

Transdisciplinary Pedagogy for Science and Journalism Majors Linking Water Resource Information to Communities

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Editor's Note: This manuscript complements, but does not chronologically follow, "Crystal Clear" by Kuban and others (2019), a paper that appeared in IJES v. 2. In that paper, concerns about arsenic in Indiana's groundwater were explored through the lens of a student-produced documentary at Ball State University in Muncie, Indiana. This article is a quantitative exploration of student learning during the development of the Water Quality Indiana program at Ball State that led to those later student-led studies.

ABSTRACT:

Water Quality Indiana is a learning platform that leverages collaborations, community partnerships, and active mentorship of transdisciplinary student cohorts. Since 2013, this platform has engaged teams of science, technology, engineering, and mathematics (STEM) and communication and media students to investigate water quality in east central Indiana (since expanded to other domestic and international locations) in an experiential problem-based learning environment. For community partners, Water Quality Indiana provides scientific data, analysis, and multimedia deliverables about water quality, and it has a successful record of finding solutions to real-world problems. From the point of view of faculty, project deliverables enhance several aspects of a faculty portfolio. For student participants, the goal is to increase metacognition, civic engagement, and confidence in processes associated with STEM and media studies, and, therefore, the transdisciplinary skills required in an increasingly competitive workforce.

Assessing learning artifacts (e.g., assignment, quizzes, or other evaluative metrics) reveals a cognitive dissonance between metacognition and accuracy in declarative knowledge related to topics in water quality—student scores did not increase in posttest data despite an increased confidence in selected answers. In contrast, pretest and posttest results, synthesis reports, and focus group data suggest that confidence in procedural knowledge in both water quality and media production significantly increased by the end of the course. Students cited time constraints imposed by academic calendars and project deadlines as a limitation of the learning environment. Course data reveal differences based on academic background and gender: 1) media studies majors became more confident in their multimedia skills, while STEM majors became less confident; 2) note-taking style and detail is more organized and meticulous for female and STEM students compared to male and media studies counterparts.

PROJECT INTRODUCTION

Education either functions as an instrument that is used to facilitate the integration of the younger generation into the logic of the present system and bring about conformity to it, or it becomes the practice of freedom, the means by which men and women deal critically and creatively with reality and discover how to participate in the transformation of their world (Freire, 2000).

Performance-based funding models are increasingly applied by state legislatures to secondary and postsecondary education. In Indiana, performance criteria for universities include completed credit hours, on-time graduation, and degrees awarded to at-risk students (first generation, minority, etc.) and in high-impact (STEM) areas. Thus, educators are increasingly pressured to teach to a test and to pass students to prevent negative impacts to their institution and careers; consequently, pedagogical assessment is measured in numbers rather than personal experiences. Paradoxically, industry professionals value an entry-level employee's ability to solve problems and be resourceful in novel situations (Baldoni, 2010; McAdams, 2012; Marr, 2019; Wilkie, 2019; NACE, 2020). Students also desire practical, engaged pedagogy (Breiburd, 2017; Cavanagh, 2020). "Most young people...want to know exactly why they are doing something and [that] they are having a personal impact" (Twenge, 2013, p. 68). Postsecondary institutions often lack this pedagogy, for example, in the intersection of geoscience education and journalism. "Rarely do educators ask...how schools can prepare students to be informed citizens, nurture a civic imagination or teach them to be self-reflective about public issues and the world in which they live" (Giroux, 2010, parag. 3).

Scientists understand complex processes but often lack the experience to communicate those ideas to a lay audience (Reed and Walker, 2002); Bhattacharya (2012) noted that scientists commonly misunderstand the standard structure of news and the reason for word limits (Iyengar and Massey, 2018). In contrast, journalists may struggle to comprehend advanced scientific terminology; focus groups interviewed by Reed and Walker (2002) revealed misconceptions and tensions, leading to recommendations for basic media training for scientists.

Experiential Project-Based Learning

Educators and administrators have criticized the "narrow regime of teaching" and challenged educators to prepare students for a lifetime of ill-defined problems. Problem-based learning (PBL) is "a comprehensive approach to classroom teaching and learning that is designed to engage students in investigation of authentic problems" Blumenfeld (1991, p. 369). Barrows and Tamblyn (1976)

identified PBL as both a curriculum and a process in which students remain responsible for both questions and solutions to problems.

Case studies reveal that both students and teachers respond favorably to PBL-oriented courses (Tseng et al., 2013; Finkle and Torp, 1997; Barrows and Tamblyn, 1976; Rosenfeld and Ben-Hur, 2001). For example, Duch (1995) noted "PBL...challenges students to 'learn to learn', working cooperatively in groups to seek solutions to world problems." Blumenfeld (1991) identified two advantages of PBL: It encourages interdisciplinary collaboration, and it is adaptable to many situations and different learning styles. Giroux (2010, parag. 7) argued that instruction should "provide the knowledge, skills and social relations that enable students to expand the possibilities of what it means to be critical citizens."

Experiential learning theory defines learning as "the process whereby knowledge is created...from the combination of grasping and transforming experience" (Kolb and Boyatzis, 1984, p. 41). Giroux (2010, parag. 9) might argue that students must be provided this opportunity, as it allows them "to come to terms with their own power as critically engaged citizens." Yet, Giroux (2010) notes a clear absence of this brand of pedagogy in the academy, while other scholars have offered pedagogical guidance for its inclusion (Mitchell, 2008, Beckman and Wood, 2016).

Aspiring journalists need experiences through which they can learn science—the process of experimentation as well as how to report findings—and not just read about how to do it, take a test, or complete a low-stakes exercise. "The old model of two tests—a midterm and a final—is not effective for this group, or, as some may argue, is not effective for any group of learners. Generation Me's self-confidence and easy access to information leads them to prefer interactive learning" (Twenge, 2013, p. 67–68). Twenge (2013) uses "Generation Me" as a broad label for college students at the time of that publication.

The Water Quality Indiana Program

The design and implementation of Water Quality Indiana (WQI) at Ball State University (BSU) is grounded by tenets of problem-based learning (PBL) and experiential learning course design. The WQI program's transdisciplinary experiential format leverages ongoing and well-documented studies of water quality within rivers of east central Indiana to provide PBL opportunities for geoscience education and to connect student cohorts to community partners, stakeholders, and the larger public in an effort to enhance watershed management plans and restoration programs. Project deliverables are available for public access at the Water Quality Indiana website (www.waterqualityIN.com).

Table 1. Learning outcomes and descriptions for WQI

- *Master transdisciplinary skills.* Students demonstrate greater knowledge, skill, and confidence in water quality methods and multimedia production;
- *Synthesize information.* Students collect data, recognize trends, and generate predictions within the context of rivers and watersheds;
- *Foster effective communication.* Students design visual representations of scientific results from samples analysis, articulate importance, and publicly share project outcomes;
- *Create sustainable solutions.* Students develop meaningful solutions to real-world problems of water quality;
- *Bridging of scale.* Students understand connections between water quality concerns important to local communities and national implications of those events;
- *Develop a holistic outlook.* Students understand concepts of water quality science from several viewpoints and backgrounds.
- *Identify professional opportunities.* Students explore study/career paths and develop marketable skills in the geosciences and multimedia.

Some concerns about PBL and experiential programs include the up-front investment to implement the courses and the comparative value versus a more traditional classroom approach. The challenge to measuring program impact is that, despite identical setups between iterations, cohorts are essentially case studies with small populations, so results are hard to compare or generalize to a larger population. Still, in an era where students and stakeholders demand more practical applicability in higher education, it seemed prudent to assess the WQI program using quantitative and qualitative measures and to compare the results to learning outcomes aligned with workforce skills important to young professionals (Table 1).

This paper reports on program assessment of student cohorts from 2013 and 2014¹. These data provide some insight of how WQI is achieving the learning outcomes. The discussion will focus on two primary questions illustrated through the accumulated data: Does WQI and experiential PBL foster learning and confidence? What do WQI students value?

WATER QUALITY IN EAST-CENTRAL INDIANA

Large-scale deforestation and dewatering following the Swamp Land Act of 1850 resulted in increased land for agriculture with concurrent long-term degradation in topsoil quantity and quality in the midwestern United States, including east central Indiana (fig. 1). In the Mississinewa River watershed, a tributary of the Wabash River, more than 88 percent of land use is agricultural (IDEM, 2001). In the headwaters of the adjacent White River watershed, most tributary streams include ditches and tile drains in fields to remove excess soil water.

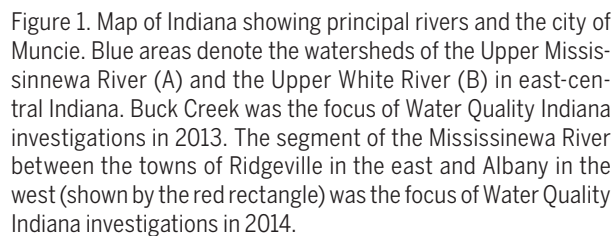
Nutrients. Agricultural runoff from ditches and tile drains is a “non-point” contamination source. Soil nutrients and

¹WQI classes are not scheduled annually. Since the 2014 class, two more classes were offered (in 2016 and in 2019). In these latter iterations, WQI expanded its geographic reach to include domestic and international water quality issues.

sediments can be challenging to identify and manage, but they are a key element of downstream water quality (Voelker and Renn, 2000). Headwater streams, with limited protections for riparian zones, are a central focus for nitrogen and phosphorous mobilization. More recently, attention has focused on point sources of contamination, including the aging infrastructure of combined sewer overflows that convey untreated municipal waste during periods of high discharge and the management of confined animal feeding operations with associated lagoons or spray fields for manure waste. The watersheds of east central Indiana rank among the highest in the nation for nutrient exports (Robertson and others, 2009).

Sediments. Excess sedimentation changes a river’s channel, resulting in flooding and loss of critical habitat for fish and mussels. In the White River, Crawford and others (1996) concluded that fish communities “have been affected by...erosion resulting from conversion of forest land to cropland [that] led to siltation of streambeds...” (p. 1). Properly managed riparian zones are vital, because sediment load largely derives from stream bank erosion rather than field runoff (Fox and others, 2006, 2007).

Debris. The Indiana General Assembly in 2009 noted: “erosion has been a problem along the Mississinewa River in Randolph County, washing away the banks. For years, trees have toppled into the river, blocking the river’s flow and forcing the Mississinewa to change course. These course changes have led to flooded farm fields, yards and other property” (IDEM, 2001). These logjams on the Mississinewa River likely resulted from channel dredging and straightening in the 1950s from the Ohio state line to the town of Ridgeville, Indiana (fig. 1). Increased river gradient culminated in an increase in peak discharge during storms, elevated bank stress, and erosion of the riparian zone. Conversely, the stream reach from Ridgeville to Albany is unaltered, trapping the upstream debris as logjams, leading to pooled backwaters, sediment deposition, eutrophication, and the



Water Quality Indiana cohorts combine data collected by students and gathered by community partners, as well as publicly available archival data. Students supplement these data with multimedia collections that include still imagery and videography, maps and interactive graphics, and interviews with stakeholders including landowners and regulators. In fall 2013, students collected data from four sites on Buck Creek, a tributary of the White River, in support of scheduled stream bank restoration activities at the confluence of Buck Creek and the White River (fig. 1). In fall 2014, the focus was four sample sites and a series of ten significant logjams, all on the Upper Mississinewa River (fig. 1), in support of long-term investigations by the UMRWMP.

I don't learn science by reading chapters out of a book, but I learned a great deal by actually going out to the stream and then taking water back to the lab, working side-by-side with our science majors. The main reason I took the class [is] because it wasn't in a traditional setting.

A central feature of the WQI course model (fig. 3) is that students self-organize into peer networks focused on, for example, literature research, media production, site



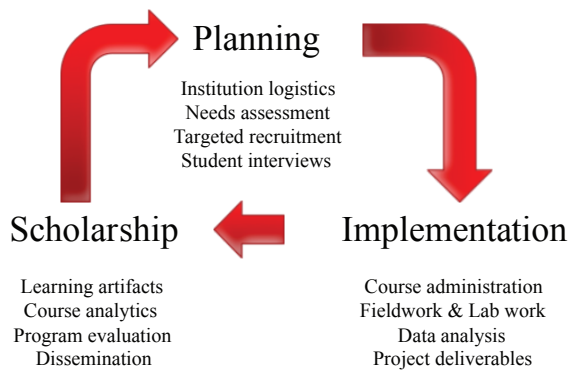


Figure 3. The three-phase implementation of Water Quality Indiana (planning, implementation, and scholarship).

access, sample collection, sample analysis, and quality control (Kuban and others, 2015). Objectives for each cohort target specific goals negotiated between the instructors and community partners (Sprague and others, 2014; Sroufe and others, 2015). Since 2013, those partnerships have included the UMRWMP, FlatLand Resources (a local environmental consulting firm), and Red Tail Land Conservancy (a nonprofit land trust). Courses included undergraduate and graduate students from dissimilar majors (geology, biology, natural resources, telecommunications, journalism) and two separate colleges at BSU (Science and Humanities; Communication, Information, and Media). The 29 students from the 2013 and 2014 cohorts included 45 percent women and 14 percent from other groups traditionally underrepresented in STEM disciplines.

Student participants are expected to contribute to teams outside their area of expertise: STEM students work on multimedia production and media students participate in sample collection and laboratory analysis. The hope is that cross-disciplinary mentorship among the students allows those familiar with requisite skills to assist those who need more practice. In the experiential PBL framework, student teams coordinate fieldwork, group activities, and product development according to an established timeline. This model allows the instructors to serve as facilitators of science and multimedia content, to manage project workflow, to coordinate with community

partners, and handle learning artifacts and assessment instruments.

Learning artifacts and assessment instruments included: 1) a traditional field notebook of all notes and data collected in the course; 2) pretest and posttest questions on STEM/media studies thematic concepts and civic engagement; 3) a synthesis report about the students' view of civic engagement and the importance of transdisciplinary learning; 4) a focus group discussion (moderated by an external colleague) to document student perceptions of expectations and course outcomes; 5) student-designed multimedia "data stories" incorporated into WQI's online resources and disseminated to community partners and media outlets, and at professional conferences; and 6) a formal report by the students that summarizes tasks, methodologies, findings, and recommendations, which is disseminated to community partners.

Here we assess the relative success of this experiential PBL course via analysis of field notes, pre- and posttest questionnaires, the focus group responses, and the synthesis reports. Selected project deliverables illustrate examples of student learning and contributions to the community. Collectively, these products and analyses address each of six learning outcomes (Table 2).

Field Notebook. The study of the natural environment is a visual language where physical surroundings inform comprise a text that must be deciphered (Frodeman, 1995), and the field notebook is an ideal tool in field-based and capstone courses in the geosciences (Compton, 1962). Water Quality Indiana students are tasked to work toward a methodical, descriptive archetype for note-taking that is not "for an audience of one" (Sanjek, 1990, p. 92) and includes notes intended for memory recall, or inscription, intended to dictate literal information, or transcription, and intended to communicate the "coherent representation of an observed cultural reality" (Clifford, 1990, p. 51), or description.

Notebook assessment for each cohort was conducted twice each semester (near mid-term and finals) using a rubric designed for a list of criteria required for each page in the book, whether that page was used for classroom/

Table 2. Association between learning artifacts and learning outcomes for WQI

Learning Outcome	Learning Artifact
<i>Master transdisciplinary skills.</i>	Pre-post, Focus groups
<i>Synthesize information.</i>	Field notebook, Data stories, Formal report
<i>Foster effective communication.</i>	Multimedia data stories, Formal report
<i>Create sustainable solutions.</i>	Pre-post, Data stories, Formal report
<i>Bridging of scale.</i>	Pre-post, Synthesis report, Focus groups
<i>Develop a holistic outlook.</i>	Pre-post, Synthesis report, Focus groups
<i>Identify professional opportunities.</i>	Focus groups

interview notes, field work, field sketches, or laboratory notes (Appendix 1). Scores for each book were normalized to the number of pages students provided, such that the number of notes played a reduced role in the grade. Permission to use the field notebook and assessment scores was solicited in sealed consent forms, opened after final grades were issued. An analysis of grades was conducted by single-tail t-test to analyze whether meta-data on student gender or declared major played any role in field notebook scores. A textual analysis of field book pages complemented the statistical results to provide interpretive context.

Pretest/Posttest Questionnaires. Shoemaker (2010) assessed students' knowledge and perceived confidence pertinent to student learning outcomes in a horticulture course. "'Know' refers to performance accuracy, and 'knowing how much they know' relates to confidence" (Lichtenstien and Fischhoff, 1977; Pennycook and others, 2017). Knowledge acquired over the course of a semester can speak directly to pedagogical effectiveness, but confidence in that knowledge is also important to assess (Colbeck and others, 2001). Twenge (2013) noted "some students can be too confident" (p. 68); educators should not necessarily associate improved confidence with correct answers. The WQI pretest/posttest questionnaire (Appendix 2) assesses declarative knowledge of a small sampling of water quality and media-related concepts along with a Likert scale gauging perceived confidence in responses to these questions.

For the 2014 cohort, an additional set of Likert scale pretest/posttest questions investigated the students' broader confidence in their ability to create, understand, and explain STEM and media information. Other questions probed the perceived role of community engagement as part of the course (Table 3). This group was asked a further suite of posttest civic engagement questions to understand perception of their connection to the community partners (Table 3).

Respondents were anonymous, but were asked to provide metadata on gender, declared major, and academic rank. For the questions on declarative concepts in science and media, the number of correct answers along with the confidence in those answers was recorded as a percentage. For the questions on process, community engagement, and project input, factor analysis and two-tailed tests of significance were conducted in SPSS software to assess whether one or more of the metadata could explain the variation in the results.

Synthesis reports. Near the conclusion of the course, students completed a structured reflexive narrative that required them to consider the learning outcomes for WQI and their program experience (Table 4). This report contributed toward the course grade, and a rubric

assessed the degree of thoroughness. Students compose no less than five double-spaced pages for this synthesis report, providing an opportunity to gauge learning and insight into curricular takeaways and phenomena.

Focus Groups. A focus group is an inexpensive and quick way to gather qualitative data from a number of people at one time, and it served as the fourth direct method of assessing WQI. To encourage discussion and to gain access to the points of view of participants, the interviewer must promote a relaxed atmosphere and ask simple questions to encourage discussion (Marshall and Rossman, 2006, p. 114). In this study, a colleague—unaffiliated with course instruction—sought interested students and conducted a 45-minute focus group session after course completion. Only 5 of 29 students participated, 3 in 2013 and 2 in 2014. Participants were asked four open-ended questions (Table 5).

To assess the focus group transcripts, we used iterative explanation building, or "the gradual building of an explanation" that is "similar to the process of refining a set of ideas" (Yin, 2003, p. 122). This process forces immersive analysis of the qualitative data, and encourages contemplation of other plausible or rival explanations. Protocols followed the five-step analysis process of LeCompte (2000): 1) Tidy up the data; 2) find items in the data; 3) create stable sets of items; 4) create patterns as a result of the sets; and 5) assemble structures that provide meaning. In the first step, "tidying up permits researchers to make a preliminary assessment of the data set" (LeCompte, 2000, p. 148). Then one searches for "specific things in the data set [to] code, count, and assemble into research results" before they "clump together items that are similar or go together," which becomes the third step (p. 148–149). After this part of the process, "locating patterns involves re-assembling [sets of items] in ways that begin to resemble a coherent explanation or description" (p. 150). The researcher builds an "overall description" to help people "see more clearly how to solve problems, improve programs, assess their effectiveness, or develop theories" (p. 151).

Project Goals

In this paper, we report on the learning artifacts and assessment data as they relate to the six learning outcomes (Table 2). Of key importance to the WQI program, as well as any other experiential PBL course, is the value students place in procedural knowledge rather than declarative concepts. Specifically, we are interested in the differences among students in generating data and deliverables as practical application of knowledge to real-world problems, and their capacity to interpret scientific

Table 3. Additional likert scale questions for the 2014 WQI cohort

Confidence in process and role of community engagement (pre-post)**Scientific process:**

- I feel confident in my ability in reading scientific results.
- I feel confident in my ability to understand scientific results.
- I feel confident in my ability to report scientific results.
- I feel confident in my ability to explain to a novice my scientific results.

Media process:

- I feel confident in my ability in creating media products that convey scientific results.
- I feel confident in my ability to understand media reporting protocols.

Community engagement:

- I understand our community partners' role in the community.
- I believe our community partners' role is important in the community.
- I know how our community partner helps the community understand water resources.

Civic engagement (post)**Contribution to the community:**

- I feel that I made a real contribution to the community.
- I believe the overall project met needs identified by members of the community.
- I believe I did NOT make a positive impact on the community.
- I interacted with people in the community about our overall project.

Project input:

- I felt forced into doing this project.
- I was NOT free to develop or to use my own ideas.
- I had some choice in the creation of the project deliverables.
- I wish I had been given more options about our overall contribution to the community.

output, make meaning of the findings, and communicate them to the public. The forms of this communication are as varied as the students' academic, ethnic, and socio-economic backgrounds but include public showcases, conference presentations, and online resources.

The collective life stories of WQI students foster discussion and provide many viewpoints through which problem-solving may occur; thus, we use metadata to explore some aspects of learning within this collaboration such as retention of and confidence in declarative and procedural knowledge, confidence in the skills and processes involved in STEM and multimedia, thoughts on civic engagement, and the effectiveness of this PBL learning environment.

RESULTS

Field notebooks

Table 6 summarizes scoring data for the 29 field notebooks assessed for WQI courses and sets of students divided into discipline, gender, and the four permutations of these two categories. One-tailed tests of significance between subgroups and for each assessment period are included. Students received significantly lower scores on the final assessment (73% versus 80%, $p = 0.003$).

The STEM students and females performed significantly better than their media and male colleagues, respectively, for the midterm assessment (85% versus 76%, $p = 0.02$; 83% versus 77%, $p = 0.06$; Table 6). This same difference is present, but not statistically significant in the final assessment. These same outcomes do not extend to the combinations of most subgroups except for STEM versus media male students (85% versus 71%, $p = 0.02$) and female versus male media students (82% versus 71%, $p = 0.05$) in the midterm assessment. STEM students are statistically similar when compared by gender for both assessment periods. Female students in both STEM and media studies performed similarly in both assessment periods.

Pre- and postcourse questionnaires

In 2013, sixteen participants—seven women and nine men—filled out the pretest. The participants divided into eight STEM and eight media students. Seniors (11) were the largest group, followed by three juniors, one sophomore, and one graduate student. For the posttest, six women and eight men completed the questionnaire; two dropped the class after completing the pretest. The participants' majors were in STEM (6) and media studies

(8). Seniors were the largest group with 78.6 percent (11), followed by two juniors and one sophomore.

The 2014 WQI cohort included sixteen, including six women and ten men, that completed the pretest. The participants were six STEM and ten media students that included seniors (10), sophomores (4), and juniors (4). Six women and eight men completed the posttest, divided into seniors (9), sophomores (3), and juniors (4). These students had majors in STEM (5) and media studies (9).

Declarative Concepts. Table 7 compiles results of the pretest and posttest data related to specific concepts in water quality and media for the 2013 and 2014 cohorts (Appendix 2). In all cases the confidence of students in their answers increased from the course beginning to the end. For the questions regarding media, the increased confidence (82% to 97%) is parallel with an increase in accuracy (65% to 74%). For science questions, however, the average accuracy stays similar (46%) despite increased confidence (57% to 83%). In fact, the accuracy for five of eight science questions decreases from pretest to posttest. The remaining three questions that increased in accuracy dealt specifically with the riparian zone,

sediment transport, and sediment erosion—concepts that were major topics in the class.

Confidence in Process and Community Engagement. Table 8 compiles statistical data for the pretest and posttest on scientific and media process and community engagement for the 2014 cohort (Table 3). In all cases, scores increased; Table 9 is the factor analysis results for these same questions. For each set, one factor, student major, was the best solution for the available student metadata with the Chronbach's alpha reliability for the pretest and posttest data of 0.70 and 0.93 for the questions on scientific process, 0.76 and 0.82 for questions on the media process, and 0.59 and 0.88 for questions on community engagement.

For the more reliable posttest data, an independent t-test reveals no difference between STEM and media studies majors for the questions on scientific process; $t(12) = -0.39$, $p = 0.17$. Similarly, the posttest data reveal no difference between STEM and media studies majors for the questions on community engagement; $t(12) = -0.22$, $p = 0.83$. The means for these populations nearly overlap—STEM ($m = 0.08 \pm 0.77$, $n = 5$) and media studies ($m = -0.05 \pm 1.15$, $n = 9$). In contrast, there is a significant

Table 4. Structure of synthesis report

Students' personal understanding of water quality science:

- Describe what can be typically measured in water-quality data collection.
- What are key takeaways from the data we analyzed this semester?
- How much would you estimate you have learned in this capacity since the beginning of the semester? (1 = nothing new; 3 = about as much as I expected; 5 = beyond what I anticipated). Explain your numerical estimate.
- What key concepts do you think will resonate, or “stick”, with you after this course concludes?

Students' connection between scientific research & multimedia production:

- In general, what does literature indicate about science reporting, i.e., journalists covering scientific issues?
- How much would you estimate you have learned about “the other side” since the beginning of the semester? (1 = nothing new; 3 = about as much as I expected; 5 = beyond what I anticipated). Explain your numerical estimate.

Students' opinions of the best & most challenging part(s) of WQI:

- What was the best part of the immersive design, or nature, of this interdisciplinary course?
- What was the most challenging part of the immersive design, or nature, of this interdisciplinary course?

Table 5. Focus group questions

What did you think of the combination of media and science students in this interdisciplinary course?

To what extent were the course objectives met, in your opinion? What could have been done as a part of the course to improve this?

What do you now understand about your own field that you didn't know before this course?

What do you now understand about the “other” field that you didn't know before this course?

Table 6: Summary of Statistical Data for Field Notebooks

		All Students		Science (Sc)		Media (Me)		Male (M)		Female (F)	
		mt	fi	mt	fi	mt	fi	mt	fi	mt	fi
N		27	26	11	11	16	15	15	14	12	12
All Mean		0.8	0.73	0.9	0.74	0.8	0.72	0.8	0.7	0.8	0.77
Stdev		0.1	0.14	0.1	0.11	0.1	0.16	0.1	0.15	0.1	0.11
T-test (one tail)		mt vs. fi		Sc vs. Me		M vs. F					
mt - mid term		$p = 0.003$		mt	$p = 0.02$			mt	$p = 0.06$		
fi - final				fi	$p = 0.36$			fi	$p = 0.1$		
		Sc		Me		T-test (one tail)					
		mt	fi	mt	fi						
N		7	7	8	7	Sc vs. Me (M)					
M Mean		0.9	0.73	0.7	0.67	mt	$p = 0.02$				
Stdev		0.1	0.1	0.2	0.19	fi	$p = 0.22$				
N		4	4	8	8	Sc vs. Me (F)					
F Mean		0.9	0.76	0.8	0.77	mt	$p = 0.23$				
Stdev		0.1	0.13	0.1	0.11	fi	$p = 0.45$				
T-test (one tail)		M vs. F (Sc)		M vs. F (Me)							
		mt	$p = 0.38$	mt	$p = 0.05$						
		fi	$p = 0.33$	fi	$p = 0.1$						

difference in the posttest data for the questions on media process, $t(12) = 5.5$, $p = 0.000$, with population means in STEM ($m = -1.09 \pm 0.74$, $n = 5$) and media studies ($m = 0.61 \pm 0.43$, $n = 9$) that are sizably different.

Civic engagement. The posttest data for the questions on community engagement and tabulated in Table 8 for the 2014 cohort and were processed by Varimax factor analysis in SPSS (Table 10). One factor, gender, was the best solution for the available student metadata with a Chronbach's alpha of 0.86 for the questions on contributions to the community and 0.73 for questions on project input. This test shows that men and women looked at the "Community and Choices" slightly differently. Men looked at their impact to the community more positively than women did. However, there were no differences between majors; $t(6) = -0.37$, $p = 0.97$.

Synthesis reports.

Qualitative textual analysis of synthesis reports from 2013 and 2014 revealed patterns in solicited narrative items from Table 4. Regarding the understanding of science, half included declarative elements, including newfound vocabulary such as "buffer strip" and "confluence." Other examples include a deeper understanding of water pollution and greater familiarity with the types of tests that monitor water quality. Not as common in the aggregate replies but still evident was evidence of procedural knowledge. In particular, students mentioned

learning more about the process of sampling water and the steps observed for proper note-taking in the field.

Regarding the connection between science and journalism, more than half criticized or offered personal opinions about lackluster science reporting, writing that "journalists are not good at scientific reporting" or that "journalists do not have a sense on how to report" science. Some acknowledged a "huge disconnect on what journalists report and the actual facts that the scientific studies show," while others suggested a more proactive solution—scientists and journalists "need to work hand-in-hand to bridge the gap." Five students mentioned technical media skills they acquired through the WQI project, including taking pictures, video, editing, lighting, delivery posture and pronunciation, and breaking down complex information. The same number of students identified technical science skills gained, including taking samples, testing pH, maintaining chain of custody, and analyzing raw data.

More than half specifically wrote "immersive" in their replies, indicating that the hands-on nature of the course appealed to them. About the same number also mentioned "stepping away from regular course work" in order to "look at the problems from another mindset" as the best part of the course. However, that also led to some challenges—teamwork being cited most often. Not surprisingly, student cited that communication suffered at times. Time was also mentioned—the amount of time invested, as well as time management in order to complete tasks as necessary.

Table 7. Summary data from Pre and Post Questionnaire.

Q Topic		Pretest, N = 32				Posttest, N = 28					
		Correct	Certain	Think correct	Combined	Correct	Certain	Think correct	Combined	> Acc	> Conf
Water Quality Questions											
1	NEPA	31.3%	6.3%	43.8%	50.0%	28.6%	32.1%	57.1%	89.3%	*	*
2	non-point source	78.1%	21.9%	43.8%	65.6%	75.0%	35.7%	53.6%	89.3%	*	*
3	dissolved oxygen	53.1%	18.8%	43.8%	62.5%	50.0%	21.4%	50.0%	71.4%	*	*
4	tile drains	37.5%	18.8%	40.6%	59.4%	28.6%	42.9%	42.9%	85.7%	*	*
5	riparian zone	40.6%	6.3%	25.0%	31.3%	42.9%	25.0%	53.6%	78.6%	*	*
6	sediment transport	46.9%	25.0%	28.1%	53.1%	71.4%	42.9%	28.6%	71.4%	*	*
7	stream velocity	43.8%	15.6%	50.0%	65.6%	35.7%	57.1%	35.7%	92.9%	*	*
8	sediment erosion	34.4%	28.1%	37.5%	65.6%	35.7%	46.4%	39.3%	85.7%	*	*
Summary		45.7%	17.6%	39.1%	56.6%	46.0%	37.9%	45.1%	83.0%		
Media Questions											
1	attribution	81.3%	56.3%	25.0%	81.3%	89.3%	67.9%	28.6%	96.4%	*	*
2	quotes	28.1%	56.3%	28.1%	84.4%	50.0%	67.9%	32.1%	100.0%	*	*
3	rule of thirds	71.9%	59.4%	21.9%	81.3%	75.0%	60.7%	35.7%	96.4%	*	*
4	shot sequence	50.0%	25.0%	50.0%	75.0%	67.9%	57.1%	39.3%	96.4%	*	*
5	interview questions	93.8%	68.8%	25.0%	93.8%	100.0%	82.1%	17.9%	100.0%	*	*
6	video editing	12.5%	21.9%	53.1%	75.0%	25.0%	50.0%	46.4%	96.4%	*	*
7	natural sound	93.8%	56.3%	25.0%	81.3%	92.9%	78.6%	17.9%	96.4%	*	*
8	truthful reporting	87.5%	65.6%	21.9%	87.5%	92.9%	85.7%	10.7%	96.4%	*	*
Summary		64.8%	51.2%	31.3%	82.4%	74.1%	68.8%	28.6%	97.3%		

Focus Groups

Water Quality Indiana participants valued the process, or the procedural knowledge, involved with the PBL environment as opposed to the declarative knowledge associated with it. For example, from one student:

I actually learned quite a bit about the interviewing process, how to set them up and how to actually make the scene look when you're meeting someone, which is not something that any of my science classes have ever even remotely touched.

Similar themes were present throughout the transcript and transcended disciplinary divides. For example, a multimedia student explained that "being out in the field and...able to know what to look for in terms of reporting" was an important outcome. A science student explained that they "learned a lot about how you want people to see things—not just how you wanted to see it." This reflects other comments from participants indicating their interest in learning more about software programs that allow for video and audio editing as well as storytelling.

Moreover, students noted improved confidence later in the semester. "At the beginning, I was definitely a little weary [sic] of the entire situation just because it was the first time with the class. As it went on, though, [it] definitely came together, and I started to get a little more confidence." From another student: "I've actually been a little bit more confident in talking with some of my professors."

With regards to the learning outcomes, most dwelled on the presentation of scientific findings and their

multimedia deliverables that explained the importance of those results. Two student statements encapsulate this success. One student in multimedia studies indicated that "taking [scientific] information and making it available for the normal, non-scientific person is something that we also did and that was also a success." Another multimedia studies student mused: "lower-level journalism classes do theoretical work. It doesn't necessarily feel real. But after having done something like this...you feel the full force of the work and research and interviews and publishing... I think just seeing the whole process from day one [including] presenting the website and scientific models...was just a really cool process to see, and I think it gives you a different perception...."

In terms of course challenges, participants identified the need for additional time. In short, they said they needed more time to not be overwhelmed by the process that they ultimately indicated as valuable. They also desired more contact with the community partner, wanting more time to speak with them and to understand the role that nonprofits play in the maintenance and restoration of local water quality.

DISCUSSION

A central question about experiential PBL is how collaborative environments that combine students from a range of disciplines influence metacognitive reflexivity and, therefore, knowledge and scholarship. For WQI, which includes students from the natural sciences and multimedia production, one outcome would be an improved comprehension of the methods and deliverables

Table 8. Varimax factor analysis of scientific and media process, community engagement, and student metadata.

Questions	Home department	Pretest			Posttest		
		N	Mean	Stdev	N	Mean	Stdev
Community	Journalism	10	0.21	0.82	9	-0.05	1.15
	Geology	6	-0.34	1.25	5	0.08	0.77
Science	Journalism	10	-0.29	0.99	9	-0.28	1.07
	Geology	6	0.48	0.90	5	0.50	0.68
Media	Journalism	10	0.52	0.64	9	0.61	0.43
	Geology	6	-0.87	0.90	5	-1.09	0.74

Questions	Pretest					Posttest				
	Levene's test		T-test (two-tailed)			Levene's test		T-test (two-tailed)		
	F	p	t	df	p	F	p	t	df	p
Community	0.02	0.90	0.82	14	0.30	0.42	0.53	-0.22	12	0.83
Science	1.07	-1.54	0.99	14	0.15	0.54	-1.94	0.39	12	0.17
Media	0.20	3.65	0.64	14	0.00	3.14	0.10	5.50	12	0.00

expected in both scientific and media outlets. This discussion synthesizes the available assessment data to answer that question, presents some aspects of what students value in this course framework, and explores how participating student performance differs.

Does experiential PBL foster learning and confidence?

At first glance, the results suggest that field notebooks did not increase metacognition (Table 6); however, it is important to realize that the nature of experiential PBL courses impose compressed time frames for data collection, synthesis, and dissemination. These courses also include deadlines, reports, and a showcase of course outcomes, all alongside obligations and examinations for other courses. Therefore, some scores may reflect individual prioritization and stress cited in the synthesis reports, which may support a shift toward PBL opportunities that span the academic year as opposed to one semester.

Similarly, pretest and posttest accuracy on the declarative concepts related to water quality did not increase during the class with the exception of specific topics directly related to field investigations (Table 7). However, focus group transcripts reveal an increased understanding of the scientific process and suggested that learning reached farther than the target goals of the class projects and addressed the learning outcomes in Table 1. In particular, the synthesis reports and focus group comments suggested that students had a broader understanding of methods of scientific communication and more holistic means to understand water quality.

In contrast, accuracy improved among the media-based questions (Table 7). These results could reflect the structure of the course; preparations for a public showcase dominated the last few weeks and included intensive multimedia production and presentation. The synthesis reports and focus group participants identified these process-based activities such as collecting interviews and using software for multimedia storytelling as valuable evidence of learning outcomes (Table 1), including mastery of transdisciplinary skills, public communication, and the need to bridge between local events and impacts on the broader community.

Broadly, the synthesis report and focus group data reveal that procedural knowledge in water quality may have improved among student cohorts, citing an increased ability to comprehend the process, or how to do something, but not necessarily the specific water quality concepts assigned. The 2014 data from the confidence-in-science and media-process questions support this statement (Table 9). Interestingly, the perceived confidence of students in their posttest answers for the declarative concepts increased for every question in water quality and media studies (Table 7), consistent with Shoemaker's (2010) study. This result could arise from a conditioned notion that students believe that they should know more than they actually do when they complete a course. In the case of WQI, immersion in fieldwork and laboratory analysis may lead to a misplaced perception of expertise, which signifies the importance of content delivery (not necessarily lecture) in paired or foundation courses. In other words, student education in STEM should not rely solely on experiences or PBL as the modes of learning.

Table 9. Results from confidence and engagement questions				
2014 cohort (Likert scale 1 - 4)	Pretest		Posttest	
	Mean	Stdev	Mean	Stdev
Process and Community Role	N = 16		N = 14	
<u>Science process</u>				
reading results	2.81	0.70	3.00	0.85
understand results	2.75	0.50	3.07	0.70
report results	3.06	0.70	3.07	0.59
explain results	2.75	0.60	3.07	0.70
<u>Media process</u>				
creating products	3.06	0.90	3.14	0.64
understand protocols	3.25	0.70	3.57	0.62
<u>Community engagement</u>				
understand role	3.06	0.56	3.57	0.49
role is important	3.44	0.50	3.57	0.49
know function	2.94	0.66	3.50	0.50
Civic Engagement				
<u>Contributions to community</u>				
I made contribution			3.13	0.33
project met needs			3.50	0.50
I did not make positive			1.63	0.48
<u>Project input</u>				
felt forced			1.63	0.48
not free to develop			1.38	0.48
some choice			3.13	0.78
more options			2.25	0.66

How do WQI students differ?

The field notebook represents one measure of how students synthesize scientific findings (Table 2). The results reveal differences in scores based upon declared major and gender, which may distinguish between styles of note taking among students (Table 6). While the use of field notebooks is a common practice in the geosciences and is one factor that can explain the scoring difference between groups, the scoring difference based upon gender is less clear. Curiously, the limited posttest data on civic engagement indicates that it did not matter what major the students identified, but it did matter if they were male or female on how they felt they positively affected the community—female students were more critical of that role than their male counterparts (Table 9). Selected pages within the field notebooks provide some context for the scoring patterns. Despite a clear grading

rubric, male students more frequently disregarded instructions than their female classmates. This is particularly well defined with male students from media disciplines where note-taking more frequently consisted of short bullet points including names and contact information, key quotes, and other information (fig. 4); students in media often rely on personalized shorthand, audio recordings, or memory (Adams and Hicks, 2001, p. 89–90). The impression is that the notes are rushed and sometimes archived after a conversation or sample collection. In contrast, female students scored better across both disciplines. Pages of their notes, while in some cases missing information, tended to be more clearly organized and meticulously written (fig. 4). This follows the results of other studies of gender differences in note-taking, such as Reddington (2011), in which women demonstrated increased transcription fluency, working memory, verbal ability, and conscientiousness.

Interestingly, STEM and media students did not respond in a significantly different way on the pretest and posttest questions on scientific process. However, the means for STEM ($m = 0.50 \pm 0.68$, $n = 5$) and media studies ($m = -0.28 \pm 1.07$, $n = 9$) students suggests that a larger sample size could reveal that media studies majors were still not confident in their science skills at the end of the course (Table 9). In contrast, the questions on community engagement, despite a lack of statistical significance, have pretest means that suggest a more engaged group of media studies majors and posttest means that converge. With a larger sample size, this could mean that all WQI students learned more about the community where they lived.

Regarding students' confidence in multimedia process, there was a significant difference between declared majors. The pretest and posttest means for media studies majors were 0.52 and 0.61, while the means for STEM majors were -0.87 and -1.09, a difference in opposite directions (Table 9). This shows that media studies majors were still more confident in creating media and reporting than STEM majors after completing the course. It could mean that media studies majors throughout the semester became more confident in their multimedia skills, while STEM majors became less confident. This could show a positive learning curve in that STEM majors realized that there was more to reporting and effectively communicating scientific results than originally thought.

Table 10. Varimax factor analysis of community role and project choices

Questions	Gender	Posttest			Levene's test		T-test (two-tailed)		
		N	Mean	Stdev	F	p	t	df	p
Community	Male	4	0.63	1.10	4.49	0.08	2.23	6	0.07
	Female	4	-0.63	0.27					
Choices	Male	4	-0.11	1.24	2.56	0.16	-0.29	6	0.78
	Female	4	0.11	0.87					

It could also show that the media studies majors knew more than they thought. Both directions could indicate changes in metacognition resulting from a transdisciplinary learning environment.

What do WQI students value?

Vocational skills and a deeper comprehension about subject areas within and beyond a college major augments a student's marketability (Pierce and Miller, 2007; Fahmy, 2008; Neidobf, 2008; Goudreau, 2012; Pitt and Tepper, 2012; Jett, 2013); the WQI learning environment fosters career exploration and skill development in the geosciences and multimedia (Table 1). While at BSU, one student returned as a community partner, two as paid course assistants, two others continued project work as independent studies. After graduation, two alumni pursued graduate degrees in geosciences and at least four found employment in STEM fields.

Posttest data on scientific and multimedia process suggest that WQI students were more comfortable with requisite skills required for each field (Table 8). From the synthesis report and focus group data, WQI students appreciated the hands-on nature of the course and the transdisciplinary method of finding solutions to real-world problems—in line with course learning outcomes (Table 1). These solutions can have tangible outcomes. For example, deliverables from the 2014 cohort on the location and severity of logjams in the Mississinewa River watershed (Figure 2) were instrumental to a Lake and River Enhancement grant from the Indiana Department Environmental Management to assist with logjam removal and farmland flooding.

Posttest results on the community engagement questions from 2014 (Table 3) suggest that students may have already understood that government agencies and nonprofit organizations are valuable to the study and conservation of water resources, but gained a better understanding of their function (Table 8). Overall,

students felt that the course met objectives and contributed to the community, but were mixed in their view of options provided to contribute.

The synthesis report data demonstrate that WQI students were critical of scientific reporting and appreciated the opportunities to develop media stories related to their investigations. For example, a student-produced radio segment aired on Indiana Public Radio in 2013 that included interviews with community partners and local stakeholders to highlight stream restoration along the White River in Yorktown, Indiana. Student contributions to WQI in our 2013 and 2014 iterations resulted in a student-produced course website, exposure in regional media (newspapers and radio), conference abstracts (Borgmann and others, 2014; Florea and Kuban, 2014; Kuban and others, 2014; Sprague and others, 2014; Saydshoev and others, 2014; Kuban and Florea, 2015; Purtha and others, 2015; Sroufe and others, 2015), a peer-reviewed journal article (Kuban and others, 2015), and an invitation to the White House Water Summit in 2016. Since then, student contributions to WQI's objectives have led to two regional Emmy nominations, film-production awards, film festival screenings, and additional publications in academic and trade publications.

CONCLUSIONS

The WQI program sharply contrasts with a traditional classroom education. It is (by design) student-driven, community-focused, and modular. Its transdisciplinary implementation encourages peer teaching and broad dissemination of course products; collaborations, therefore, can span institutional boundaries. For this learning environment focused on concepts of water quality and media that relies significantly on engagement with community partners and stakeholders, our assessment to date identifies points of success and improvement for the achievement of learning outcomes.

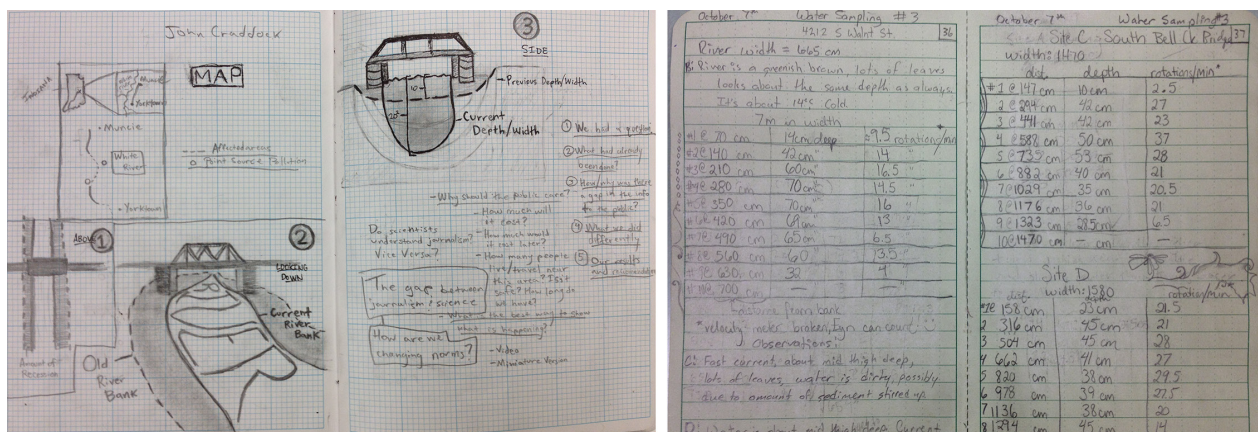


Figure 4. Representative pages from the field notebooks of students in multimedia (left) and STEM (right) studies.

1. Students from vastly different academic backgrounds can work effectively in groups when they have a clearly defined project and goals aimed at solutions to real-world problems.
2. There is a pervasive distinction in note-taking style and detail in the field, the lab, and during interviews based on gender and academic background; female-identifying and STEM students adhered more closely to the rubric and were significantly more detailed and meticulous than male-identifying and media counterparts.
3. Academic background does matter, not only for context and relevance, but also for the experience with and confidence in the requisite skills and processes in conducting investigations in STEM and media studies topics.
4. Experiential PBL learning environments provide an excellent platform to develop tangible workforce skills, but time constraints imposed by academic calendars and project deadlines can limit acquisition of declarative knowledge of those topics.
5. Despite the stationary or decreased scores in many concepts of water quality by the end of the course, student confidence in answers strongly improved, illustrating a cognitive dissonance between student metacognition and thematic expertise that should act as a caution to both students and faculty concerning curricular engagement diversity.

Finally, a recurring theme of “immersive learning” endeavors, such as WQI, is the perceived negative impact on the careers of young faculty focused on significant grants, high-impact publications, and positive student evaluations to achieve tenure. The authors, who began this pedagogical initiative as young career faculty and have both since attained promotion and tenure, are acutely aware of this stress point and have modeled WQI as a consulting business through which students work for community-partner clients with guidance from faculty. Resulting student deliverables can leverage value-added to a several aspects of a faculty portfolio, not only in teaching and service, but also through purposeful publication and media presence.

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Appendix 1: Field Notebook Grading Rubric
Water sample and calibration data managed on separate sheets

General category

Book title	2 points	_____
Author name	2 points	_____
Date range	2 points	_____
Table of contents	4 points	_____

Field data – each page

Name(s)	1 point	_____
Date & page number	1 point	_____
Start Time	1 point	_____
Location (GPS)	1 point	_____
Weather conditions	1 point	_____
Field site condition (slumped, well-exposed, wet, etc.)	1 point	_____
Rock formations/soil types/water bodies present	1 point	_____
Purpose of the site examination	1 point	_____
Detail	1 point	_____
Legibility	1 point	_____

Field sketch – each page

Name(s)	1 point	_____
Date & page number	1 point	_____
Start Time	1 point	_____
Location (GPS)	1 point	_____
Scale information	1 point	_____
North arrow	1 point	_____
Legend	1 point	_____
Units	1 point	_____
Detail	1 point	_____
Legibility	1 point	_____

Laboratory notes – each page

Name(s)	1 point	_____
Date & page number	1 point	_____
Start Time	1 point	_____
Lab Location	1 point	_____
Sample information	1 point	_____
Analysis method	1 point	_____
Results /precision	1 point	_____
Units and significant digits	1 point	_____
Detail	1 point	_____
Legibility	1 point	_____

Class/group notes – each page

Name(s)	1 point	_____
Date & page number	1 point	_____
Start Time	1 point	_____
Class/group work location	1 point	_____
Topic	1 point	_____
Purpose/activity	1 point	_____
Accuracy	1 point	_____
Proper citations/Referencing	1 point	_____
Detail	1 point	_____
Legibility	1 point	_____
A) Total number of pages x10		_____
B) Total number of marks in each category x 1		_____
C) Row A – row B		_____
Row C divided by row A x 200 (NOTEBOOK GRADE)		_____

Appendix 1: Pretest posttest questionnaire on declarative concepts in water quality and multimedia

Science

1) The National Environmental Policy Act of 1969 (NEPA) requires the preparation of an Environmental Impact Statement (EIS) for:

- Any projects that may significantly impact the environment
- All federal projects with budgets greater than one million dollars
- ***All federal projects with the potential to significantly impact the environment
- Any construction project, public or private

2) An industrial site has a permit to release treated industrial waste into a local waterway. The effluent emerges from two large pipes. Such discharge would be called:

- Non-point-source pollution
- **Point-source pollution
- Neither, the discharge is not pollution

3) You have a sample of pure water at 20°C that is open such that it has equilibrated to the oxygen in the atmosphere. The sample of water warms to 30°C over the course of an hour. Assuming no other changes, what would happen to the amount of oxygen in the sample?

- It would increase
- **It would decrease
- It would stay the same
- None of the above answers are correct

4) A 'tile drain' in agricultural is?

- A ceramic-lined ditch that separates fields
- Vertical pipes scattered in a field designed to drain surface waters
- **A subsurface, perforated pipe that helps to reduce soil saturation

5) The 'riparian zone' refers to:

- The steepest part of a river bank
- **The zone adjacent to a river with hydrophilic vegetation
- The entire floodplain surrounding a river
- All areas within a 100-year flood zone adjacent to a river

6) Sediments of silt or clay size are largely transported in a river by:

- **Suspension
- Saltation
- Bedload
- Dissolved load

7) The velocity of water in a straight segment of a stream is greatest

- In the center and at the bottom
- Near the banks
- It all moves the same speed
- **In the center at 40% of the depth

8) Methods to reduce sediment and nutrient loss from an agricultural field include all of the following except:

- Contour or strip farming
- 'No till' farming
- Riparian buffers
- **Drainage tiles

Media

1) Attribution in a news story provides which of the following?

- Names the source
- Allows the reader/viewer/listener to know who is responsible for the statement
- Helps the reader/viewer/listener evaluate the credibility of the statement
- **All of the above
- None of the above

2) Which of the following questions would likely generate the best quotes or sound bites from an interviewee?

- Do you agree with the government's decision to raise taxes?
- **What happened when the robbery suspects entered the store?
- Does the governor's decision hurt his chances of winning re-election and why is the legislature opposed to his ideas?
- Didn't the director's action make you angry?

3) The Rule of Thirds requires that all photographers/videographers shoot two-thirds of their story with the subject fully centered in the frame.

- True
- **False

4) What is the minimum number of shots needed to make a sequence?

- 1
- **3
- 5
- None of the above

5) Five pieces of information should be evident in all standard news stories. Which of the following best represents these elements?

- Commentary, rumors, who, what, number
- **Who, what, where, when, why
- Dramatization, when, where, why, how
- What, speculation, defamation, legality, number
- None of the above

6) When editing video, whenever possible, you should 'cut' the content where?

- **During movement
- After movement occurs
- When aesthetically appropriate
- None of the above

7) What do media practitioners call the audio that always exists at a scene?

- **Natural sound
- Reporter track
- Stereo sound
- Sound effects
- None of the above

8) In some instances, it is OK to publish/broadcast a story that contains inaccurate information, as long as some part of it is true.

- True
- **False