or scales to inform the development of data collection instruments for B-WET's evaluation system.

Methods

Given B-WET's focus on watershed education and the lack of an available synthesis of watershed education research, this review sought to identify and summarize results from watershed education studies. These studies were identified by 1) searching electronic databases, 2) reviewing related research syntheses (e.g., on ocean and climate literacy), 3) examining each of the identified publications' respective references, 4) contacting environmental education researchers with relevant expertise, and 5) drawing on our own work.

In addition to focusing on single watershed education studies, this review also drew on insights from <u>syntheses</u> conducted of relevant bodies of research including:

- ocean and climate literacy education (Fortner, Unknown; Payne & Zimmerman, 2010; Tran, 2009; Tran, Payne, & Whitley, 2010),
- outdoor education (Dillon et al., 2006; Rickinson et al., 2004),
- instructional practices leading to changes in environmentally responsible behavior (Zelezny, 1999; Zint, 2012)
- environmental literacy (Coyle, 2005; Marcinkowski et al., 2012; OECD, 2009)
- place based education (Smith, 2012)
- inquiry-based science instruction (Minner, Jurist, & Century, 2010)
- (science) teacher professional development (Fishman & Davis, 2006)

Syntheses from these particular bodies of research were reviewed because they:

- focus on outcomes of interest to B-WET,
- provide insight into how these outcomes have been measured, and
- address the effectiveness of instructional practices supported by B-WET through its MWEEs.

It was appropriate to draw on these syntheses rather than to identify and review single studies within these research domains because 1) these syntheses are thorough and comprehensive in scope and 2) conclusions drawn from syntheses have greater reliability than ones from single studies.

Results

This section synthesizes the results from the literature review. It is organized mainly around questions related to watershed education. However, there are also a number of textboxes which answer related questions that cannot be addressed on the basis of findings from the watershed education literature.

More specifically, each of the following questions is addressed in the order presented below:

- Is there a need for watershed education?
- What should the objectives of watershed education be?
    - What instructional practices can foster environmentally responsible behaviors?
- What are the potential benefits of watershed education for students and teachers?
- What instructional practices have resulted in the student benefits identified above?
    - What are the benefits of place-based instruction?
    - To what extent is inquiry-based science instruction more effective in fostering students' understanding of science concepts than more passive techniques?
    - What do we know about the value of outdoor fieldwork and the factors that influence how much learning will take place as a result?
- What do we know about teachers' watershed education practices?
- What professional development practices can strengthen teachers' watershed education efforts?
    - What professional development practices support teacher learning and change?
- What studies and resources can be drawn on to inform the development of data collection instruments for B-WET's evaluation system?

When relevant and possible, implications for B-WET are addressed (these are highlighted in ***bold and italics***).

Is there a need for watershed education?

There appears to be a great need for watershed education. This is supported by the results from a range of descriptive studies with adults and children, suggesting that the US public is not "watershed literate." For example, when presented with multiple choice definitions of "a watershed" as part of a national environmental literacy survey, only 41% of adults were able to identify the true meaning of the term and 35% did not venture a guess; that is three out of five American adults did not know what a watershed[5] is (NEETF, 1998). This same study also revealed that only one in five American adults (22%) knew that run-off is the most common form of pollution of streams, rivers and oceans, compared to nearly half (47%) who thought the most common source is waste dumped by factories (NEETF, 1998). Findings from another set of national studies of both adults and children were consistent with these results, suggesting that:

- 44% of adults and 74% of children indicated that they did not know what a watershed[6] is,

[5] The report offers the following definition of a watershed: "an area of land that, due to its natural drainage pattern, collects precipitation and deposits it into a particular body of water. In the West these land areas are often called drainages and through the nation they are sometimes referred to as river or stream basins" (NEETF, 1998).

[6] Respondents answered this question after being provided with the following definitions: "A watershed (often referred to as a river basin) is an area that, due to its natural drainage pattern and geography, collects rainfall, snowmelt or irrigation that runs over land and then deposits it into a particular body of water. A watershed is often referred to as a river or

- 65% of adults and 59% of children believed that watersheds and wetlands are the same thing,
- 26% of adults and 54% of children did not know into which body of water rain in their neighborhood flows,
- 86% of adults and 85% of children admitted that they were not familiar with the term non-point source pollution,
- only 19% of adults were able to correctly identify non-point sources of pollution as the largest source of water quality problems, and
- only 35% of adults identified land use, land development, and urban sprawl as the most serious threats to watershed health (Penn, 2001a, 2001b).

Results from these studies are troubling[7] because they suggest that the US public lacks the necessary knowledge to understand issues related to water quality, point and non-point source pollution, and the impact of land use practices and personal actions on watersheds (Patterson & Harbor, 2005; Schueler & Holland, 2000). As a result, the US public is unlikely to recognize the need for a watershed-based management approach (Coyle, 2005; Eflin & Sheaffer, 2006; NEETF, 1999; Schueler & Holland, 2000).

In addition to these national studies, research has also been carried out to explore grades 4-12 students' understanding of watersheds in greater depth. These sets of studies identify students' ideas related to watersheds, as well as gaps in their understanding. For example, children have the common perception that watersheds are human made sheds that have water inside or on top of them (Patterson & Harbor, 2005), although this conception is more likely to be held by elementary and middle school than high school students (D. P. Shepardson, Harbor, & Wee, 2005). Considering the water cycle as a component of watersheds similarly increases by grade level (D. P. Shepardson, et al., 2005).

Students' ideas about watersheds also tend to be limited to mountainous terrains, rivers and streams, even among Midwest students (D. Shepardson, Harbor, Cooper, & McDonald, 2002; D. P. Shepardson et al., 2003; D. P. Shepardson, et al., 2005). Thus, students tend to portray watersheds as areas of land with high relief and elevation where water is cycled, stored, or transported (D. P. Shepardson, Wee, Priddy, Schellenberger, & Harbor, 2007, 2009). It may be because of these ideas that students have been found not to consider runoff, groundwater, or the impacts of human activities and biological entities on watersheds (D. Shepardson, et al., 2002; D. P. Shepardson, et al., 2003; D. P. Shepardson, et al., 2005).

Moreover, students have also been found not to understand:

- the basin shape of watersheds (Dove, Everett, & Preece, 1999),
- that bodies of water are interconnected and flow into larger bodies of water (Dove, et al., 1999; D. P. Shepardson, et al., 2005),
- that watersheds occur in urban areas (Dove, et al., 1999; D. P. Shepardson, et al., 2005; D. P. Shepardson, et al., 2009),

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stream basin. Non-point source pollution occurs when water runs over land or through the ground and picks up pollutants and deposits them into rivers, lakes, oceans, and groundwater" (Penn, 2001a, 2001b).

[7] It is acknowledged that these studies were conducted over a decade ago and thus, that individuals' understanding of watersheds may have changed. At the same time, however, we are not aware of any interventions that have taken place to remedy this situation.

- the connections between water and land; i.e. water flowing through landscape-scale systems (D. P. Shepardson, et al., 2005; D. P. Shepardson, et al., 2009), and
- aspects of watershed systems that are not readily visible (Covitt, Gunckel, & Anderson, 2009).

Several of these studies also explore why students may have such ideas and gaps in understanding. For the most part, results suggest that students' limited conceptions appear to be due to the diagrams and other graphics in presentations, textbooks, websites and materials about watersheds and the water cycle. For example, several studies revealed that students omit human activities and biological organisms from their illustrations of the water cycling through watersheds; both are typically also missing from instructional diagrams (Ben-zvi-Assarf & Orion, 2005; D. P. Shepardson, et al., 2007, 2009). Others have argued that students do not have the necessary systems perspectives to recognize the movement of water under the ground (Dickerson & Dawkins, 2004), the conservation of water (Ben-zvi-Assarf & Orion, 2005), and the role and effects of the biosphere and human activities (Ben-zvi-Assarf & Orion, 2005; D. P. Shepardson, et al., 2005; D. P. Shepardson, et al., 2007).

Importantly, despite adults' and children's limited knowledge as related to watersheds, there is evidence to suggest that they are interested and willing to take action to help protect watersheds, but that in order to do so, they need relevant procedural knowledge (Penn, 2001a, 2001b). These findings are consistent with the results from a national study investigating the US public's understanding of and willingness to act to protect the oceans (Project, 2009).

The need for watershed education is further supported by the fact that related concepts have limited representation in K-12 national and state frameworks and standards, although there are some movements toward mandating watershed education (Gruver & Luloff, 2008). In addition, there are few resources that teachers can choose from and these resources tend to be national in scope (e.g., Project WET, Project WILD-Aquatic, and Wonders of Wetlands). They therefore are not place-specific and may lack local relevance (Gruver & Luloff, 2008). Moreover, these national materials may also not be aligned with relevant education standards (Gruver & Luloff, 2008).

Overall, these findings suggest that B-WET's focus on watershed education is very much warranted. There is a great need for enhancing individuals' watershed literacy and this need is unlikely to be sufficiently met through the formal education system and existing programs that have only a national scope.

What should the objectives of watershed education be?

There have been a number of initiatives to develop environmental science literacy objectives linked to the National Science Education Standards that could be drawn on to help identify objectives for watershed education and, thus, to help determine what teacher or student outcomes to potentially assess as part of B-WET's evaluation system. These initiatives include the Great Lakes Literacy Principles (http://www.greatlakesliteracy.net/), the Ocean Literacy Principles (http://oceanliteracy.wp2.coexploration.org/) and the Climate Literacy Principles (http://www.climatescience.gov/Library/Literacy/).

There have been two researchers, however, who developed science objectives specifically for watershed education:

(1) Shepardson et al. (2007) suggested that students should develop the following understandings:

- Watersheds are defined by elevation and relief.
- Watersheds have a structure that includes running water and still water.
- Watersheds consist of biological and physical components.
- Watersheds are changed by natural processes and human activity.
- Watersheds function to transport, store, cycle and transform water and materials.
- Watersheds are polluted by point sources, non-point sources and biological, organic and thermal pollution.

(2) Endreny (2010), building on the work by Shepardson et al. (2007), developed a similar set of objectives:

- The water cycle (precipitation, evaporation, condensation, infiltration and run-off) is responsible for the water in the watershed.
- A watershed is any body of water and the land that drains into that body of water.
- Topography defines and separates the watersheds.
- Smaller watersheds connect to each other forming larger more inclusive watersheds.
- Land use in watersheds affects water pollution. This includes run-off pollution.
- A watershed contains biological components that interact and influence the watershed.
- The watershed contains physical and biological components.
- A watershed is influenced by human and natural factors.

These "literacy" initiatives and the two researchers' objectives provide insight into the understanding individuals may need to be considered scientifically watershed literate.
More specifically, we propose that a watershed literate individual should be able to 1) define the term "watershed", 2) identify their local watershed(s), 3) identify how watersheds are connected to the ocean via streams, rivers, and human-made structures, 4) identify the functions that occur in a watershed (transport, store, and cycle water), 5) recognize that both natural processes and human activities affect water flow and water quality in watersheds, 6) identify connections between human welfare and water flow and quality, 7) identify possible point and non-point sources of water pollution, 8) identify actions individuals can engage in to protect/restore water quality in watersheds, and 9) identify how humans seek to manage watersheds. These objectives provide some guidance as to what outcomes to measure to assess students' and possibly, teachers' scientific watershed literacy as part of B-WET's evaluation system.

It is important to note, however, these resources and studies do not provide insight into the other characteristics individuals may need to have to act to protect watersheds and related ocean, coastal, and Great Lakes ecosystems; B-WET's desired longer-term outcome. This is important because scientific literacy may be necessary but is unlikely to be sufficient for environmentally responsible behaviors (Hines, Hungerford, & Tomera, 1986-1987; Hungerford & Volk, 1990).

What instructional practices can foster environmentally responsible behaviors?
If instruction in science may not be sufficient for fostering environmentally responsible behaviors, what instructional practices may be? A recent review of ten published behavioral outcome evaluations of environmental education programs (Zint, 2012) helps to identify potentially successful practices. Specifically, this review suggested that EE programs <u>cannot</u> foster changes in behaviors if they:

- lack clearly defined behavioral outcome objectives,
- focus on general environmental knowledge or attitudes (vs. ones related to desired behaviors),
- are top down (i.e., not designed to meet audiences' needs),
- passive (i.e., information transmission focused, lacking participant involvement), and
- are short (i.e., a few hours) in duration.

and that EE programs <u>can</u> foster changes in behaviors if they:

- have behavioral outcome objectives,
- are designed based on behavior theories/models [see (Heimlich & Ardoin, 2008) for a review of relevant theories/models],
- consider participants' needs, context and background,
- incorporate experiential learning (e.g., field trips, service learning), and
- are longer (i.e., 1-2 years) in duration.

These results are quite consistent with a meta-analysis of 18 studies that also sought to identify the instructional factors to which changes in environmental responsible behavior can be attributed (Zelezny, 1999). This meta-analysis, for example, also suggested that shorter (less than 10 hours) and passive programs were less likely to result in environmentally responsible behaviors than longer ones that actively involved participants. The same author, however also concluded that programs in traditional classroom settings were more effective than ones in non-traditional classroom settings (i.e., ones that included field studies). Due to the limitations of the reviewed studies, however, it is unclear how the author could be confident in drawing this *particular* conclusion (Rickinson, et al., 2004)

Although B-WET encourages its grantees to include experiential learning opportunities as part of their MWEEs and to offer programs of a certain length, B-WET does not stress that grantees engage in the other practices that these reviews have identified as leading to changes in environmentally responsible behaviors. That is, B-WET does not <u>explicitly</u> stress that grantees target specific behaviors, draw on behavior theories/models and/or that they build on participants' needs, context or background to facilitate changes in their environmentally responsible behaviors.

What are the potential benefits of watershed education for students and teachers?

Studies identified through this literature review provide some evidence to suggest that watershed education can have a number of benefits for students including to:

- improve their understanding of watersheds in ways consistent with National Science Education Standards (Endreny, 2010),
- enhance their environmental attitudes, a sense of environmental stewardship, and responsible environmental behaviors (Bodzin, 2008),
- increase their advocacy for the environment (Stapp, 2000), and
- strengthen their civic responsibility (Eflin & Sheaffer, 2006).

In addition, there is evidence that professional development can increase teachers' understanding of watersheds, water quality, and stream monitoring (D. Shepardson, et al., 2002) ***As such, these studies suggest that watershed education can have some of the types of benefits B-WET expects its funded projects to have for both students and teachers.***

What instructional practices have resulted in the student benefits identified above?

The authors of watershed education research provide evidence that the following instructional practices can lead to the types of student outcomes identified above:

- (long term) place-based hands-on science inquiry (Bodzin, 2008; Endreny, 2010; Patterson & Harbor, 2005),
- outdoor learning experiences (Bodzin, 2008),
- demonstrations/models that make invisible parts of watershed systems visible (Covitt, et al., 2009),
- instructional technologies (e.g. Web-based GIS maps and Google Earth) (Bodzin, 2008), and
- service learning (Eflin & Sheaffer, 2006).

What are the benefits of place-based instruction?
Place-based instruction is a relatively new teaching and learning approach that is aimed at "fostering both community and environmental renewal" (Smith, 2012). Place-based initiatives typically involve students in investigating and reporting on issues in their local communities, drawing on individuals and resources within their home communities. Because place-based education represents a relatively new approach and has received limited funding, little research is available on its effectiveness. In his review of place-based education practices and impacts, Smith (2012) summarizes the evidence that is available on place-based education, draws on research from related domains (e.g., authentic and service learning), and offers theoretical justifications in support of this approach. Smith concludes that place based learning has the potential to increase student achievement, contribute to stewardship, civic engagement, and self-efficacy, as well as other outcomes. **Given the nature of the evidence and arguments presented by Smith (2012), there appears to be some arguments for B-WET students and teachers to be involved in investigating local watersheds from a place-based education perspective.**

Interestingly, Dr. William Stapp, the developer of an international river and watershed education program entitled the Global Rivers Environmental Education Network (GREEN), has attributed the successes of his program to a similar set of features:

- watershed analysis,
- experiential learning,
- interdisciplinary (natural and social science) approach,
- integrated problem solving,
- action-taking strategies, and
- peer and community based support networks (Stapp, 2000).

To what extent is inquiry-based science instruction more effective in fostering students' understanding of science concepts than more passive techniques?
This is the question that a review of 138 studies published between 1984-2002 sought to answer (Minner, et al., 2010). The review, however, is not only useful in terms of helping to answer this question. It is also valuable in that it presents a conceptual framework that operationalizes what is meant by inquiry-based science instruction (Table 1).

Table 1. Conceptual framework for inquiry science instruction (From Minner et al., 2010)

Presence of **Science Content**	· Science as Inquiry · Life Science · Physical Science · Earth and Space Science			
Type of **Student Engagement**	· Students manipulate materials · Students watch scientific phenomena · Students watch a demonstration of scientific phenomena · Students watch a demonstration that is NOT of scientific phenomena · Students use secondary sources (e.g., reading material, the Internet, discussion, lecture, others' data)			
		Elements of the Inquiry Domain		
		Instruction emphasizes **Student Responsibility for Learning** when it demonstrates the expectation that students will:	Instruction emphasizes **Student Active Thinking** when it demonstrates the expectation that students will:	Instruction emphasizes **Student Motivation** when:
Components of Instruction	**Question**	Decide which questions to investigate; seek clarification of the investigation question(s).	Generate investigation question(s); use prior knowledge to inform the question(s); consider or predict possible outcomes of the question; explore the reasons question(s) are being asked to determine if they are appropriate for scientific investigation; refine questions so that they can be investigated; discuss questions based on previous study or data collected.	**it demonstrates the expectation that students will**: display/express interest, involvement, curiosity, enthusiasm, perseverance, eagerness, focus, concentration, pride (all affective)
	Design	Identify when and where they need help understanding the design; ensure that they (or the class/group/partner) grasps the design and how to implement it; decide what investigation design to use; ensure that the design addresses the research question.	Use prior knowledge to inform the design; determine if the design is an appropriate match for the question including variables and procedures; debate the merits of different investigation designs and whether it is "doable" and will result in needed data; consider where and how issues of bias may need to be addressed; generate investigation designs.	
	Data	Decide the data organization strategy; decide what data collection strategy to use and/or how to adapt it; identify if they or others need help collecting or organizing data; seek out clarification and advice when it is needed.	Alter and refine their approach to gathering, recording, or structuring the data based on information they acquire as they proceed.	
	Conclusion	Decide what strategies to use to summarize, interpret or explain the data; identify when they or others need help in summarizing, interpreting or explaining; and seek out other relevant information to assist in drawing conclusions.	Ensure that their conclusions are supported by their data; apply prior knowledge to summarize, interpret, or explain the data; construct conclusions; consider conclusions' reasonableness and credibility; identify applications of their findings to other situations and/or contexts; offer explanations for variations in the findings among the class and/or within their working groups; generate new questions that arise out of their explanations.	
	Communication	Decide how to structure their communication; seek advice and suggestions from others about how/what to communicate; provide feedback to others about their communication.	Engage in sound discussion and debate; demonstrate the logic they used to draw conclusions and interpretations; articulate the reasonableness and credibility of others' work; discuss appropriate communication mechanisms including language, visual aids, technology, etc.; articulate the merits and limitations of their work.	

In terms of answering the question about the effectiveness of inquiry-based science instruction, the authors did not find "overwhelming positive" (p. 493) evidence that inquiry-based science instruction is more effective than traditional, passive instruction in improving students' understanding of science concepts. However, they indicate that there is "a clear and consistent trend" (p. 493) in the achievement of these outcomes when students are engaged in actively thinking about and drawing conclusions from data. **These findings suggest that even if students were not actively involved in collecting data but had the opportunities to examine and discuss NOAA data (a desired part of B-WET's MWEEs), they may increase their understanding of underlying science concepts.**

The fact that it is likely to be important to provide direct personal experiences (e.g. through outdoor activities, field investigations) with watersheds, if B-WET's desired outcomes, are to be achieved is supported by the authors cited throughout this section as well as by education theory and research from other, related contexts:

- Dewey (1938) is probably the most notable education researcher to advocate for supporting students' learning through direct personal experiences.

- A survey of adults in the Pacific Northwest found that individuals who had direct connections with coastal areas through personal visits or business interests were more knowledgeable about coastal and ocean resource issues than those who did not (Steel, Lovrich, Lach, &

Fomenko, 2005). In this particular study, individuals who were more knowledgeable of ocean science concepts were also found to be more knowledgeable and supportive of policies and regulations to protect oceans (Steel, et al., 2005).

- An experimental study to determine the added value of a field trip during which middle school students collected (and presumably analyzed) data from a freshwater system, found that these particular students had a more advanced understanding of ecological concepts than students who did not have this opportunity (Manzanal, Barreiro, & Jimenez, 1999).

The synthesis of ocean and climate literacy research that referenced the above study by Steel et. al (2005) also stressed the importance of enhancing students' systems thinking within the context of ocean and climate change education (Tran, 2009; Tran, et al., 2010). These authors' literature review on systems thinking education suggested that within this context it is important to 1) ensure that teachers have advanced pedagogical knowledge to scaffold student thinking; 2) design activities that give students control to create and manipulate models (virtual and physical); and 3) provide opportunities for students to talk with peers to reflect on, articulate, and share their thinking. ***Given B-WET's interest in fostering systems thinking, the findings from Tran's (2009; 2010) review of this literature are relevant to the program.***

Altogether the findings reviewed in this section support the effectiveness of many of the practices that B-WET advocates for through its MWEEs, such as the inclusion of outdoor field work to enhance student learning (see following text box). Many of the practices that MWEEs encourages have been linked to the types of outcomes B-WET hopes to achieve, such as increasing students' understanding of science concepts. At the same time, it must be noted that there is limited evidence that these practices lead to changes in environmentally responsible behaviors. Within a watershed education context, only one study provided some evidence of changes in environmentally responsible behaviors (Bodzin, 2008) and a review of research on outdoor fieldwork and visits (Rickinson, et al., 2004) identified only two such studies (Bogner, 2002; Mittelstaedt, Sanker, & Vanderveer, 1999).

What do we know about the value of outdoor fieldwork and the factors that influence how much learning will take place as a result?

To answer this question, we drew on a synthesis of research on outdoor learning (Rickinson, et al., 2004) as well as a summary of parts of this particular synthesis (Dillon, et al., 2006). The review was based on 150 studies published between 1993 and 2003. It led the authors to conclude that there is:

> *"substantial evidence to indicate that field work, properly conceived, adequately planned, well thought out and effectively followed up, offers learning opportunities to develop their [students'] knowledge and skills in ways that add value to their everyday experiences in the classroom"* (Dillon et al., 2006 p. 107).

The authors base this conclusion on their synthesis' findings that fieldwork can have positive learning, attitudinal, interpersonal and social outcomes. Moreover, field work appears to result in affective and cognitive interactions that support higher-order learning. Specific outdoor education practices associated with these outcomes were found to include:

- the length of the program (i.e., longer, sustained ones, tend to be more effective),
- the preparatory work prior to the outdoor learning experience [including preparing students for the cognitive (concepts and skills), geographic (setting), and psychological (process) aspects],

- the learning experience itself (e.g., appropriate amount of structure, opportunities to directly interact with environment, facilitating and role modeling by educators, choice among learning activities), and
- follow up work that links the outdoor with indoor/classroom-based activities.

As such, these particular results support the emphasis B-WET places on its MWEEs inclusion of preparation and reflection phases (in addition to the focus on implementation).

The synthesis also identified a range of external and personal factors that influence the amount and quality of field work that will be offered and how much learning will take place as a result. External factors include:

- fear and concern about health and safety
- teachers lack of confidence in teaching outdoors
- school curriculum requirements
- shortage of time, resources, and support
- trends in education and other policies

Personal factors include learners':

- age (i.e., younger students tend to be more enthusiastic than older students)
- prior knowledge and experience
- fears and phobias
- learning styles and preferences (e.g., preference for teacher led vs. student led activities)
- physical disabilities and special education needs
- ethnic and cultural identity, and
- the educational setting (i.e., there is a need to balance novelty and familiarity)

What do we know about teachers' watershed education practices?

We know extremely little about teachers' watershed education practices. There has been one mail survey of Pennsylvania teachers on the topic (Gruver & Luloff, 2008). This particular study focused on identifying factors that may determine teachers' watershed education practices (i.e., measured as teaching about watersheds beyond the standards, revising existing watershed curriculum, initiating cross-department collaboration about watersheds, seeking ways to involve students in watershed learning, and development of a new watershed curriculum). Results revealed that gender, age, classroom confidence, and self-efficacy significantly influenced teachers' watershed education behavior. ***This particular study therefore supports B-WET's assumption that funded professional development programs should strengthen teachers' confidence to teach about watersheds.***

Although the study by Gruver and Luloff (2008) did not offer additional insight into the specifics of teachers' watershed education practices, research into teachers' practices in outdoor and other environmental education contexts suggests that they will be unlikely to use outdoor settings or to conduct field investigation to teach about watersheds because they probably feel that they lack the necessary knowledge/skills and are concerned about managing their students in outdoor settings (Rickinson, et al., 2004; Simmons, 1998). ***Given that outdoor experiences and field investigations are a prominent aspect of B-WET's MWEE's, these findings support the need for professional development***

that provides teachers also with the knowledge and skills they perceive as necessary to conduct outdoor field investigations with their students.

What professional development practices can strengthen teachers' watershed education efforts?

Just as our knowledge of teachers' actual watershed education efforts are limited, so is our knowledge of professional development practices that may enhance their watershed education efforts. Two studies have addressed teacher professional development within the context of watershed education, but they did not focus on teachers' subsequent practices. One of these articles provides a description of a professional development program that engaged teachers in watershed science to strengthen their understanding of science inquiry (D. P. Shepardson, et al., 2003). To achieve this goal, teachers conducted site surveys of watersheds, designed and conducted their own study, used technology to assist with their investigations, and presented their results. This professional development is described to have been a success as it engaged teachers in "doing" science. The other article, presents actual empirical evidence to support that a similar professional development program increased teachers' understanding of watersheds, water quality, and stream monitoring (D. Shepardson, et al., 2002). This particular professional development included a 2 day pre-institute workshop, a 2 or 3 week summer institute and follow-up workshops during the academic year, and again, had teachers design and conduct a local watershed science research project. Table 2 identifies the changes in teachers' responses to an open-ended question to test their understanding of what a watershed is as a result of the professional development. The authors also report that teachers gained an increased awareness of the impact land use has on watersheds due to the professional development they participated in. ***As such, the results from this particular study support the value B-WET places on teachers being actively involved in collecting and using watershed data as part of the program's funded professional development activities.***

Table 2. Teachers' responses to an open-ended question testing their understanding of what a watershed is before and after a professional development (D. Shepardson, et al., 2002)

TABLE 4. Teacher Responses to Open-Ended Items on Watersheds

Open-response item/category	Pre-assessment (% of teachers)	Post-assessment (% of teachers)
What is a watershed?		
A source of water	44	24
An area that drains water	5	38
A topographical area	0	21
An area that drains into a stream	31	66
Watershed quality		
Supports biological community	33	57
No pollutants	26	69

Note. Teacher responses often contained multiple ideas. Therefore, the percentage totals may exceed 100%.

Not only has there been limited research focused on professional development within the context of watershed education but there has generally been little research on professional development activities outside of formal classroom settings (Phillips, Finkelstein, & Wever-Frerichs, 2007). The exceptions include three studies that provide insight into professional development practices that may be effective in changing teachers' science inquiry practices, including in watershed education contexts.

One of these three studies is particularly relevant as it explored the effectiveness of different professional development practices within the context of GLOBE (Penuel, Fishman, Yamaguchi, & Gallagher, 2007). GLOBE is an international, inquiry-based earth-science education program that calls for teachers to engage students in data collection (based on scientific protocols), to report data about the atmosphere, hydrology, soils and/or land cover/biology to a Web site for use by students and scientists, and to have students lead investigations using the data collected for the program. Professional development for teachers is provided by a variety of local organizations. Based on data collected from these providers, a sample of teachers, and the extent to which teachers followed through on data reporting, the authors were able to identify a number of effective professional development practices. For example, teachers' perceptions about how coherent their professional development experiences were (i.e., "teachers' interpretations of how well aligned the professional development activities are with their own goals for learning and their goals for students" p. 931), the incorporation of time for teachers to plan for implementation, and the provision of technical support were found to be particularly important to effective program implementation.

The second of the three studies examined the types of support US informal learning organizations provide for K-12 students and science teachers (Phillips, et al., 2007). As in B-WET's case, these institutions provided direct-to-student programs as well as teacher professional development (Table 3), among other types of support. The study found that informal learning organizations use a combination of features effective at changing science teachers' practices (Table 4) including experiential components (i.e., teachers are encouraged to participate in activities or experiences in much the same way that their students would) (Darling-Hammond, 1998). These institutions also offered an extended duration of professional development support for teachers (≥25 hours contact hours), consistent with the 30 or more contact hours that teachers have associated with perceived increases in their knowledge and skills (Garet, Porter, Desimone, Birman, & Yoon, 2001).

Table 3. Examples of the types of programs offered by informal science institutions (ISIs) for K-12 students and science teachers (From Phillips, et al., 2007).

Type of programme	Number of ISIs	Percentage of ISIs[a]
Direct-to-student programmes	307	65
Structured and educationally supported field trips (providing teachers with activities that precede and/or follow up on their students' visits to the institution)	259	55
Outreach programmes ('van' programmes, travelling demonstrations, support for school science fairs, etc.)	245	52
Teacher PD programmes	279	59
Teacher special events (one-day workshops or special gatherings that take place on a single day)	205	44
Teacher multi-day workshops (PD events that last at least 8 h but less than 40 h; e.g., a three-day workshop on a specific topic or a series of five Saturday sessions)	117	25
Pre-service and formal teacher education connections (courses, apprenticeships, pre-service observations, and/or research opportunities for individuals enrolled in teacher education programmes)	107	23
Teacher coaching and classroom support (demonstrations, shared teaching, and/or other forms of in-school support by staff or teacher interns from your institution)	97	21
Teacher institutes (PD experiences, usually on consecutive days, that cumulatively involve 40 h or more of participation)	76	16
PD provider training (training for administrators or staff providers of teacher PD)	70	15
Teacher internships (teachers working in the museum on a full-time or part-time basis, e.g., a teacher on a special assignment or a teacher serving as a science specialist for the district)	61	13

Table 4. Features of professional development adopted by informal science institutions ISIs found to be effective at changing science teachers' practices (Phillips, et al., 2007)

Programme feature	Included (%)	Not included (%)
Teachers learning science by participating in activities that they can use in their classroom	88	3
Teachers learning how to integrate your institution's resources into their curriculum	74	11
Teachers engaging with exhibits	59	21
Web resources sponsored by or affiliated with your institution	40	45
Teachers borrowing curriculum kits from your institution	39	43
Teachers learning how to use your institution's curriculum kits	32	48
Educators from your institution performing demonstrations in participating teachers' classrooms	29	51
Educators from your institution providing other forms of support at participating school sites	28	42
Teachers learning science by participating in activities geared specifically to teachers or adults, so that they cannot use the activities with their students in their classrooms	25	56
Teachers visiting informal science institutions other than yours	23	56
Teachers attending lectures	22	55
Teachers examining and discussing student work with other teachers	22	56
Educators from your institution providing instructional coaching in participating teachers' classrooms	20	67
Teachers providing instructional coaching in other teachers' classrooms	7	66
Online discussions among participating teachers	6	72
List-serve memberships	10	73
Teachers visiting other teachers' classrooms	3	77

The third of the three studies compared the teaching practices of novice science teachers who had the opportunity to learn about and practice teaching in an informal learning setting and ones who went through a traditional teacher education program with limited opportunities to practice constructivist and inquiry based teaching (Saxman, Gupta, & Steinberg, 2010). The authors found that science teachers in the former group outperformed the control group in constructivist and inquiry-based teaching practices.

What professional development practices support teacher learning and change?

A synthesis of what we know about teacher learning from the perspective of the learning sciences, identified many of the same components that have already been described as well as several additional ones that can support teacher learning and change (Fishman & Davis, 2006). For example, the review suggests that effective professional development:

- is of extended duration
- emphasizes content, pedagogy, and pedagogical content knowledge
- is coherent with other learning activities
- requires teachers to examine their own practice
- promotes reflection
- provides opportunities for social support
- is closely coupled to what is expected to be taught in the classroom
- situates teachers' learning in representations of practice (i.e., "practice-based")
- is structured around (educative) materials and activities that teachers can employ directly in their own classroom practice.

Note that if B-WET's funded professional development activities do in fact illustrate how teachers can meet school requirements, standards, or curriculum needs through watershed education, the likelihood that several of these effective professional development components would be in place, would be increased.

Overall, this review supports that teachers' professional development has to have certain characteristics to help ensure that teachers will adopt the desired changes in instructional practices. B-WET's MWEEs encourage a minimum length of 3 professional development days which, depending on the length of the day may be close to the 30 hours that teachers have reported as necessary for changing their knowledge and skills (which may not be sufficient to also change their practices). However, B-WET's MWEEs acknowledge that additional professional development features are necessary to help ensure changes in teachers' practices. The quantity and quality of these features will also play an important role in helping to determine to what extent teachers participating in B-WET funded professional development will adopt the desired practices.

What studies and resources can be drawn on to inform the development of data collection instruments for B-WET's evaluation system?

If teacher' or students' "watershed literacy" were to be assessed, it would likely be useful to draw on the national environmental and river literacy studies (NEETF, 1998; Penn, 2001a, 2001b) which included questions to assess individuals' understanding of watersheds. Using these questions could be valuable as B-WET participants' knowledge could be compared with that of the participants in these national studies. However, this would depend on our ability to obtain and use these surveys' questions. At this time, for example, we have not been able to obtain the wording of the questions used by NEETF (1998). There is also a "Watershed IQ" instrument which may be relevant to assess teachers' and students' watershed knowledge (NEETF, 1999). However, this instrument does not appear to have been used as part of a study and therefore, B-WET's results could not be compared with those from other sample populations.

If students' knowledge of watersheds were to be assessed, the various studies of students' ideas and gaps in understanding provide some useful information to build on as well. However, it is important to know that these studies relied on qualitative data. That is, the majority asked students to draw watersheds and explain their drawing, develop concept maps, or interviewed them. One study also provided students with a map of a river and its tributaries in a watershed and asked them to explain which towns would be affected by water pollution entered in a particular location.[8] These qualitative methods were appropriate for assessing students' in-depth understanding of watersheds. Moreover, such assessments are more consistent with inquiry-based instruction than quantitative approaches. However, given the knowledge, skills, and resources such qualitative methods require, they are unlikely to be feasible for B-WET's evaluation system at this time. Nonetheless, if quantitative student instruments were developed, the choice of questions and response options could be informed by these studies. For example, a question asking for the definition of a watershed could include a multiple choice option of a shed that contains water (as this is a popular perception youth and adults hold). Similarly, it may be possible to provide students with the drawing of a watershed and present them with multiple choice options exploring their understanding of its different elements and/or how it may be negatively or positively affected by human actions under various conditions. In terms of what watershed understandings or related outcomes to assess, 1) B-WET's logic model, 2) the literacy initiatives, 3) the objectives developed for watershed education, and 4) especially the results from the current study of expected watershed education outcomes are expected to be helpful.[9]

Should it be appropriate to assess to what extent students change their environmentally responsible behaviors as a result of the watershed education they receive through B-WET funded programs, the instrument to determine whether the B-WET Chesapeake professional development and meaningful watershed educational experience programs attain their goal of a future citizenry committed to protecting the Bay (Kraemer, Zint, & Kirwin, 2007) would be appropriate to adapt for this particular purpose.

There are also other tested instruments that have been used to assess various aspects of environmental literacy that could potentially be built on. For example, there have been several studies that have assessed individuals' ocean (and coastal) literacy (AAAS, 2004; Project, 2009; Steel, et al., 2005). In addition, there have been both national and internal studies that have assessed students' environmental literacy (Marcinkowski, et al., 2012; OECD, 2009). And then there are several sites that identify relevant instruments developed by environmental and conservation psychologist (see http://www.conpsychmeasures.com/CONPSYCHMeasures/index.html for overview) and informal science educators (search http://www.pearweb.org/atis/tools/jump). The conpsychmeasures.com site, for example, includes the Children's Environmental Attitude and Knowledge Scale (CHEAKS), used by Bodzin (2008) to investigate the impacts of a watershed education program on children. This particular scale includes a number of items to assess children's knowledge as related to water (e.g., one question asks about the main sources of water pollution), as well as items to gauge their attitudes toward engaging in actions to use less water. Of course, there are also a range of other instruments that could be built on to assess a variety of other potential outcomes of B-WET supported programs. For example,

[8] The majority of the students did not focus on tracing water through the river system in the watershed but focused on other cues such as the proximity of towns and/or their connections to draw their conclusions about the impact of pollution in the watershed.

[9] This study of watershed educators is currently being conducted under the leadership of Dr. Zint in collaboration with Anita Kraemer.

if the current study of expected watershed education outcomes reveals that it may make sense to focus on assessing students' environmental science research skills (e.g., measurement techniques, sampling, interpreting data) or attitudes toward science and science careers, instruments that have been used as part of evaluations of GLOBE [see (Cincera & Maskova, 2011) for a review] could be among those to draw on.

It may also be very informative to learn solely about the perceptions students have about their outdoor field experiences as part of B-WET's evaluation system. In other words, are students indicating that they have experiences consistent with those reported by grantees and/or teachers? One instrument that could be adapted for this purpose (assuming it is possible to obtain access to the actual items) is the Science Outdoor Learning Environment Inventory (SOLEI) (Orion, Hopstein, Tamir, & Giddings, 1997). This scale was developed to measure students' perception of their outdoor learning environment under the assumption that positive learning environments predict both cognitive and affective student outcomes. This particular scale measures students' environmental interactions, integration of outdoor with indoor learning, student cohesiveness, teacher supportiveness, open-endedness, preparation, as well as organization and material environment.

With regard to assessing relevant teacher outcomes, there have only been two studies directly focused on watershed education. One of these assessed changes in teachers' understanding of watersheds, water quality, and stream monitoring and some of the study's qualitative data may help to inform the development of quantitative items for an instrument to be used as part of B-WET's evaluation system (Shepardson et al., 2002). The other study of factors that influence teachers' water education efforts provides insight into how to potentially measure teachers' behaviors related to watershed education, their confidence including self-efficacy as related to watershed education, and their watershed related knowledge (see Table 5 for an excerpt from the article describing the measures that were used) (Gruver & Luloff, 2008). This study also suggests that it may be important to measure teachers' age and gender as these variables helped to predict their watershed education behaviors (vs. years and grades taught, which did not).

Table 5. Measures used by Gruver and Luloff (2008) of factors predicting teachers' watershed education efforts

Variable Measurement: The Dependent Variable of Teacher Behavior

Prowatershed teacher behavior was operationalized using nine actions demonstrative of positive behavior toward teaching about watersheds on the basis of CBAM. Respondents were asked whether they (a) attend local watershed meetings, (b) attend watershed conferences, (c) attend watershed seminars or workshops, (d) volunteer to teach others about watersheds, (e) develop new watershed curriculum, (f) revise existing watershed curriculum, (g) initiate cross-departmental collaboration about watersheds, (h) seek ways to involve students in learning about watersheds, and (i) teach about watersheds beyond the standards. Responses ranged from 1 (*never*) to 5 (*very frequently*).

Exploratory factor analysis revealed these nine items were indicative of two behavior types: (a) curricular behavior (teaching about watersheds beyond the standards, revising existing watershed curriculum, initiating cross-departmental collaboration about watersheds, seeking ways to involve students in watershed learning, and developing new watershed curriculum) and (b) active behavior (attending local watershed meetings, attending watershed conferences, volunteering to teach others about watersheds, and attending watershed seminars or workshops). We created composite index variables for both behavior categories (Cronbach's α = .89 for curricular behavior, .84 for active behaviors). The focus of the present study was on curricular behavior, the dependent variable.[1]

Teacher Confidence

We measured overall teacher confidence by three variables: classroom confidence (scale), self-efficacy (scale), and watershed knowledge (single item). We operationalized these variables separately but added them to the model as a block.

Classroom confidence. We operationalized classroom confidence in teaching about watersheds using five teaching-confidence statements in which teachers self-rated their own confidence levels. Responses ranged from 1 (*not confident*) to 5 (*very confident*). We asked respondents if they felt confident (a) teaching about watersheds, (b) that students understood watershed concepts after being taught about them, (c) relating information about watersheds to other teachers, (d) teaching required watershed competencies, and (e) that students were gaining required competencies. Following exploratory factor analysis, we included all five statements in a composite measure of teaching confidence (Cronbach's α = .87).

Self-efficacy (self-reported effectiveness). We operationalized teacher self-efficacy regarding teaching about watersheds using four statements in which teachers self-rated their own teaching efficacy. We measured self-efficacy on a 7-point Likert-type scale ranging from 1 (*strongly disagree*) to 7 (*strongly agree*). We asked respondents how much they agreed or disagreed with the following statements: (a) When teaching about watersheds I welcome students' questions; (b) I understand watersheds well enough to teach about them effectively; (c) I am at a loss when trying to help students understand watersheds; and (d) I don't have enough information to teach about watersheds. Following exploratory factor analysis, we included all four statements in a composite measure of self-efficacy (Cronbach's α = .84).

Watershed knowledge. We included a single watershed-knowledge question in the survey to assess general understanding of watershed processes. Toward the end of the survey, we asked the question "How familiar are you with the watershed you live in and how it is linked to either the Chesapeake Bay, the Delaware Bay, or the Gulf of Mexico?" We made every effort to portray the question as one of general interest to the study and not as a quiz question (i.e., it was not the first question of the survey and was among a series of questions regarding watershed curricula). We measured watershed familiarity on a 5-point Likert-type scale ranging from 1 (*not familiar*) to 5 (*extremely familiar*). We collapsed these categories to 0 (*familiar*; *extremely familiar*, *very familiar*, and *familiar*) and 1 (*unfamiliar*; *somewhat familiar*, and *not familiar*).

Engaging students about watersheds. We measured this single item on a 7-point Likert-type scale ranging from 1 (*strongly disagree*) to 7 (*strongly agree*). We asked respondents how much they agreed or disagreed with the following statement: "I do not know how to excite my students about watersheds."

The three professional development studies described earlier may also provide particularly helpful guidance. For example, both providers and teachers could be asked about the features of their professional development and these results could be used to attempt to predict teachers' science inquiry practices. The instruments used in these studies provide guidance in terms of what professional development components to ask about and how, as well as how to potentially measure teachers' science inquiry instructional practices (Penuel, et al., 2007; Phillips, et al., 2007). And Saxman et al.'s (2010) study points to potential ways to assess pedagogy, science content, and lesson planning based on Praxis II assessments and the XAMonline preparatory guides. In the latter study, improvements in teachers' inquiry and constructivist-based science instruction were also observed by rating teachers' skill at engaging student interest, making student thinking visible, and the extent to which students were allowed to construct their own understanding. While this is not feasible for B-WET's evaluation system at this time, it would be possible to ask teachers about the extent to which they feel better prepared to engage in these practices as a result of B-WET funded professional development.

Overall, this review suggests that there are instruments that can be drawn on to inform how constructs could be measured as part of B-WET's evaluation system. Which instruments may be drawn on or which studies may be used to inform the choice of constructs and measures will depend on what specific questions the evaluation system will focus on.

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