Shifting Attitudes:
The Influence of Field Trip Experiences on Student Beliefs

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Abstract:

This paper reports on the findings of a review of the literature on interactions between affective and cognitive learning, in general, and, specifically, during field trips for university students in natural science or engineering disciplines. The paper presents a study that tests concepts raised from the literature review by exploring affective learning during a 10-day field trip to a water-poor region of Mexico. Student beliefs about the relevance of water resource management are compared before and after the field trip using a survey instrument. Also, student beliefs are compared to those of water resource experts. Results of the study are put in the context of the literature and strategies are recommended for optimizing affective learning within experiential, informal activities such as field trips.

Key Words:

field trips; beliefs; attitudes; instructional design; affective learning.

Introduction

The notion that affective learning is highly interconnected and related to cognition is intriguing – perhaps especially to those of us who are educated with the scientific tradition of impartiality and objective enquiry where affect is ostensibly absent. The interconnection between cognition and affective learning is significant to the authors of this paper because we are involved in the design and delivery of international field trips aimed at increasing the conceptual knowledge of sustainability and resource management in university students.

In particular, we have recently designed a series of field trips that have focused on the sustainability of water resources in the northern Mexican state of Sonora. Anecdotally, we have observed that, while the field trip objectives are to increase the conceptual understanding of water resource management (e.g. the interactions between climate and water availability, the impacts of wastewater disposal on water quality, the patterns of water use by humans), students on these field trips seem to experience attitudinal change as they witness events such as reservoirs that are empty as a result of long-term droughts or rivers that are black and bubbly as a result of the dumping of untreated wastewater. We wonder, then, if the field trip, or more generally, informal science education pedagogy, is an opportunity to explore the impacts of teaching methodologies on affective learning. We also wonder if, by attending to the affective learning of our students, we are laying the groundwork to enable students to develop expert understanding of the cognitive aspects of water resource management.

We begin the paper with a brief summary of what is known about affective learning and its interconnections with cognition, and a review of the informal science education literature as it relates to these interconnections. Next, we describe a 26-student field trip designed to explore water resources management issues in Sonora, Mexico and a beliefs survey intended to assess how field trips may influence learning in the affective domain and thereby shift learning along the novice-expert continuum. The students' survey responses, taken immediately before and after the field trip, are compared to measures of the beliefs of expert scientists and engineers of water resource management, to test the hypothesis that the students' attitudes toward, and beliefs about, water resources management become more like experts as a result of the fieldtrip experience. We then analyze the results of the survey, using the attitudes of experts toward the same issues as a reference point. Finally, we reflect on how the observed attitude changes may relate to the design of the field trip and the same interconnections between affective learning and cognition that we explored at the beginning of the paper.

Interconnections between Cognition and Affect

Reviews of the psychology literature related to the nature of knowledge reveal that the connections between affection and cognition may rest within mental frameworks, sometimes called schemas, which are thought to represent, and provide structure for knowledge, including affective and conceptual knowledge, residing in personal memory (e.g., Phillips, 1995; Dole and Sinatra, 1998; Johnson and Munakata, 2005). According to schema theory, we are each born with a relatively small number of undeveloped mental schemas, and, throughout our lives, these branch into many more specialized and intricate schemas (Quartz and Sejnowski, 1997). As these multidimensional schemas become increasingly complex and interconnected, we move from novices to experts within knowledge domains (NRC, 1999).

Conceptually, a schema on any give topic (e.g., "water") may include conceptual knowledge (e.g., "liquid"), beliefs (e.g. "all animals drink clean water"), attitudes (e.g., “clean water is good”), and other types of knowledge. Also, schemas are interconnected – thus the mental schema associated with the topic of “water” is interconnected with the mental schemas associated with “drink”, “food”, “dehydration” and so on (Nelson et. al., 2001). The more an individual retrieves information from specific areas in the brain (and the pathways connecting different areas in the brain), the stronger the areas become – i.e., the easier it is to recall this knowledge. Further, some knowledge can be considered “cold” – i.e., with no particular emotional response associated with it, and other types of knowledge can be “warm”. So, knowledge of “thirst” may be “cold” if a person has not experienced thirst, or emotionally significant (i.e., “hot”) if the person has experienced the pain of dehydration (Sinatra, 2005).

Acquiring knowledge, that is ‘learning’, can be described as the act of constructing personal idiosyncratic multidimensional schemas. The origins of this notion of learning is attributed to Jean Piaget (1896-1980) and is referred to in the psychology literature as ‘cognitive constructivism’ (Liu and Matthews, 2005). The act of intentional learning involves the mindful and critical focusing on external stimuli that we perceive through our senses. The more authentic the mental exploration of the stimuli (e.g., testing, questioning, observing and making mental notes, self-explaining, and critiquing of one’s previous understanding), the more previously constructed schemas are retrieved and the more complex they become (Dole and Sinatra, 1998). Depending on the “temperature” of the knowledge within schemas, schema retrieval, construction or reconstruction will involve the recall of feelings. Similarly, beliefs and attitudes will be recalled if this affective knowledge has been embedded within the “old” schema.

Knowledge can be acquired by mechanisms other than intentional learning. For example, behaviour learned by fear conditioning is mediated by a non-conscious mechanism (Ledoux, 1994). Also, Mezirow (1996) contents that learning is influenced by “contemporary culture and social forces” manifested in expectations and presuppositions via communication norms such as those found in language.

It follows from constructivist learning theory that what each of us focuses on, and is mindful of, depends on our beliefs and attitudes, as well as other types of knowledge - acquired through various means - we each possess, including our emotions and the highly conceptual knowledge related to the bio-physical and social systems in which each of us live. In addition to influencing a person’s initial interest in subject matter and the motivation to engage with subject matter, the intricacy of schemas and their interconnections suggests that the details of subsequent knowledge construction (i.e., which packages of knowledge are interconnected) is influenced by a person’s previous cognitive and affective activities related to the topic at hand.

Learning during Field Trips

The literature on modes of learning as they relate to international field trips for university students in natural science or engineering disciplines, the setting for our field trips, is scarce. The majority of the related literature deals with the more general sphere of informal science education, which covers natural- or social-science-based learning activities such as short-term visits (hours to a day) to natural areas and more structured settings such as museums, zoos, aquaria, or gardens. Here, we review the informal science education literature with a focus on the impact of informal science learning experiences on the affective domain.

Orion (1993) found that field trips can facilitate the construction of abstract concepts by providing the setting for long term memorized episodes. Meredith et al. (1997) proposed that the short-term affects experienced in informal science learning may serve to influence cognitive learning and may initiate or reinforce long-term affective dispositions such as attitudes, interests, values, and commitment. Ballantyne and Packer (2005) found that encounters with natural areas allow participants to apply theoretical knowledge to real life examples, engage emotionally with environmental issues and have the possibility to produce changes in environment-related behavior. Brody (2005) observed that, during informal science experiences, participants were able to learn discrete scientific concepts associated with the site as individuals, but that in groups, participants elaborated on these understandings and associated deeper meaning with these understandings.

In a review of the informal science literature, DeWitt and Storksdieck (2008), suggested that experiences during field trips can evoke strong emotional responses, which can further result in positive affective learning impacts. Hofstein and Rosenfeld's (1996) literature review found that the effects of informal activities on affective outcomes can be mixed, but that some studies found that attitudes towards science can be improved by informal science learning. Scarce (1997) posited that field trips offer enriching experiences central to successful learning because they are both personal experiences and lived social events that become "ways of knowing." According to Wright (2000), since experiential learning activities allow students to participate in activities that help link theory and practice, they become excited and motivated to learn, spurring on new experiential activities.

To summarize the findings in this literature, informal science education can provide frameworks— by eliciting emotional responses motivation and providing both personal and social experiences— that can lead to effective cognitive learning. This suggests that informal science education can add to and lead to the development of new schema and interconnections between schema, given the real-world, concrete experience by individuals, reflection by individuals and social milieu that may occur during informal science activities.

Field Excursion to Study Water Resource Management in Sonora State, Mexico

The field trip that is the subject of this study was part of the "Expanding Cities: People, Water and Infrastructure" (ExCit) program. ExCit was a consortium of five universities: the University of British Columbia (UBC) and Laval University in Canada, Michigan Technological University (MTU) in the United States, and the University of Sonora (UNISON) and the University of Guadalajara in Mexico, that operated from 2003 to 2007. The purpose of the ExCit program was to exchange students among the three countries and to train these students in the political, social and economic aspects of urban and rural water resources systems, water and wastewater treatment, and the remediation of contaminated water resources. The exposure of the students in the program to a wide range of urban water resource problems and solutions outside of their home regions was intended to give them a broad "North American" perspective and to enhance their future professional activities.

In addition to study abroad experiences, the ExCit program offered one- to two-week field trips to selected regions in the three countries each year to students and faculty in the consortium. The field trips featured intensive experiences in the selected regions and exposure to field methods in water resources management. More than 50 students participated in the field trips over the four-year period. The field trip in 2006 focused on water resources issues in the Rio Sonora basin in northwest Mexico (see Figure 1 for location). The basin covers a total area of 29,000 km^2. The main branch of the Rio Sonora is approximately 300 km long. The climate is arid to semi-arid. The watershed comprises a large city, Hermosillo (approximately 800,000 inhabitants), and more than twenty small to medium size rural communities. The economy is based on agriculture, mining, manufacturing, all of which exert demands on the scarce water resources and contribute to water quality problems in the watershed, including contamination from human and animal wastes. The Rio Sonora watershed, along with the entire state of Sonora experienced severe drought conditions over the period 1994-2003.

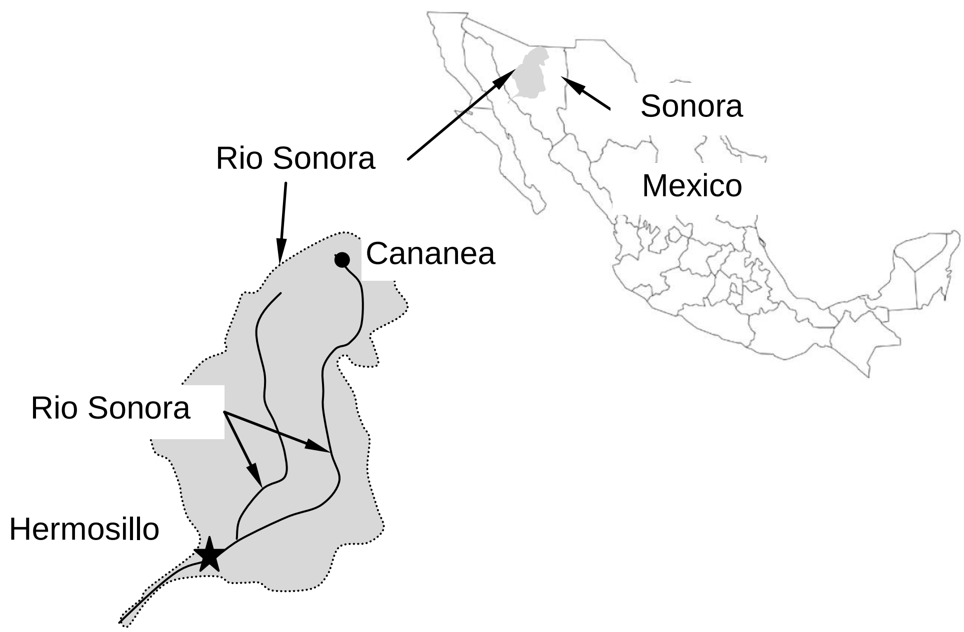

Figure 1. Location of Field Trip Area of Study

The students on the Mexican field trip course consisted of 26 undergraduate and graduate students from MTU, UBC, UNISON, and Laval. The students' academic programs included civil, environmental, and geological engineering; geology; and social sciences. Table 1 describes the university status of the field trip participants. The field trip activities are summarized in Table 2. The activities, which consisted of lectures and tours led by local experts and field exercises, were selected to expose students to a variety of problems and perspectives related to the regional water resources issues.

Every two days, the students gathered into groups of three to four and made short oral reports and led discussions on the preceding days' events and results from field measurements. In addition, students were encouraged to discuss the field trip activities during the one to three hour bus rides between stops. The oral reports and discussions were intended to share information and reflections among the students.

Table 1: University Status of Field Trip Students

University and Status	Fraction
MTU graduate students	38%
MTU undergraduate graduate students	23%
UBC graduate students	15%
Laval graduate students	15%
UNISON undergraduate students	8%

Table 2: Summary of Field Trip Activities

Activity	**Significance**
Presentation on management of water in Hermosillo by local hydrologists and water managers	General overview of water use and supply in Hermosillo; issues in managing urban water resources in a water-scarce area
Tour of new Hermosillo well fields	Description of wells recently installed to combat water shortages; discussions of methods for calculating available quantities of groundwater
Hands-on field exercises: geophysical surveys, global positioning systems, meteorological data collection, measurement of irrigation flows, and aquifer system analyses	Typical methods used to determine availability of water supplies and quantify water use
Tour of Hermosillo reservoir and dam	Description of operation of reservoir for flood control and water supply; reservoir has been empty for more than four years, due to drought
Presentation on Rio Sonora geology by local geologist	Relation of local geology to surface water and groundwater systems and mining activities
Visit El Molinito reservoir and dam	Description of operation of reservoir for flood control and water supply; reservoir has been empty for a year, due to drought

Activity	Significance
Measure flow in Rio Sonora at El Gavilan	Typical method for determining water availability; river was dry at measurement point
Discuss water and sustainability issues with mayors, congressmen, and health officials from Rio Sonora basin	Dialogue on water quantity and quality problems in rural towns from stakeholders' perspectives
Tour of water supply and wastewater systems and measurements in Aconchi and San Felipe	Description of water quantity and quality problems in rural towns from stakeholders' perspectives
Tour of Cananea mine	Copper mine is second largest in the world; discussion of mine operations and impact on local water supply
Tour of Zanjon vineyards	Description of irrigation methods and agricultural perspective of water availability
Visit Punta Chueca and discuss water and sustainability issues with Seri elders	Indigenous perspective on local water quantity and quality issues

Survey Instrument

As a prerequisite to the development of the survey instrument, we identified a series of attitudinal concepts associated with water resource management, upon which we then based a series of belief statements that were included in the survey. These concepts are

- the role of science and technology in society
- the influence of society on water resources management practices
- the individual's abilities to implement positive change
- the significance water resources practices in everyday life

Belief statements that can be linked to each of these concepts and the direction in which we would expect that responses to the belief statements would relate to the concepts are diagramed in Figures 2.a. to 2.d. The survey was intended to record the degree of student agreement with belief statements related to each concept, providing an indirect measure of student attitude toward that concept. Results were interpreted such that the greater the degree of agreement to a belief statement, the more strong the attitude of the student to the concept.

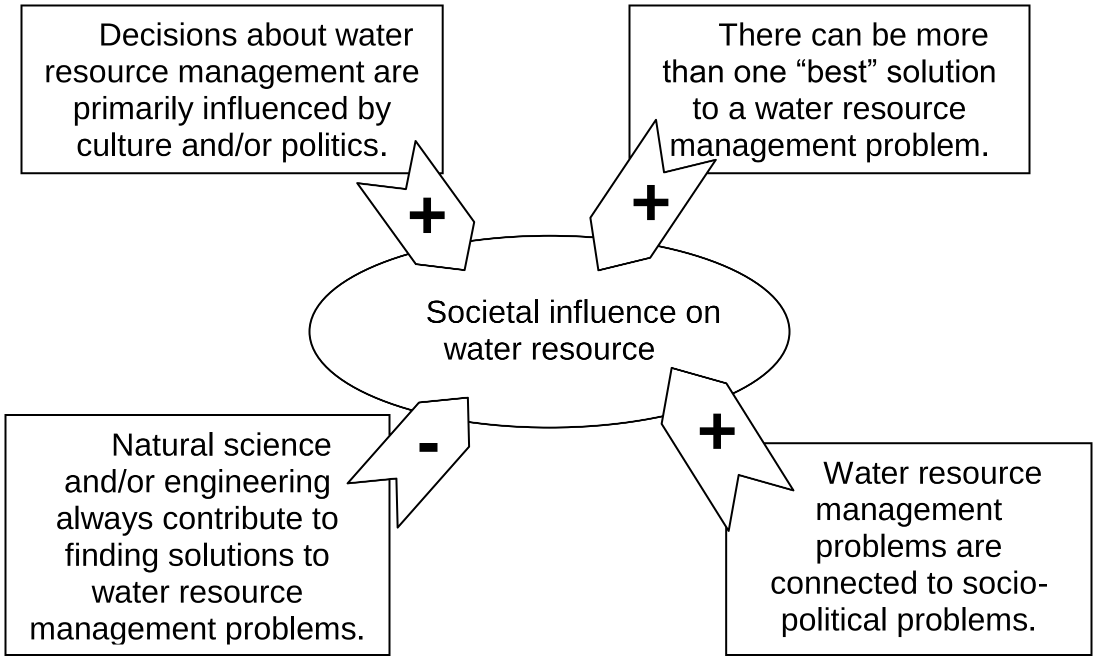

Figure 2.a. Belief-concept diagram for "Societal influence on water resource management."

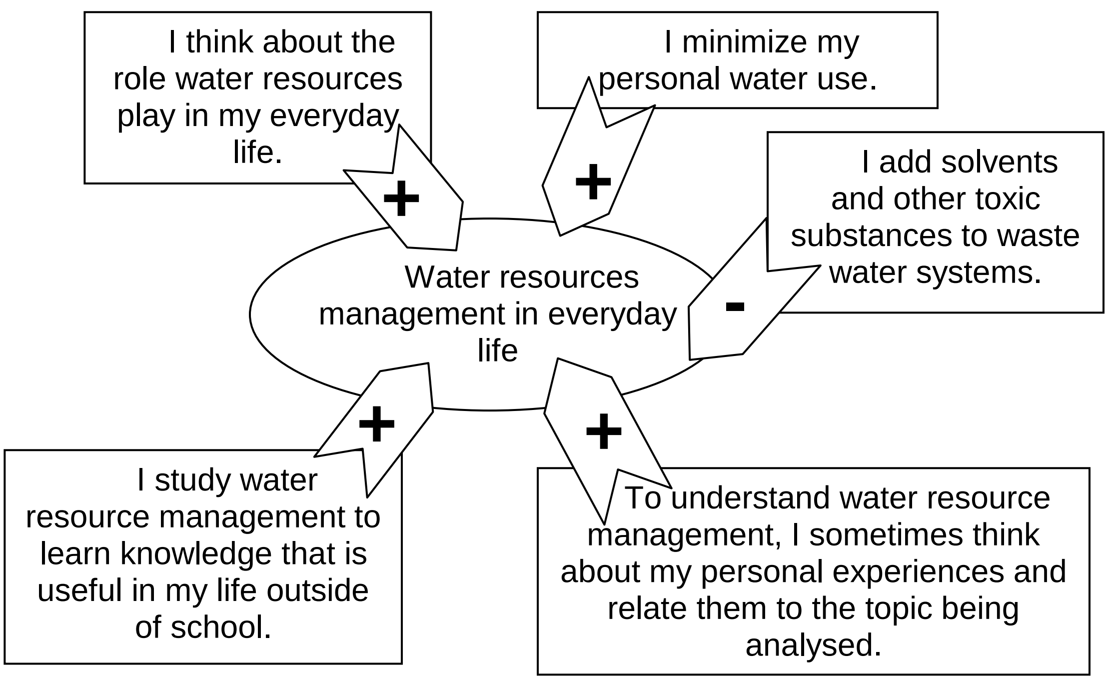

Figure 2.b. Belief-concept diagram for "Water resources management in everyday life"

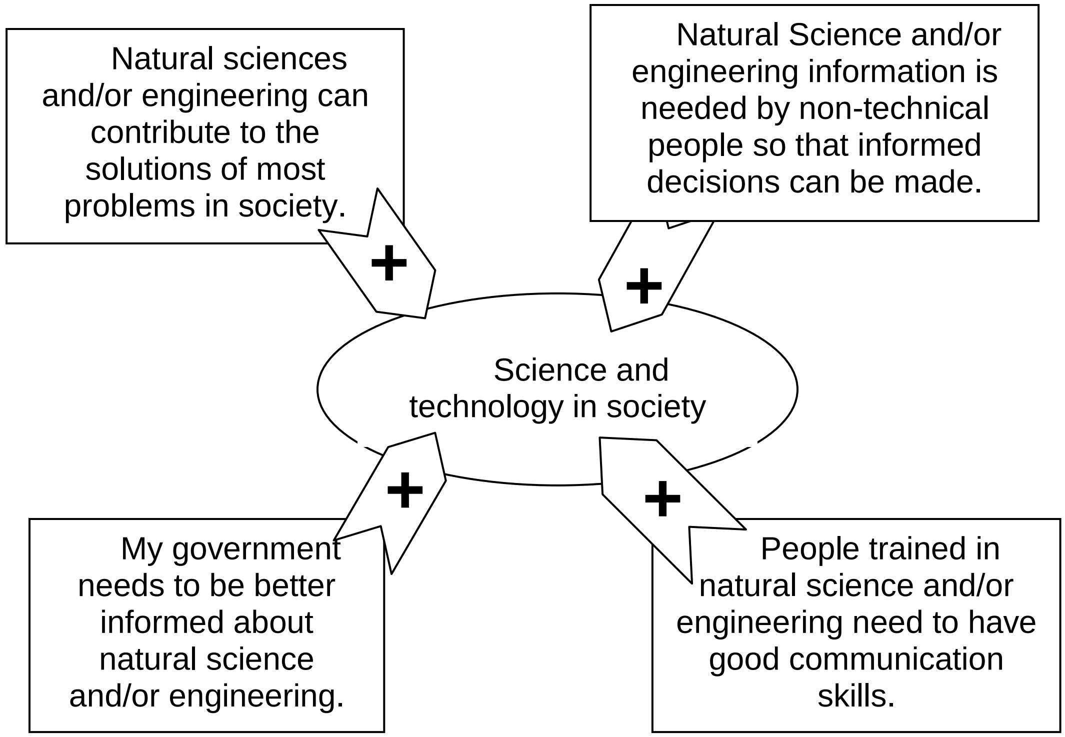

Figure 2.c. Belief-concept diagram for "Science and technology in society"

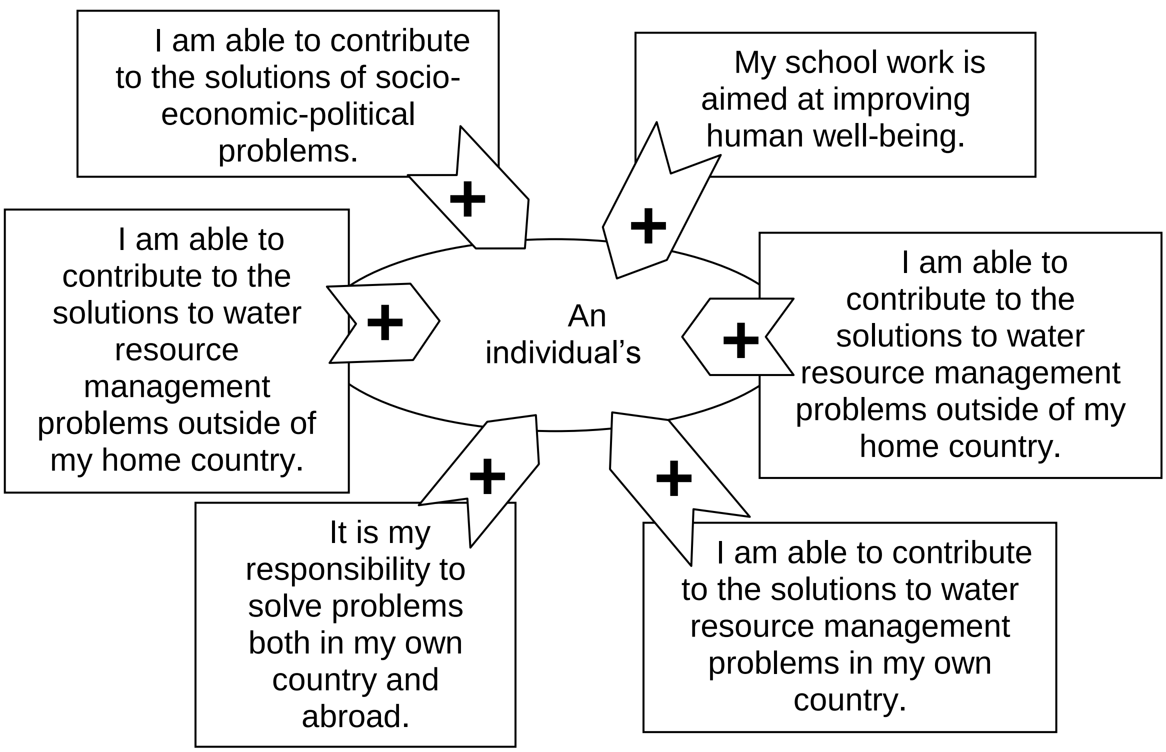

Figure 2.d. Belief-concept diagram for "An individual's actions"

In the survey, students were asked to respond using a Likert scale of agreement or disagreement with the statements. The survey given to the 26 students at the beginning and end of the field trip is summarized in Table 3. In addition, the survey was emailed to 35 water resource management professionals, who served as the experts referred to in the study's hypothesis. Since water resources management is a multi-disciplinary field, these experts were selected to give some breadth in terms of background. The experts' depth of background, as measured by the number of years of experience in the field, also was variable. A summary of the background 29 experts who responded to the survey is provided in Table 4. The experts' survey is summarized in Table 5, and is identical to the survey given to the students, except for the demographic questions and slight wording changes in two of the statements to make these statements more appropriate.

Table 3: Survey Given to Students on Field Trip

A. Indicate your home institution: Laval; MTU; UBC; UNISON; or Other.

B. Indicate your role: Undergraduate or Graduate.

Rate each of the following statements by circling a number between 1 and 5 where the numbers mean the following:
1: Strongly Disagree; 2: Disagree; 3: Neutral; 4: Agree; 5: Strongly Agree.

1. Natural science and/or engineering have little relation to what I experience in the real world.
2. To understand water resource management, I sometimes think about my personal experiences and relate them to the topic being analysed.
3. I minimize my personal water use.
4. Water resource management improves the well-being of people.
5. I am able to contribute to the solutions to water resource management problems outside of my home country.
6. Decisions about water resource management are primarily influenced by natural science and/or engineering considerations.
7. Reasoning skills used to understand nature science and/or engineering can be helpful to me in my everyday life.
8. The best decisions about water resource management are made through genuinely democratic processes.
9. I think about the role water resources play in my everyday life.
10. Learning about water resource management changes my ideas about how society functions.
11. The greatest contribution to making the world a better place is through effective water resource management.
12. Decisions about water resource management are primarily influenced by culture and/or politics.
13. There can be more than one "best" solution to a water resource management problem.

14. I am interested in participating in volunteer work.
15. Natural sciences and/or engineering can contribute to the solutions of most problems in society.
16. I am able to contribute to the solutions of socio-economic-political problems.
17. My government needs to be better informed about natural science and/or engineering.
18. My school work is aimed at improving human well-being.
19. The factors that influence decisions about water resource management are highly complex and involve consideration of social, political, economic, ecological, technological, and scientific issues.
20. To understand natural science and/or engineering, I sometimes think about my personal experiences and relate them to the topic being analysed.
21. Water resource management problems are connected to socio-political problems.
22. It is my responsibility to solve problems both in my own country and abroad.
23. Natural science and/or engineering always contribute to finding solutions to water resource management problems.
24. I study water resource management to learn knowledge that is useful in my life outside of school.
25. I am able to contribute to the solutions to water resource management problems in my own country.
26. Natural Science and/or engineering information is needed by non-technical people so that informed decisions can be made.
27. I never allow solvents or other toxic substances to enter wastewater systems.
28. People trained in natural science and/or engineering need to have good communication skills.
29. Please circle 4 (the “agree” option) to preserve your answers to this survey. (We use this question to discard the survey anyone who is not reading the questions.)

Table 4. Demographics of Experts Participating in Survey

Occupation				
Educational Institution	Government Agency		Private Consulting	Other
55%	32%		10%	3%
Discipline				
Engineering	Natural Science		Social Science	Other
58%	21%		18%	3%
Years of experience				
0-5	6-10	11-15	16-20	>20
3%	23%	40%	25%	9%

Table 5: Survey Given to Experts

Government Agency; Private Consulting; Other.

B. Indicate the discipline that best matches your background: Engineering; Natural Science; Social Science; Other.

C. Indicate the number of years of experience in your field: 0-5 years; 6-10 years; 11-15 years; 16-20 years; more than 20 years.

Rate each of the following statements by circling a number between 1 and 5 where the numbers mean the following:
1: Strongly Disagree; 2: Disagree; 3: Neutral; 4: Agree; 5: Strongly Agree.

The 29 statements were identical to those used in the student survey, except for the following statements, which were modified slightly.

18. My work is aimed at improving human well-being.

24. I study water resource management to learn knowledge that is useful in my life outside of work.

Since the survey was validated by neither student nor expert peers, we assume that the students, the experts, the reader, and the investigators all share a common understanding of the meaning of each question. The results from the pre- and post trip student surveys were compared by estimating the mean values of the responses to each of the first 28 statements listed in Table 3 and applying the Mann-Whitney U test (also known as the Wilcoxon rank-sum test). The Mann-Whitney U test is appropriate for non-parametric comparisons of two independent samples of ordinal data that do not necessarily follow a specific distribution (Rosner, 2005). The post-trip student survey results were compared to the results from the expert surveys following a similar methodology.

In addition to the attitudes survey, an evaluation survey was completed by the field trip participants on the last day of the field trip. The survey focused primarily on the students' satisfaction with the field trip. One of the questions, "Have any of your attitudes or beliefs changed as a result of your experiences this week?" and the associated responses reveals further information on how the field trip may have affected the participants' beliefs and attitudes. Where appropriate, these responses to this question are included in the following discussion in order to give a student voice to the analysis results.

Survey Results and Discussion

Tables 6 and 7 show results from the pre- and post-trip student and expert surveys, respectively. The asymptotic, two-tailed significance (also known as the "*p*" value) generated from the Mann-Whitney U test is given in the last column of Tables 6 and 7. The asymptotic, two-tailed significance is an indication of probability that the "null hypothesis" cannot be rejected. The null hypothesis here is that the data from the independent samples come from the same population; in other words, the samples are not different from each other. Thus, a low value of the significance indicates that the null hypothesis can be rejected and the two samples are different from each other. The statements with the asymptotic significance of less than or equal to 0.1 are highlighted, indicating that there is at least a 90% probability that significant differences in the compared data sets exists.

Table 6: Comparison of Results from Pre- and Post-trip Student Surveys

	Averages of Student Responses			
Statement	Pre-trip	Post-trip	Difference	Asymptotic Significance
2	3.79	4.27	0.48	0.01
3	3.36	3.42	0.07	0.83
9	3.64	4.04	0.40	0.12
24	4.14	4.04	-0.10	0.82
27	3.57	3.81	0.24	0.22
4	4.68	4.50	-0.18	0.57
6	2.36	2.08	-0.28	0.49
8	3.18	3.12	-0.06	0.95
10	3.86	4.27	0.41	0.09
11	3.57	3.35	-0.23	0.43
19	4.75	4.92	0.17	0.33
15	3.46	3.65	0.19	0.49
17	4.11	4.42	0.32	0.16
26	4.64	4.69	0.05	0.70
28	4.57	4.77	0.20	0.32
12	4.36	4.54	0.18	0.27
13	4.50	4.50	0.00	0.98
21	4.68	4.73	0.05	0.83
23	3.00	3.19	0.19	0.52
5	3.50	3.77	0.27	0.41
14	4.18	4.04	-0.14	0.96
16	3.54	3.81	0.27	0.22
18	4.11	4.35	0.24	0.13
22	3.86	3.81	-0.05	0.90
25	3.79	4.27	0.48	0.09
1	2.04	2.00	-0.04	0.51
7	4.43	4.42	-0.01	0.69
20	3.75	4.15	0.40	0.07

Table 7: Comparison of Results from Post-Trip student and Expert Surveys

	Averages			
Statement	Post-trip Student	Experts	Difference	Asymptotic Significance
2	4.27	3.54	-0.73	0.04
3	3.42	3.64	0.22	0.56
9	4.04	3.22	-0.82	0.05
24	4.04	3.28	-0.76	0.05
27	3.81	4.47	0.66	0.04
4	4.50	4.57	0.07	0.95
6	2.08	2.55	0.47	0.32
8	3.12	3.02	-0.10	0.88
10	4.27	4.15	-0.12	0.70
11	3.35	2.55	-0.80	0.04
19	4.92	4.86	-0.06	0.71
15	3.65	3.94	0.29	0.23
17	4.42	4.75	0.33	0.16
26	4.69	4.49	-0.20	0.48
28	4.77	4.86	0.09	0.62
12	4.54	4.11	-0.43	0.13
13	4.50	4.78	0.28	0.98
21	4.73	4.04	-0.69	0.04
23	3.19	4.57	1.38	0.01
5	3.77	3.01	-0.76	0.06
14	4.04	3.92	-0.12	0.54
16	3.81	3.11	-0.70	0.03
18	4.35	4.22	-0.13	0.13
22	3.81	3.25	-0.56	0.08
25	4.27	4.22	-0.05	0.45
1	2.00	1.53	-0.47	0.12
7	4.42	3.89	-0.53	0.08
20	4.15	3.88	-0.27	0.11

The average response to the statements for all respondents was 3.9, indicating general agreement with the belief statements in the survey. Statistical differences between both the pre and post trip responses and the post trip and expert responses arise only in the level of agreement. The survey results shown in Table 6 suggest that four student beliefs may have been significantly intensified by the field trip. That is, students tended to agree more with the following statements after the field trip compared to before the field trip excursion:

- 2. To understand water resource management, I sometimes think about my personal experiences and relate them to the topic being analysed.
- 20. To understand natural science and/or engineering, I sometimes think about my personal experiences and relate them to the topic being analysed.
- 10. Learning about water resource management changes my ideas about how society functions.
- 25. I am able to contribute to the solutions to water resource management problems in my own country.

The four beliefs that changed over the course of the field trip are similar in that they each refer to the perceived place of self in the world. In other words, the field trip experiences may have changed how students see themselves in their place in the world. Several of the students' responses to the question, "Have any of your attitudes or beliefs changed as a result of your experiences this week?" from the student satisfaction survey echo this supposition:

"I'll promote wise water utilization at home."

"I now really feel that these water issues are the fundamental problems facing humanity and that it is everyone's responsibility to address these issues."

"I thought seeing the city/village officials take their time to discuss their issues with us really drove home how much they care and helped personalize the experience."

"I was able to really grasp the concept of a drought after seeing for myself the dry river beds and reservoirs."

"Inequitable wealth cannot be an excuse for poor resource management. I will never see water the same."

"Interesting to experience a real drought or water shortage. This will change the way I think about water resources and water use at home."

Such an outcome of the field trip is consistent with the literature which indicates that personal reflection- guided by faculty- results in, among other things, personal growth, civic engagement, and critical thinking (Ash and Clayton, 2004).

Reflection can be defined as the explicit consideration of an experience through the lens of a specific learning objective (Hatcher et al., 2004). Such reflection took place during the field trip when students gave reports or led formal discussions. The reflection may also have occurred in a more personal form during informal discussions over meals and during transportation to and from the field trip learning activities. No matter the venue, these reflections may have led to students developing a greater sense of empowerment and a more defined sense of self in the world.

The fact that the degree in student agreement with most belief statements (24 out of 28) was not changed because of the field trip experience may be due to the maturity of the field-trip participants, 77% of whom were graduate students. Certainly, these results differ from earlier studies of elementary school students where it is shown that field trips have a significant affect on student attitudes (Bradley et al., 1999; Farmer et al., 2007). Perhaps beliefs of more mature learners are less likely to be affected by the field trip because previous life experiences may have previously demanded reflection. The reflection that may have occurred during the field trip may have cemented the students' existing beliefs rather than inspired new beliefs.

Students may have been articulating this "maturity effect" when they responded to the question "Have any of your attitudes or beliefs changed as a result of your experiences this week?" from the student satisfaction survey by stating

> "It rather affirmed my belief that the problems in these communities are universal; insufficient funds to manage deteriorating infrastructure with limited technical capacity. Nonetheless, people can and will survive, doing what they can to get by"
>
> "No, my major focuses on how the social, political, and cultural issues interact with engineering/natural sciences"
>
> "No, they have only been re-enforced. Water management requires that we take into consideration the natural and engineering aspects as well as the social implications."
>
> "Not really, but this was good reinforcement"

The possibility of a "maturity effect" was explored with a comparison between undergraduate and graduate student responses. This comparison revealed that pre-trip beliefs significantly differed between graduates and undergraduates (asymptotic significance <0.10) for three questions, shown in Table 8. None of the answers to the questions in the post-trip survey differed, in a statistically significant sense (asymptotic significance <0.10), between undergraduate students and graduate students. This analysis implies that the differences in the questions listed in Table 8 were reduced after the trip, suggesting that the trip could have matured the undergraduate students. However, because a difference was detected for only 3 out of 28 belief statements, the "maturity effect" between graduates and undergraduates is likely to be small for this group of students.

Table 8: Pre-Test Questions for which Undergraduate vs. Graduate Students Responses Differed

Statement	Undergraduate Average	Graduate Average	Asymptotic Significance Undergraduate vs. Graduate
6. Decisions about water resource management are primarily influenced by natural science and/or engineering considerations.	3.17	1.95	0.03
26. Natural Science and/or engineering information is needed by non-technical people so that informed decisions can be made.	5.00	4.47	0.04
28. People trained in natural science and/or engineering need to have good communication skills.	4.00	4.68	0.10

The results in Table 7 show that there were statistically significant differences (asymptotic significance <0.10) between student post-trip and expert degree of belief for 11 out of 28 statements. Nine of 11 of these differences were negative, indicating there was a lower degree of belief in the statements by the experts. However, there was a large, positive difference for statement 23. “Natural science and/or engineering always contribute to finding solutions to water resource management problems.” Apparently, the experience gained by the experts has given them more confidence in their disciplines when it comes to solving water resources management issues. On the other hand, however, there was a smaller and statistically less significant, although positive, difference between the degrees of agreement for statement 15. “Natural sciences and/or engineering can contribute to the solutions of most problems in society.” This result may indicate that the students and experts are more alike when it comes to the limitations of their disciplines to solving societal problems in general.

Of the four student beliefs that appear to have shifted as a result of the field trip, it is interesting that, as illustrated in Table 9, students’ responses to statement 2 indicates that their beliefs were more like an expert’s before the field trip than after the trip experiences. Even more interesting is the suggestion that the experts agree less with statement 9 than the students both pre and post field trip. Both of these statements are clearly related to personal experiences. Perhaps, while the field trip may have intensified the students’ belief that personal experiences can play a role in water resource management and that water resource management can play a role in personal experiences, the years of professional practice gained by the experts has minimized the significance of personal experiences to them.

Table 9. Shifts of Students Pre- and Post-trip Relative to Experts' Degree of Belief on Statements

Statement	Pre-trip Average	Post-trip Average	Expert Average	Shifted Closer (+) or Farther (-)	Asymptotic Significance Pre-trip vs. Expert	Asymptotic Significance Post-trip vs. Expert
2. To understand water resource management, I sometimes think about my personal experiences and relate them to the topic being analysed.	3.79	4.27	3.54	-	0.07	0.04
9. I think about the role water resources play in my everyday life.	3.64	4.04	3.22	-	0.09	0.05

The comparison of the student post-trip survey results with the expert responses does not support the hypothesis of this study, namely that the students' attitudes toward, and beliefs about, water resources management become more like experts as a result of the fieldtrip experience. On the contrary, the sparse evidence (only 4 out of 28 belief statements) from the study hints that, at least in a personal sense, students think more like experts before the field trip compared with after the field trip.

Reflections on the Idea of Affective and Cognitive Learning during Field Trips

The study described above suggests that Sonora field trip experiences encourage students to construct specialized mental schemas related to water resource management that include, and are branched to, attitudes and beliefs about how their personal lives (both bio-physical and social) are connected to water. Such schemas may be a consequence of each student's focused engagement with the topic resulting from activities such as visiting a mine site, discussing water and sustainability with local politicians, discussing issues with fellow-students and personal reflection on experiences (i.e. self-explaining, self-critiquing of previous knowledge about water resources). Such activities, designed to enhance the student's knowledge of the connections between climate and water availability, impacts of wastewater disposal on water quality, patterns of water use by humans, and so on, may also have cued at least some students to access previously constructed knowledge about "self-in-world". In so doing, the activities may have aroused emotion that strengthen, or emphasized, the connections to "self-in-world' attitudes within their water resource management schemas.

Results from our study suggest that undergraduate students demonstrate a greater positive change in the degree of agreement with some belief statements compared to graduate students. Field trip learning activities may have a greater influence on the belief sets of the younger, undergraduate, students, whose mental schemas are perhaps less intricate than the older, more experienced, graduate students. The survey instrument used to capture student and expert beliefs is not sensitive to the entrenchment of beliefs as a result of the field trip experiences. It may be that, for the graduate students, the structure and content of their water resource management knowledge pertaining to beliefs and attitudes was not constructed or reconstructed as a result of the field trip experiences. However it may be that their relevant schemas and the interconnections between these schemas were strengthened during their visit to Sonora State.

The study also suggests that the water resource management schemas of students who have just completed a field trip may include more, and/or stronger, links to beliefs and attitudes about their lives than the water resource management schemas of experts. Such a result would be a manifestation of the idiosyncratic nature of schemas. It may be that the experts did not link attitudes and beliefs about themselves to their expert knowledge while they constructed their understanding of water resource management. Or it may be that, over time, such links, while initially present within their mental schemas, have not been recalled during the accessing of this knowledge. Thus any links to such beliefs and attitudes that initially existed, have weakened and even disappeared.

A different explanation for the study results discussed in the paragraph above may relate to the socio-cultural environment in which students live compared to experts. Just as Mezirow (1996) suggests, it may be that the student's life, amplified during the field trip experience during which students live closely, re-enforce the belief set associated with an attitude of empowerment respecting self-in-world. Thus, the students exhibit stronger beliefs than do the experts, who likely live within a social setting quite different from the student.

The review of field trip literature suggests that informal excursions provide students with the motivation (including the social environment, the immediate need for understanding, and the personal relevance), and the reflection time necessary for "high engagement" that leads to the possibility of strong conceptual change in the subject at hand (Dole and Sinatra ,1998). Personal interactions and sensatory stimulation (i.e., seeing, smelling, and touching) elicit emotional responses that "warm" concepts as individuals build their knowledge. We may have observed this process as we watched the students from the United States and Canada on the Sonora field trip gape at the polluted sources of drinking water and the reservoir dams holding nothing but air.

Implications for the Design of Water Resource Management Learning Activities

Given what we have learned from this field trip and our subsequent analyses and reflection, we have some suggestions on how to analyze and design water resource management learning activities and how to improve future studies on field trip learning. First, whereas the educational psychology and informal science literature suggests that there may be a link between the beliefs and attitudes learned during fieldtrips and conceptual learning during fieldtrips, i.e., those who develop more complex beliefs have different degrees of cognition, we did not test this supposition in our work. Future field trips could embed instruments that examine changes in knowledge regarding the principles and practice of water resources management alongside of surveys aimed at assessing changes in beliefs and attitudes. Alternatively, one could track the performance of students in relevant coursework, after they return from the field trip to their respective universities. It would be especially interesting to assess whether high performance by field participants, if observed, was due to increases in motivation associated with participation in the field trip. Huk and Ludwigs (2009) used an augmented Cognitive Load Theory framework to design a study that tested the hypothesis that both affective and cognitive support during learning of economics concepts increases understanding. These authors found that, neither affective support without cognitive support, nor cognitive support without affective support, influenced student understanding. However, when both affective and cognitive supports were provided together, student understanding of the economics concepts increased above those students in the control group. It may be that the framework developed by Huk and Ludwigs could be appropriately modified and applied in subsequent studies of the learning during our international field trips.

Second, if there is a set of beliefs and attitudes that are linked to the best-practice applications of water resource management knowledge, how can we thoughtfully enable students to construct water resource management schemas such that the beliefs and attitudes are embedded within the conceptual and cognitive understanding of water resource management? In this work, we assumed that set of beliefs about science and technology, personal efficacy, daily life, and the social context were linked to water resources management, but it is obvious that more careful assessment of the characteristics of these linkages is needed. Next, we need to determine where connections between beliefs and attitudes and the technical concepts involved in water resources management may lie. As educators, we may think we understand how to draw upon beliefs and attitudes to motivate students to learn technical concepts, but it may be that the learning activities we design are based on our largely uninformed understanding, and may therefore be naive and ineffective.

Third, we wonder if the notion of a “threshold concept” might inform the design of field trips. Meyer and Land (2003) describe threshold concepts as acting like portals or gateways to new knowledge construction. For example, Baillie et al. (2006) suggest that the learning threshold model may inform the design of activities aimed at learning the concept of complex numbers. Perhaps the beliefs and attitudes related to “self-theories” of who one is, and the power one possesses, are threshold concepts. Once a student had developed a positive and empowered sense of self-in-world, that student has walked through a gateway into a new world of possible decisions and action. If we can embed activities into subsequent field trips that are designed to help students learn such attitudes, then we might begin to claim success in these learning events. Another possible threshold concept relevant to the water resource management field trips may relate to an understanding of the socio-political context of water resource problems: we have observed that, unlike their peers studying the humanities, engineering and natural science students can become frustrated when they see an obvious technical solution to a water resources problem in a given situation, which has not been implemented. This type of situation may be their first realization that socio-political contexts cannot be ignored, which may motivate the students to learn more about the social sciences.

Finally, whereas this field trip and our analysis of the effect of the field trip activities on learning focused on water resources management, we think that most, if not all, of the observations we've made in this work can be applied to other natural resources and related management disciplines, such as forestry, agriculture, and urban and regional planning.

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