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Abstract

This study suggests that community service learning experiences facilitate the reconstruction of civil engineering student beliefs about both the type of work performed by civil engineers and the broad impact of civil engineering knowledge. Further, the service learning experiences highlight for students 1) the importance of relationships between people, 2) the value of variations in perspective, and 3) the responsibilities of civil engineers in society as holders of expert knowledge. Meta-cognitive and self-regulated learning activities may be the mechanisms by which student beliefs evolve during service learning. Therefore, the quality of community service learning experiences may be enhanced by increasing the opportunities for students to articulate and organize their knowledge, critique their perspectives, compare and contrast their understanding with the understanding of others, and engaged in activities requiring knowledge integration.

Keywords

Civil engineering, Community service learning, Affective learning, Beliefs

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ABSTRACT

This study suggests that community service learning experiences facilitate the reconstruction of civil engineering student beliefs about both the type of work performed by civil engineers and the broad impact of civil engineering knowledge. Further, the service learning experiences highlight for students 1) the importance of relationships between people, 2) the value of variations in perspective, and 3) the responsibilities of civil engineers in society as holders of expert knowledge. Meta-cognitive and self-regulated learning activities may be the mechanisms by which student beliefs evolve during service learning. Therefore, the quality of community service learning experiences may be enhanced by increasing the opportunities for students to articulate and organize their knowledge, critique their perspectives, compare and contrast their understanding with the understanding of others, and engaged in activities requiring knowledge integration.

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INTRODUCTION

Our understanding of the mechanisms by which humans acquire and retain knowledge has advanced in recent years. For example, it is well established that different types of knowledge (for example procedural knowledge, semantic and event knowledge, beliefs, and many other knowledge types) reside and are organized within memory, influence each other, and are physically interconnected (Phillips, 1995; Dole and Sinatra, 1998; Johnson and Munakata, 2005; Quartz and Sejnowski, 1997; Goswami, 2006). The role of emotion (i.e., personal feelings) in knowledge construction is being revealed (e.g. see Sinatra, 2005) – and it is now clear that beliefs, attitudes and other types of *affective* knowledge, are intimately entangled with, and inseparable from, "concrete" (e.g., semantic and event) knowledge (Southerland et al., 2001; Koballa and Glynn, 2007). Intrinsic and extrinsic motivation, goal orientation, self-determination, self-efficacy and other motivational constructs influence learning (Glynn and Koballa, 2006). And it is also clear that meta-cognition and self-regulated learning activities (i.e., higher-order thinking) such as *intentional* knowledge organization and *intentional* knowledge integration, enhance learning (Volet, 1991; Pintrich, 2002; Pintrich, 2004). Similarly, the more we attentively test,

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question, self-explain, and critique our knowledge, the more entrenched in memory our knowledge becomes (Dole and Sinatra, 1998).

These recent advances in understanding learning mechanisms suggest that activities facilitating higher-order thinking have the potential to significantly improve the effectiveness of civil engineering programs charged with increasing the breadth of learning achieved by their graduates (Canadian Academy of Engineering, 1999; ASCE, 2008). The more students take opportunities to test, explain, and critique both their cognitive and affective knowledge and the knowledge of others, and the more they synthesize, integrate, and organize the knowledge they aspire to acquire, the more engaged they become (Kuh, 2003, 2008) and the more easily they retrieve the knowledge that has been embedded in memory. An active and engaged life at university that includes experiences of higher order thinking about a broad range of knowledge types, including beliefs, increases academic success and the potential for professional excellence. This paper presents results from a study aimed at exploring the efficacy of service learning as a vehicle for engaging students in the construction of beliefs about the role of civil engineering work within the societal context. It relies on the learning theory literature to explain the results, then offers suggestions for teaching that might enhance the quality of student learning.

BACKGROUND

Affective Learning in Civil Engineering Education

Included among the many calls for increased breadth of learning achieved by civil engineering graduates is a new emphasis on affective learning. For example, the "sustainability" and "attitudes" learning outcomes identified in the American Society of Civil Engineering's Book of Knowledge (ASCE, 2008) imply belief sets related to professional ethics and world-views, which, while not necessarily new to civil engineering practice, are newly emphasized within the post-WWII context. The call for development of such beliefs within curricular experiences is evident within the civil engineering profession (ASCE, ICE, CSCE, 2006), and the academy is responding, as demonstrated in the engineering education literature and at engineering conferences (e.g., see Ang et al., 2011).

The relevance of attending to the development of appropriate beliefs during civil engineering studies is evident in the teaching and learning literature as well as the professional literature. All humans have the capacity to form and express beliefs of different scales (e.g. from semantic to ideological) and about various subjects (e.g., from observable to non-observable, moral, esthetic, world-views, what we desire, what we wish for others, what we value, and so on) (see Nola and Irzik, 2005, p. 24). Although the notion of "belief" varies between disciplines (for a review of the discourse on beliefs and knowledge see Southerland et al., 2001), our beliefs are foundational to learning: what each of us focuses on, and is mindful of, depends on, among other concepts, our beliefs (e.g. Liu and Matthews, 2005; Mezirow, 1996). In addition to influencing a person's initial interest in, and the motivation to engage with, subject matter, beliefs continue to influence the interpretation of concepts throughout the knowledge structuring, and restructuring, processes (Dole and Sinatra, 1998; Gregoire, 2003).

Thus, our increased understanding of knowledge acquisition mechanisms and the clear expectation for change in civil engineering education, challenges curricula and course designers to attend with rigor to the development of appropriate beliefs, in addition to the acquisition of traditional knowledge related to topics such as calculus, mechanics, and numerical analysis. The difficulty of supporting affective learning within the engineering science culture of intellectual impartiality and objective enquiry, where affect is ostensibly absent, is balanced by the engineering tradition of hands-on experiences (e.g., capstone project courses) that may afford untapped opportunities for the learning of professional belief sets and other appropriate affective knowledge. In other words, there may be a place within project courses for attentive development of professional beliefs and attitudes.

Service Learning and Civil Engineering Education

Evidence suggests that community service learning (CSL) experiences can influence student beliefs (Brown et al., 2007; Moely et al., 2002). Therefore, CSL may be an effective pedagogy engendering the development of explicitly stated, professional, beliefs. CSL can also play a critical role in providing meta-cognitive opportunities, and has been shown to facilitate learning related to broad citizenship knowledge and engagement, intercultural knowledge and competence, ethical reasoning and action, skills for lifelong learning, and the ability to integrate and apply learned concepts (Kuh, 2008).

CSL can be defined as learning within the context of service-work. The goals of the service-work are identified by, and achieved with, a community organization. Performing the work enables students to achieve learning objectives related to their academic study. Key to CSL is structured reflection during which students take time to connect the course learning objectives to their service-work experiences within, and on behalf-of, the community. Students receive responses to their reflections from mentors whose aims are to clarify confusion, underscore and disaggregate thorny or messy issues, facilitate independent problem-solving, and encourage knowledge organization and integrative, critical, and creative thinking. (The definition of CSL presented here is drawn from the authors' experiences, Bringle and Hatcher (1999), and Harlap and Fryer (2011).)

CSL is perceived by civil engineering educators as a pedagogy enabling programs to respond to the call from accreditation bodies (for example, see Zhang et al., 2007; Borg and Zitomer, 2008; Dewoolkar et al., 2009) and others (for example, ASCE, 2008; Kumar and Hsiao, 2007), to increase the "breadth of learning" experienced in engineering education. It emerged within North American civil engineering programs in the mid 1990s (Coyle et al., 2005), and has since been deployed within a variety of learning environments and at different levels of study (for examples of service learning applications in civil engineering programs, see Padmanabhan and Katti, 2002; Coyle et al., 2005; Zhang et al., 2007; Dinehart and Gross, 2010; Dewoolkar et al., 2009). Civil engineering students generally work in teams on projects defined by either a local or an international community organization. As well as working with faculty members, students may also work directly with citizens within the community, with representatives from community organizations (i.e., "the client"), or with graduate students. Projects may be sufficiently small such that students can complete the required tasks within one term, or large enough that different student teams work on a single project over consecutive years. In addition to personal written reflections, learning artifacts may include conceptual drawings, detailed construction drawings, presentations, technical reports, posters, minutes from small-group discussions, and/or persuasive or reflective essays.

Investigations of the impacts of civil engineering CSL are beginning to appear in the literature. Swan et al. (2009) suggest that *student-related* outcomes of CSL can be categorized into:

- knowledge (i.e. conceptual and procedural knowledge);

- skills (i.e. psychomotor skills including writing, construction, and presenting work);
- attitudes and identity (i.e. affective knowledge);
- program issues (e.g. student recruitment and retention) and;
- post-education performance (i.e. long-term knowledge retention and application).

Dewoolkar et al. (2009) imply that *community-related* outcomes, such as relationship-building between institutions and communities, could be added to the list of CSL outcomes. Indeed, the interpretation of CSL as a movement supporting cultural change, or even political change, within both institutions of education and communities (Butin, 2010), may be relevant to civil engineering and is explored as humanitarian engineering by VanderSteen et al. (2010).

Studies by Zhang et al. (2007), Bielefeldt et al. (2010), and Dinehart and Gross (2010) suggest that CSL in civil engineering has a positive influence on the development of the student's affective knowledge, particularly in the domain of self-perception, compared to other civil engineering learning activities, including non-CSL capstone design experiences (Dinehart and Gross, 2010), and formal problem-based learning activities (Bielefeldt et al., 2010). These findings are re-enforced within CSL research in the broader engineering literature (Dukhan et al., 2008) and by studies of CSL in non-engineering fields, where the positive influence of CSL on beliefs of self-efficacy has been identified (Brown et al., 2007; Moely et al., 2002).

A recent study by Lathem et al. (2011) reports on the impact of curriculum renewal that includes the introduction of significant service learning experiences, on graduating student attitudes and beliefs. Among the issues raised by this paper is the influence of the curricular changes on student understanding of the roles and responsibilities of engineers within society. This study contributes to the CSL discourse respecting affective knowledge acquisition in civil engineering education by transitioning the notion of "identity", outlined by Bielefeldt et al. (2010) and others, from an individual focus of self-perception ("*Who am I?*") and self-efficacy ("*What am I able to do?*"), to terms of the societal role of the profession ("*Who are we?*" and "*What must we do?*"), and, in so doing, raises several questions. Do beliefs about the profession influence student acquisition of other types of civil engineering knowledge throughout the program? Which experiences in the curriculum might influence these beliefs? If classroom experiences affect student beliefs about the profession, what aspects of the experiences activate the mechanisms by which the learning of beliefs is achieved? Would such beliefs influence a student's subsequent civil engineering practice?

The work reported here explores the question of "Who are we?" raised by Lathem et al. by posing the question: does CSL influence the beliefs about the role of civil engineering in society held by civil engineering students? The investigation is an example of classroom research in which the course design is grounded in CSL literature, the research results are interpreted by the application of learning theory, and the interpretation of results suggests improvements to learning activities. The paper supports the argument that meta-cognition and self-regulated learning during CSL experiences leads to more sophisticated student beliefs about the role of civil engineering in society.

CONTEXT OF THE INVESTIGATION

In 2006, evidence of immature student decision-making during 4th year capstone design projects that included an apparent inattention to the conceptual design phase of the project, lack of awareness of the design context, and disruptive team dynamics, prompted a team of civil engineering faculty members at a large, research-intensive, university situated in Canada, to implement meaningful design experiences within every year of the civil engineering curriculum. Design-oriented CSL projects were deeply embedded into two consecutive core-program courses of the entering year of the program (2nd year of engineering study). Ideas for the CSL assignments were drawn from a review of the CSL literature (e.g., Bringle and Hatcher, 1996, 1999; Eyler and Giles, 1999; Eyler, 2001; Ash and Clayton, 2004; Hatcher et al., 2004). Providing significant CSL experiences to students new to civil engineering was perceived as a means to engage students in their learning, to introduce students to the impact of the social, economic, and ecological context of infrastructure design, construction, operation and renewal, and to focus on the conceptual stage of the design process. Paramount to the development of the CSL component was the goal of attending to affective learning related to self-image as a professional. The learning outcomes and student assignments for the CSL projects are provided in Table 1.

Table 1: Course-level CSL Learning Outcome and Student Assignments

2nd Year Learning Outcome	**Student Learning Artifact (i.e. course assignment)**
Apply the basic steps in the design process, including the development of three conceptual designs	- CSL team Technical Report due at the end of Term 1
Apply basic project management concepts, including project planning	- CSL team Technical Report due at the end of Term 1
Describe the influence of the social context on the design process	- CSL team Technical Report due at the end of Term 1
Create a working framework of sustainability concepts as applied to civil engineering projects	- Bi-weekly meeting with senior student mentor - CSL team Technical Report due at the end of Term 1
Enhance team work and leadership skills	- Peer evaluation of team work
Enhance communication skills	- Technical Report in Term 1 - CSL team presentation due at the end of Term 1 - A minimum of two meetings with the client in Term 1 - A minimum of 20 hours on-site and under the direction of the client during the build in Term 2 - A poster presentation summarizing the project process and outcomes after the build is complete in Term 2
Develop reflection skills	- Two CSL team Term 1 reflection *discussions* led by a mentor, one before meeting with the client, one after completing the Term 1 technical report - One Term 2 pre-build reflection journal entry and one post-build reflection journal entry - A reflection essay due at the end of Term 2

The CSL activities at this Canadian university are supported by a central unit charged with encouraging CSL as a means of achieving the student learning goals associated with the university's strategic plan. Coordinators have been placed in each of 4 large faculties, including within the engineering school. The coordinator attends to relationship building between the community organizations and the academic units, and the individual instructors. S/he also acts as a knowledge hub for best-practice CSL activities, and has a budget to support CSL student work.

The 2nd year civil engineering students experience CSL as one of 5 to 7 team members who are tasked with:

- meeting the "client" (i.e., the community organization partner),
- determining the client's needs,
- creating conceptual and detailed designs for the client's project
- planning for the implementation of the design, and
- implementing the plan (i.e., building the design).

The project usually involves a small construction project, for example, a fish smokehouse for an Aboriginal community, a play-house for a daycare centre in an inner city neighbourhood, an authentic Ming Dynasty fence for a public Chinese garden, a demonstration Pelton wheel for a society devoted to children's education. The students learn about the process of project design, project management and project planning, and, more generally, design decision-making. Importantly, they learn how to function within a team, and how to communicate effectively with a client.

Senior student, or young professional, mentors are tasked with helping their teams initiate each project. The mentors then run team reflection sessions before and after the design/planning experiences during which questions are asked aimed at triggering connections between the work at-hand, and the course learning objectives. These mentors also read and respond to individual reflection journal entries written by the 2nd year students before and after each team builds their project.

The community organization, whose representative takes on the role of co-educator of a student team, benefits from the collaborative relationship that develops between the organization, the academic institution, and the student team. The fish smokehouse CSL project, completed by civil engineering students in 2009, illustrates this mutually beneficial relationship. The smokehouse, which has spiritual and cultural significance in West Coast Aboriginal cultures, was proposed as a CSL project by an Aboriginal society whose aim is to support displaced First Nations people living within an urban setting known as the poorest postal code in Canada. Working to design and build the smokehouse under the guidance and leadership of elders from the Haisla, Tshimshian, and Kitlope First Nations, the civil engineering student team began to understand the profound effect that infrastructure can have on people's cultural well-being. From the community organization perspective, members of the Aboriginal community gained the ability to prepare and eat food in a manner that, in many respects, pre-dates European contact. Cultural events are now organized annually during which the smokehouse is continually in use. Both the organization and the students benefited from the project. Organizations like the Aboriginal support society are willing to become co-educators with the university because of the benefits accruing to the community - learning outcomes are achieved in large measure because of the commitment to the CSL team of the community organization.

METHODOLOGY

Data collection aimed at informing the research question involved the application of both qualitative and quantitative research methods (see Figure 1). As discussed by Woolley

(2009), such a mixed-methods design is appropriate here because, simply put, the research question in this study involved a "what" (i.e., what are the beliefs that change during 2nd year of study in the civil engineering program?) and a "why" (i.e., why do the beliefs change?). Therefore, the initial stage of the investigation measured changes in beliefs about the role of civil engineering in society held by cohorts of 2nd year civil engineering students via analysis of the results from an informal, pre-year and post year, Likert-scale, survey instrument. Trends of change in beliefs were identified. Next, post-year focus group discussions about what was learned from CSL experiences were organized for the final cohort. Themes that emerged from these discussions were identified. Finally, informal quantitative results related to the trends in belief changes were compared to qualitative findings about the emergent themes from the focus group discussions. This comparison provided insight into the influence of CSL experiences on the beliefs held by students, which, in turn, suggested improvements to the CSL assignments.

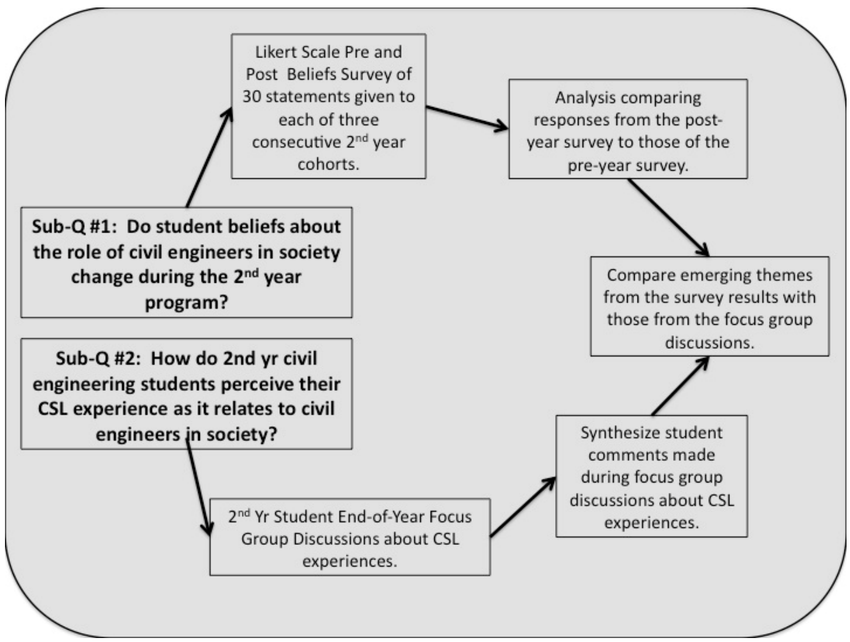

Figure 1. An outline of the mixed method research design.

Quantitative Analysis: The survey instrument and application

An informal Likert-scale survey was developed for the purpose of recording the level of student agreement with 30 belief statements related to their perception of the role of civil engineering in society on a scale of 1 to 5. The survey instrument was developed in a similar fashion to the instrument reported by Nesbit and Mayer (2010). The belief statements are presented in Figures 2a and 2b. The subsequent analysis of the survey data assumes that the students, the reader, and the investigators share a common understanding of the meaning of each belief statement. In other words, this informal survey was not validated.

The survey was applied to three cohorts (i.e. in 07/08, 08/09, and 09/10) at the beginning and end of their 2nd year of civil engineering study. Only survey data from students who completed both the pre and the post surveys were analyzed. To match the pre and post surveys to an individual student, additional information was collected while the survey was being completed. The proportion of students who completed both the pre and the post surveys relative to the total number of students in each cohort is presented in Table 2.

Once survey data from the cohorts were collected, two analyses were performed. First, a pre-to-post comparison for each of year cohorts 1, 2, and 3, identified significant belief changes within each cohort. (Only post-course survey data was available for cohort 4, so the pre-to-post comparison was not performed for this final cohort.) The Wilcoxon Signed Rank test was applied and a p value of less than or equal to 0.1 was taken to indicate significant change. This test was selected because it is well suited for non-parametric comparisons of two dependent samples of ordinal data that do not necessarily follow a specific distribution (Altman, 1993). This analysis enabled the identification of belief changes within each cohort.

Second, a comparison of the cohorts across different years was performed. The Mann-Whitney U test was used to compare pre-course survey data between year cohorts 1, 2, and 3 (recall that pre-course survey data was not available for cohort 4). It was also used to compare post-course survey data for all four year cohorts. The Mann-Whitney U test was employed because it is designed for non-parametric comparisons of independent samples of ordinal data that do not necessarily follow a specific distribution (Rosner, 2005). Also, average pre-year grades of all four cohorts were compared (see Table 3). The analysis described in this paragraph was performed to investigate measureable differences between the cohorts.

Qualitative Analyses: Focus Group Discussions

At the end of the 2nd year program for the forth cohort, focus groups were conducted to gain insight into what may have influenced changes in student beliefs over the eight-month period of the 2nd year program – i.e., why the change? Two focus groups were held during which a total of nine 2nd year civil engineering students discussed the following topics:

1. Their motivation for entering the civil engineering program and their thoughts about the role of civil engineering in society before beginning the program.
2. The perceived relevance of CSL experiences to their future engineering practice.
3. Their thoughts at the end of the 2nd year program about the role of civil engineering in society.

Each focus group discussion was recorded and transcribed. Consideration of group dynamics, interactions, and the group situation (see Vicsek, 2007, for a discussion of focus group analysis techniques) is absent from the analysis. Rather, quotations from individuals within groups were considered in isolation and there was no attempt made to distinguish the statements of the first group with those of the 2nd. Statements made by individuals were synthesized into dominant themes. The authors assumption that results of the 4th cohort focus group discussions were representative of all four cohorts was tested by comparing the post-course survey results and the average incoming grade of the 4th cohort to those of the earlier 3 cohorts.

FINDINGS

Analysis Results of the Informal Beliefs Survey Data

The number of students in each year cohort, and the number of students who completed both the pre and post surveys, are presented in Table 2. The average cohort response to each belief statement is provided in Figures 2a and 2b. The fourteen belief statements for which significant changes within cohorts was measured (i.e., $p \leq 0.1$), using the Wilcoxon Signed Rank test, are signaled by an asterisk in Figures 2a and 2b. Of these fourteen belief statements, ten of the belief statements showed change in at least 2 cohorts and three changed in every cohort.

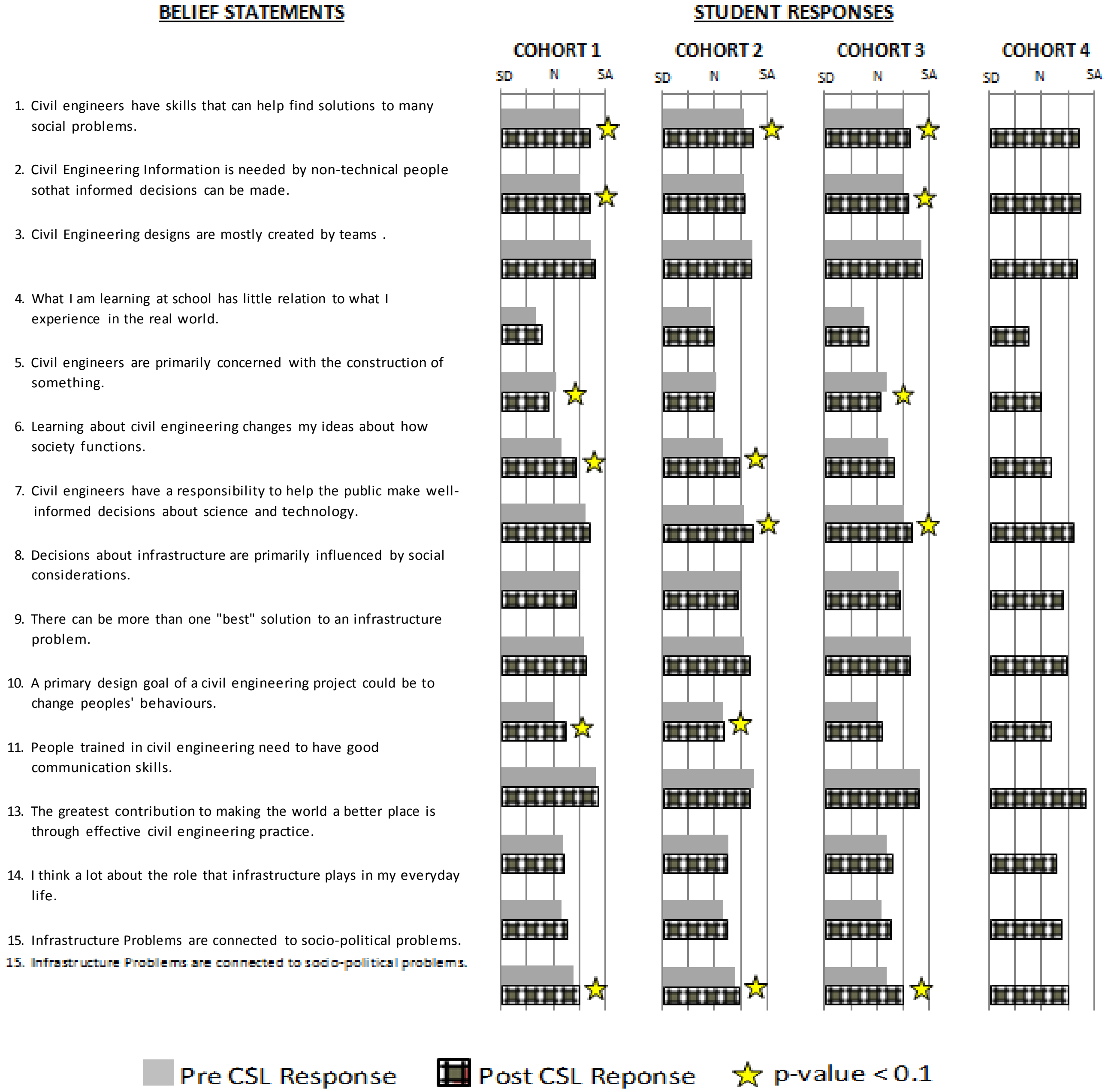

Figure 2a. The level of pre-course and post-course student agreement with belief statements 1 to 15, in four cohorts is illustrated. Those beliefs exhibiting change ($p \leq 0.1$) between pre and post-course responses are indicated by the asterisk.

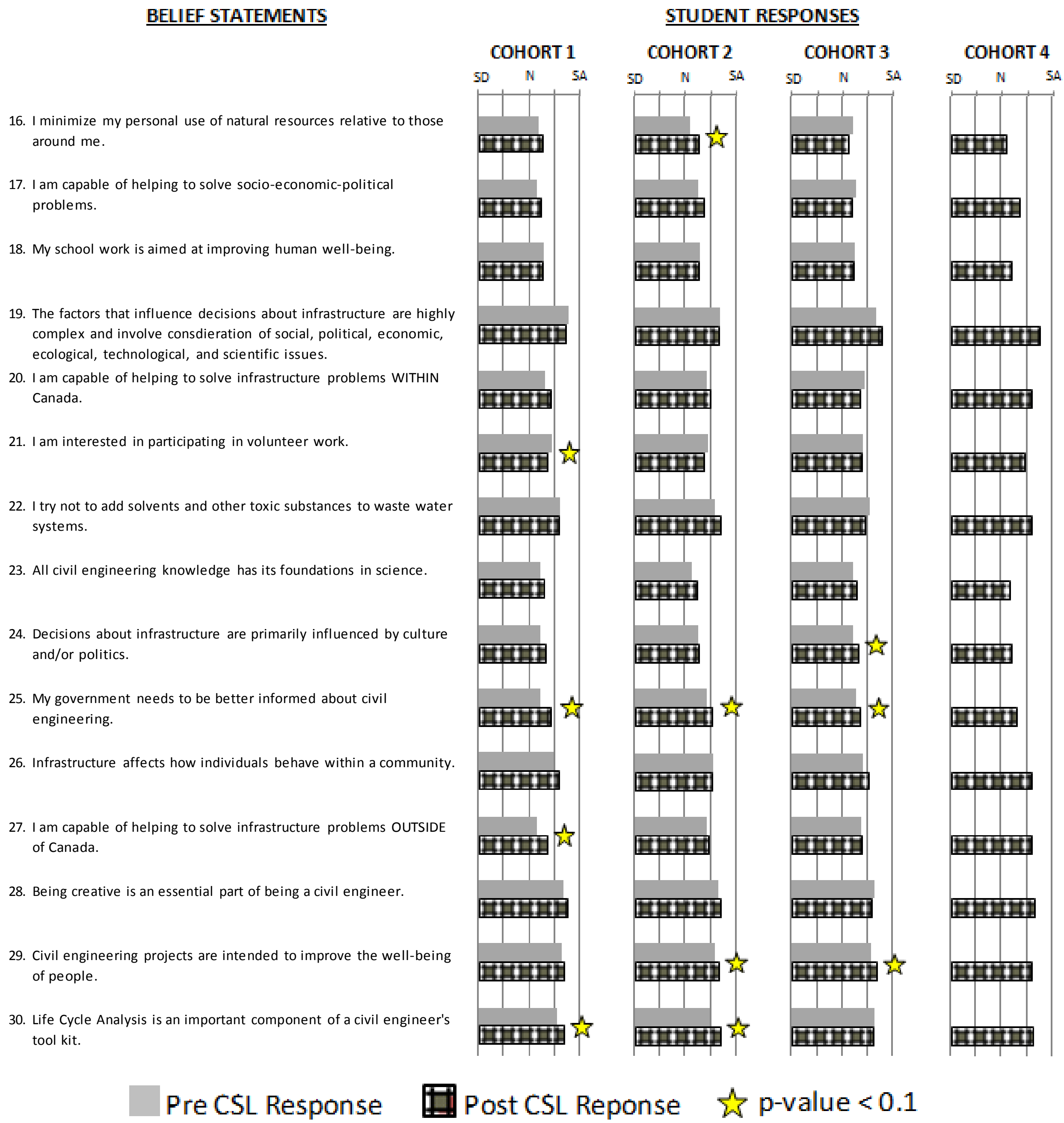

Figure 2b. The level of precourse and post-course student agreement with belief statements 16 to 30, in four cohorts is illustrated. Those beliefs exhibiting change ($p \leq 0.1$) between pre and post-course responses are indicated by the asterisk.

When the statements exhibiting change in one or more cohorts were clustered together, two trends of change emerged:

1. Changed beliefs about the work performed by civil engineers.
2. Changed beliefs about the impact of civil engineering knowledge.

The comparison of the 4th cohort post-year responses with those of previous cohorts, using the Mann-Whitney U test, revealed no significant differences. Also, there was no difference in average grades among different cohorts entering the 2nd year program (see Table 3). Therefore, the comparison between the 4th cohort and the previous cohorts indicates no significant differences.

Table 2. CSL survey response rates for different cohorts.

Cohort No.	Cohort Year	Survey Responses		
		Number of Students in the Cohort	Number of Students who completed the survey	Response Rate
1	2007/08	116	59 (pre & post)	51%
2	2008/09	120	67 (pre & post)	56%
3	2009/10	125	51 (pre & post)	41%
4	April,2011	127	45 (post only)	35%

Table 3. Placement (1st Year) Standings (Grades) of the 2nd Year Cohort

Year	Number of students	Average Cohort Grade	Cohort Grade Standard Deviation
2007/08	116	79.1	6.0
2008/09	120	75.2	5.6
2009/10	125	77.3	5.0
2010/11	127	77.9	---

Focus Groups: Results of Data Analysis

The discussions in each of the two focus groups started out with participants describing their thoughts about civil engineering as they entered their 2nd year of engineering study, in September, 2010. While some students described civil engineering in terms of designing and building infrastructure, others were more vague, for example, one student said "*I didn't know much about it*", another commented that "*civil engineers [just] get things done*". When the students began describing their CSL projects, the following themes were observed to emerge:

- Civil Engineering and People: Teams, Clients, the Public.
- Different Perspectives: the challenges and benefits of listening to, and learning from, different perspectives and different values.
- Sharing Expert Knowledge: Challenges and Impacts.

Theme 1: Civil Engineering and People

There was consensus among focus group participants that relationships with people play an important part in the successful completion of the CSL projects.

> *"…through the CSL project I learned about the extreme interconnectedness between everyone involved in the project, for example regarding materials, from who's getting the materials, to the professionals who manufacture the materials, to the client, to the people who are using it ….."*

But, while manufacturers, suppliers, and others may have been mentioned during the discussions, there were three groups of people who were particularly important to the students: teams, clients, and the public.

The importance of teamwork became a topic of focus group discussion as soon as students began describing their CSL projects. Comments like the two provided below were common across the discussions.

> *"I think for me, [the biggest surprise] was the teamwork. …"*

> *"The whole team work thing [was really surprising] ..."*

And, just as with teammates, the communications and relationships with clients dominated the discussions of the CSL projects. For example, students offered comments such as:

> *"Client contact was the biggest issue – takes most time and effort. I used to think that engineers just design something. It's not [the case]!! There is a lot of communication challenge with the client."*

> *"Communicating with clients is a huge challenge! I hadn't thought of this before."*

> *"… Managing the expectations of the client of what they could get for the money – like negotiat[ing] that with them – this was a big challenge."*

Of special note is the surprise several students expressed in learning that clients change their minds:

> *"Before I took this course I thought clients would know what they want!"*
> *"…it was discouraging, because the clients kept changing their mind."*

As the conversations moved into discussions about the relevance of CSL, a third group of people emerged: the public.

> *"Sometimes [civil engineering is] about educating the public - I never thought about this before …"*

> *"Civil engineers know all the stuff and take it for granted and don't realize that everyone else doesn't really understand. We need to get the ideas out there and, like, yeah, sell the public on the ideas of sustainability."*
> *"Public knowledge and, again, when doing large infrastructure, educating the client."*

> *"The public can inform the civil engineers. The public has just as much knowledge as civil engineers."*

One student connected CSL to learning about how non-engineers view the profession:

> *"I'm of the belief that there is a wide mis-belief about engineers in general … I feel like, as engineers, that stereotype of the guy with the calculator who just doesn't talk and who just sits back and does his number crunching and that's all there is to engineering, has to change in the public eye, and that's our responsibility as young professionals that we have to represent*

ourselves as being societally [sic] conscious and interested. And I think that part of CSL was just kicking us in the butt and making us go talk to people and not become that stereotypical engineer. (other students agree "uhhuh", "yep", etc.)"

Theme 2: Different Perspectives: the challenges and benefits of listening to, and learning from, different perspectives and different values
As students in the focus groups began to reflect on the influence of their CSL experiences regarding their future professional practice, all the participants expressed a perceived need for the practitioner to reach out to those with different ways of seeing situations. Some articulated a need to be heard:

> *"…the person you are working for who doesn't have a background in engineering needs to hear the perspective of the civil engineer … "*

Others saw the challenge as one of listening:

> *"We [civil engineers] should push our boundaries – in addition to calculations and stuff, we need to understand what people want and be able to understand the perspectives of others."*

Most students saw the challenge as a "two-way" communication issue:

> *"It's really important to share perspectives – the client needs to understand where we are coming from and we need to understand where they are coming from…"*

> *"…people from all different faculties: economics, the social sciences. Inter-faculty discussions would be good. … For example, economic students tend to not realize that there's a closed-loop. For that one reason, it's important that they interact with people from science and engineering. Engineers tend to not see some of the social side effects generally. So if we can work with social scientists we can get a broader view of things, and our decisions can be better informed. "*

> *"Other engineers, like electrical, geological, … everyone needs to work together to get the job done. It's more apparent now than before I went into civil… "*

Theme 3: Sharing expert knowledge: challenges and impacts
For the students in one of the focus groups, the discussion about perspectives naturally led them to consider the responsibilities associated with the possession of expert knowledge:

> *"Because we will have a specialized knowledge and …. The way other people, for example people in …international relations and poli sci and arts, stuff like that, and, the way they approach a problem – especially in infrastructure, it's really obvious - it's <u>very</u> different. What they're looking for and expecting, they are like our clients…, they have unreasonable expectations because they have no idea of the limitations, no framework for assessing a solution. And, a lot of times they will get, um, very defensive of that. So as engineers, we need to recognize how to interact with people that way, and how to offer constructive information and constructive solutions, without stepping on toes and without being so*

> *technical that you're offensive. You have to be able to, not dumb-down your solution, but present it to everyone. ["yes, I would agree with that". "Uh huh". And general agreement from students in the group]. And CSL is a stepping stone for that – to start learning about communicating a technical idea to someone without your expertise."*

By the end of the discussions, students began to think more about the positive impacts they could have as professional civil engineers:

> *"Before going into this course sequence, I thought the role of civil engineer was always related to BIG projects. Now, working on this small project, I can see that even this small project has a big impact on people… As engineers, we have a bigger role to make sure that the project relates to society and is not harmful."*
>
> *"Addressing environmental issues, promote education that links with community – the project was an education piece…."*
>
> *"My project will help change people's minds so that they will choose to use bikes. I think my project will touch a lot of people."*

While the three themes emerging from the focus discussions represent the voice of 9 students (i.e., 20% of cohort 4 survey respondents), they are consistent with the "hallway" discussions about CSL between students and faculty from previous cohorts that the authors have observed. In addition, the themes emerging from these focus group discussions support the findings of Sudmant et al. (2011), who report that students from across an array of faculties at the Canadian university, including the engineering school, increased self-assessed proficiencies in sustainability, interpersonal skills, leadership skills, and team-member skills, as a result of engaging in either curricular, or co-curricular, CSL activities.

DISCUSSION

This investigation is an example of classroom research designed to improve the quality of the student's education. Learning theory provides insights into the study's results, which, in turn, inform improvements to CSL activities and assignments.

Social-learning theory, as discussed by Dewey (1938), Mezirow (1991) and others (e.g. Van Wynsberghe and Andruske, 2007), explains the differences between cohorts respecting specific belief changes (see Figurse 2a and 2b). Since each CSL project is unique, with unique circumstances, and each CSL cohort consists of a different set of individuals, the social environment of each cohort necessarily differs, and the social experience, required to learn beliefs, also varies. These differences in social environments may explain the variation in cross-cohort survey results. Variation aside, the changing *trends* in belief-sets for all three cohorts can be described as (1) a change in the beliefs about the nature of civil engineering work, and (2) a change in beliefs about the potential impacts of civil engineering knowledge.

Learning theories related to belief change, also called conceptual change theories (Gregoire, 2003), further illuminate the study results. The cognitive reconstruction of knowledge model (CRKM) developed by Dole and Sinatra (1998) postulates that whether a person intentionally attends to learning a concept, depends on the learner's existing knowledge (including beliefs) and his/her motivation. Motivation is related to a combination of four factors; dissatisfaction with existing ideas, personal relevance of information, the learner's need for cognition, and social influences. The CRKM highlights the significance of motivation to learn – something that CSL may strongly influence. The students who participated in this study's focus groups experienced an array of emotional responses to CSL. Some felt frustration and even disappointment in dealing with clients. Others had similar responses to the challenge of relationship-building with teammates. Still others were delighted with over-coming these challenges and with contributing, by their efforts, to an asset-building community. All spoke about their experiences with verve, and were *motivated*. These focus group observations of the 4th cohort are congruent with informal instructor observations of previous cohorts.

The CRKM also suggests that, if the learning concepts at-hand are perceived as plausible, coherent, and comprehensible, then the learner will direct significant mental capacity toward consideration of the concepts. If consideration involves high levels of meta-cognition and self-regulation (e.g., critical thinking, knowledge integration and knowledge organization, strategic studying, and so on), then strong, long-lasting, conceptual change will occur within memory. Again, this component of the CRKM is relevant to CSL because working with clients is perceived by students as part of civil engineering work. While it is challenging to develop the skills associated with project work, students find these skills plausible, coherent, and comprehensible. Further, the learning activities associated with the CSL (e.g. reflection journaling, creating designs within a team, reporting to clients and the instructor about conceptual designs and the final design) necessitate the explaining, testing, and critiquing of their own ideas and the ideas of others. Indeed, as they were confronted with clients unlike themselves, their CSL experiences may have compelled some students to reconsider the fit of civil engineering within their notion of how society works. Dole and Sinatra (1998) suggest that the mechanism of belief construction and reconstruction is the same as other types of conceptual learning. Therefore, through stimulating emotions, requiring attentive intellectual expressions of knowledge, and eliciting meta-cognition and self-regulated learning, the CSL experiences may have strengthened and entrenched in memory the complex knowledge, including professional beliefs and attitudes, acquired by applying the processes of design and planning, and by implementing the projects. Whether this construction of beliefs is propagated into the senior undergraduate years and beyond (as suggested by Swan et al. (2009)) is an interesting question and one that is yet to be explored within the context reported here.

REFLECTIONS

Lessons learned….

Highlighting the unique social learning opportunities afforded by CSL as well as the power of CSL to support meta-cognition and self-regulated learning, suggests improvements to the learning activities and assessments required of students. It may be that the highest quality CSL is fraught with emotional experiences and that the best CSL assignments require students to test, explain, and critique both their cognitive and affective knowledge and the knowledge of others, and to synthesize, integrate, and organize the knowledge they aspire to acquire. In addition to written journals in which student reflections are triggered by questions such as "What was surprising about your CSL project experiences and why?", assignments that task students with identifying what they have learned, listening to the experience of their peers, comparing what they hear from others with their own experiences, and then synthesizing what is learned from the comparison process, may exploit the learning environments offered by CSL. For example,

- facilitated, structured, group discussions in which students compare their experiences across projects ("what have we learned that is relevant to civil engineering?"), identify similarities and differences between learning observations, and discuss the meaning of the knowledge gained from CSL experiences,
- the graphic organization of the knowledge described in the discussion groups – including identifiers of professional attitudes and beliefs,
- argumentation (Bricker and Bell, 2009) exercises that explore the relevance of CSL experiences to professional practice, and
- written summaries that synthesize the knowledge gained,

may influence the development of professional beliefs and attitudes about the role of civil engineering in society.

And questions raised …
Beliefs about the civil engineering profession, held by civil engineering students, change as the students pursue their studies. Further, there is at least informal evidence (provided in this paper) that CSL activities influence these changes. For the authors of this study, these findings lead us to ask:

- How does self-definition with civil engineering (i.e. "as a future civil engineer, how, and to what, will society allow me to contribute?") influence learning, including the construction of semantic, event, and procedural knowledge (i.e. traditional civil engineering knowledge)?
- Do meta-cognitive and self-regulation influence the learning of this traditional knowledge?
- What is best-practice assessment of student achievement in acquiring beliefs?
- If, as it is implied here and elsewhere (Lynch et al., 2009), educators should attend to the student development of professional belief-sets, how does this influence curriculum design? For example, how should affective learning outcomes be articulated? Where should affective learning objectives be placed within a curriculum such that learning is optimized? How does attending to the learning of professional beliefs influence the vertical and horizontal integration (see Hubball and Burt, 2004) of other learning throughout the curriculum?

CONCLUSION

The work reported here suggests that student engagement in meta-cognition and self-regulated learning, achieved in the unique social environments of CSL, may be the mechanisms by which civil engineering students are able to develop (and re-develop) beliefs about the role in society of their future profession. The motivation and interest in their CSL projects, expressed by students during focus group discussions, may have led to higher-order thinking, which, in turn, supported the reconstruction of beliefs about the profession. Student activities that might enhance the quality of learning within the courses described in this paper include structured discussions, graphic organizers, argumentation exercises, and written summations of the knowledge gained.

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