REVISITING TRANSFORMATIONAL LEARNING OF MILLENNIAL COLLEGE-AGE SCIENCE AND ENGINEERING STUDENTS VIA EXPERIENTIAL LEARNING COMMUNITIES

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ABSTRACT

In summers of 2010 and 2012, UNF instructors took students to the Southwestern United States to study sustainable design as part of the UNF “Transformational Learning Opportunity” program. As part of the courses, customized learning communities were created at a variety of field locations and various assessment methodologies were used to determine the level of student engagement. During the 2010 post-course assessment, a new hybridized quantitative methodology was developed called “content analysis with stance indications” to assess the degree of transformational learning that took place for each student. Based upon the 2010 course and post-course assessment, improvements were incorporated into the course design. This paper discusses the revised course design, reviews the revised course experience, and measures student engagement using an adaptation of content analysis. The paper concludes with a comparison of the novel content analysis results from the two courses.

Keywords: Sustainability, hands-on learning, learning by doing, content analysis, learning communities

OVERVIEW:

The increased production of science, technology, engineering, and mathematics (STEM) college graduates is widely regarded as critical to the national economy of the United States (Hill et al., 2010). The future workforce of the United States will be dominated by fast-growing STEM fields (Hill et al., 2010). Increasing the number of students including women and minorities into STEM will be dependent upon the ability of universities to reach out to and engage with the newest generation of students who have been called the “Millennials” (Rickes, 2009; Yale, 2010). Millennial students are generally motivated differently than their predecessors and will require educators to make significant changes in course design and teaching methodology. With this in mind, Engineering faculty at the University of North Florida (UNF) conducted several special “transformational learning opportunity (TLO)” courses in 2010 and 2012. The UNF faculty engaged undergraduate STEM students by tapping into Millennial student natural interests including civic/community involvement (Nicoletti & Merriman, 2007),
experiential or hands-on learning (Crone & MacKay, 2007; Hawtrey, 2007), and through the development of mentors and special “learning communities” (Rhoulac-Smith et al., 2008). This paper provides an updated analysis of three items published in the 2011 UNF study which discussed the 2010 TLO course (Brown et al., 2011):

- Discussion of course re-design/improvements and the new course experience;
- Discussion of additional assessment of student engagement using Content Analysis with Stance Indications; and,
- A comparison of the assessment results from the 2010 and 2012 course evaluations.

The first TLO was a 17-day course in 2010 (“course 1”) which included visits to a number of engineering project sites and national monuments/parks in the western United States:

- Glen Canyon Dam;
- Navajo Power Plant;
- Mercator Minerals Mine;
- Flagstaff Landfill;
- Walnut Canyon National Monument;
- Grand Canyon National Park;
- Petrified Forest National Park;
- Dead Horse Ranch State Park; and,
- Tuba City Disposal.

At each project site the field trip was led by the author and a subject-matter expert from a course-specific “learning community”. Outside leaders included experts from the Bureau of Reclamation, Department of Energy, State of Arizona, Salt River Project, Mercator Minerals, Museum of Northern Arizona, and the City of Flagstaff. The course included an overall design project and field laboratory exercises (Nabors et al., 2009) involving water resources, surveying, waste management, and geology.

The second TLO was a 15-day course in 2012 (“course 2”) which focused on sustainable design and energy and included visits to:

- Glen Canyon Dam;
- Navajo Power Plant;
- Mercator Minerals Mine;
- Ivanpah Solar Electric Generating System;
- Las Vegas Valley Water Authority Ops Center;
- Grand Canyon National Park;
- Zion National Park;
- Red Rock National Recreation Area (optional for recreation only); and,
- Hoover Dam overlook.
Outside leaders included experts from the Bureau of Reclamation, Bechtel Construction, Salt River Project, Mercator Minerals, Las Vegas Valley Water Authority, and Zion National Park. The course included three design projects for community partners at Zion National Park.

**COURSE RE-DESIGN/IMPROVEMENT AND NEW COURSE EXPERIENCE**

During development of course 1, an extensive literature search was conducted to evaluate the best practices to promote learning and student engagement. The best practices from the literature were compared to practices tailored to Millennial science and engineering students. Table 1 lists the final course elements adopted for use during initial course design.

![Table 1: UNF TLO Actual Design Course Elements 2010](image)

<table>
<thead>
<tr>
<th>Student Engagement</th>
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<tbody>
<tr>
<td>1. Students work in small teams.</td>
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<tr>
<td>2. Course taught cooperatively between instructor and specific learning communities</td>
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<tr>
<td>using community experts.</td>
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<thead>
<tr>
<th>Applied Engineering</th>
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<tbody>
<tr>
<td>1. Field exercises focused on common water resources and survey tasks.</td>
</tr>
<tr>
<td>2. Field visits/trips to real engineering project sites.</td>
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<table>
<thead>
<tr>
<th>Current Issues – Sustainability</th>
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<tbody>
<tr>
<td>1. Use sustainability and sustainable design issues to frame learning.</td>
</tr>
<tr>
<td>2. Have learning community experts discuss sustainability issues at their project</td>
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<tr>
<td>sites.</td>
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<tr>
<th>Location</th>
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<tbody>
<tr>
<td>1. Hold course in magnificent natural setting of the American Southwest.</td>
</tr>
<tr>
<td>2. Visit two national parks for entertainment in addition to project sites.</td>
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<table>
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<tr>
<th>Expert Interactions</th>
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<tbody>
<tr>
<td>1. Instructor to spend a substantial amount of one-on-one time with small teams.</td>
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<tr>
<td>2. Learning community experts interact directly with students during field trips.</td>
</tr>
</tbody>
</table>

Following the course experience and after completing the overall assessment, several course improvements were recommended.

**Meeting Basic Physical Needs**

Instructors must never forget that all students have other needs and stressors outside of the class environment. Therefore, consideration regarding Maslow's hierarchy of needs (Maslow, 1943) should be significant in the overall course layout. Shoura & Singh (1998) reiterated the overall importance of these considerations to the engineering profession. Their conclusion that professional engineers must have basic physical and social needs met before they can effectively perform higher level job functions is consistent with the authors’ findings and
observations on student learning experiences during course 1. Considerations regarding travel distances and time; meal distribution and timing; bathroom breaks while traveling; and, private time for individual reflection are very important to ensure a successful field course. For course 2, a new base camp was chosen in Las Vegas, Nevada which shortened the driving time for field trips due to its centralized location versus the field trip sites. The shorter drive times improved student attention at the project sites and allowed further individual time for student reflection (Walker, 2005).

Physical Setting
One of the key lessons learned is the importance of considering the various elements that impact the effectiveness of individual learning spaces and learning communities. These considerations are supported by Kolb’s research on learning space (Kolb, 1984; Kolb & Kolb, 2009). A university campus was chosen as the base camp for course 1. The location had a number of limitations including Spartan accommodations, poor Internet access and a restricted menu. For the Millennial students, these issues presented a significant distraction from the learning opportunities in the course. Disconnection from the Internet was particularly disconcerting and disorienting leading to distraction and dissatisfaction with the learning space. The base camp location in course 2 was a major hotel chain in Las Vegas. Students resided in a hotel suite with a full kitchen and high-speed wireless Internet. Students did their own grocery shopping and cooking and were fully connected to the Internet. Each learning team lived in a single suite, allowing significant opportunity for socializing and discussion of the course material. These accommodations resulted in significantly happier students who jumped out of bed each morning, with a high enthusiasm for learning new ideas.

Personal Reflection
An important outcome from the course 1 assessment was that students felt the course was “too packed” and did not allow for enough individual downtime for students. Downtime was important since students were tasked with homework during the course as well as keeping daily journals. For course 2, one field trip was deleted from the schedule and replaced with a free day for students to catch up on course work or just relax and recharge. Some students used the extra free day to explore natural areas outside of Las Vegas while others simply completed their homework while relaxing at the hotel pool. Overall the additional downtime permitted the students to move through Kolb’s learning cycle (Kolb, 1984) and to process their field experiences using written reflection in their journals (Walker, 2005).

Addition of Design Focus
Another course improvement made for course 2 was the addition of team engineering design projects supporting a community partner in the region where the TLO course was planned. UNF partnered with Xanterra Parks & Resorts Inc., the primary service company at Zion National Park, and Zion National Park staff on two sustainable engineering design projects. The two UNF teams worked on the design of a “zero waste composting facility” and net-metering for onsite Zion buildings. These projects were successful, with the industry partners
very satisfied with the proposed student designs. In addition, as a donation to the industry partners, the TLO class collaborated to design and construct two portable, solar-powered cellular phone charging stations. These were donated to Xanterra and Zion park staff for use by maintenance personnel. The design projects in course 2 supplanted the field labs completed during course 1. Overall this change was embraced by the engineering students who exhibited great pride in their design efforts.

Additional Assessment of Student Engagement using Content Analysis with Stance Indications

Following the completion of course 2, additional assessment of student engagement was undertaken using the approach outlined in Brown et al. (2011). The approach is a hybrid version of traditional Content or Context Analysis. Content analysis and similar analogues were originally developed in the 1960s (Janis, 1965; Stone et al. 1966) and subsequently refined by Krippendorff (1980) into a well-accepted technique to objectively make inferences and draw conclusions from written text. General content analysis is fairly broad and ranges from simply counting frequency of occurrence of certain words or themes to making inferences of underlying meaning of sentences or paragraphs. Brown et al. (2011) used both word frequency and coder interpretation to determine the degree of student engagement from personal student journals. The journal information was stripped of all personal information prior to use and then was processed for assessment purposes. The analysis methodology was coined “content analysis with stance indications”. The personal journals provided the most complete understanding of overall student engagement and personal transformation. Both Walker (2005) and Lowe et al. (2007) argue that reflection or personal debriefing can move students through Kolb’s learning cycle. More recent literature also demonstrates the continuing value of various forms of content analysis (Mason & Davis, 2007; Jones & Kayongo, 2008).

The methodology is a computer-assisted quantitative technique to determine student feelings or intentions regarding four separate thematic areas. The four themes that were the focus of the 2010 study and this new study of the 2012 course include:

- Students engaged by place;
- Students engaged by learning community;
- Students engaged by course or course content; and,
- Other, which are things affected by non-academic needs or meeting basic human needs/requirements.

The reader is referred to the original paper by Brown et al. (2011) for a detailed description of the actual methodology logistics.

The new 2012 data set included personal journals from eight students submitted electronically as part of the course requirements. The journals contained over 27,000 words and varied in level of detail as well as writing style. Then, keywords were identified that described student
experiences. The keywords included adjectives (e.g. awesome,), verbs (e.g., learn, know, comprehend), adverbs (e.g., quickly), and other (e.g., not, don’t, again). For this study, the data unit selected was individual words and word groups (e.g., good, great, best or do, doing, done). Out of the approximately 27,000 words, about 225 word samples/keywords (or about 1%) were selected for further analysis and coding. Out of the 225 words, several were combined or eliminated as part of data recording. In addition, each word or word group was counted to determine frequency of occurrence. This was accomplished using the Microsoft Wordtm “find” function which also permits word counting to be completed automatically. The revised word list was sorted by frequency of occurrence and as part of data reduction, only word/word groups that appeared more than nine times were carried forward in the analysis. Using this filter, 44 word or word groups were used for the final content analysis for this study. This total was comparable to the 2010 assessment where 62 word or word groups were utilized. After assembling matrices and data sheets for two coders, the coders segregated the 44 word or word groups into one of the four engagement themes for the course.

A key element of the coding segment of content analysis is data comparison and replication. For this project, two separate coders completed the content analysis with stance indications. Table 2 provides a comparison of the agreement between the scoring sheets from the two coders. The table presents the final results of the two coders by revealing the percentage of content scores that were the same for each thematic region. Generally the results indicate that the agreement was fair to good between the two coder score sheets, however, improvements to the overall methodology should again be implemented to increase the level of agreement. The overall agreement between the coders was lower for the 2012 assessment than the 2010 evaluation. A discussion for some of the differences is provided below.

<table>
<thead>
<tr>
<th>Course Assessment</th>
<th>Students engaged by place</th>
<th>Students engaged by learning community</th>
<th>Students engaged by course or course content</th>
<th>Other – Nonacademic needs</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>84%</td>
<td>84%</td>
<td>77%</td>
<td>85%</td>
</tr>
<tr>
<td>2012</td>
<td>61%</td>
<td>66%</td>
<td>89%</td>
<td>48%</td>
</tr>
</tbody>
</table>

**Comparison of the 2010 and 2012 Assessment Results**

Overall the use of content analysis with stance indications provides a good method to assess student engagement for field courses. The technique provides an objective way to make deeper inferences of student written artifacts such as daily journals. It also provides valuable feedback for future course improvement efforts. In comparing the 2010 and 2012 assessment efforts, seven out of eight themes over two cycles provided coder agreement of greater than
60%. This is certainly significantly better than pure chance. In discussions with each of the coders, there were some differences in understanding when to score a word or word set belonged in the “other” thematic region. One coder concluded this was only a minor theme in overall student engagement while the other coder felt it was more important. Also, the “other” category can lead to some confusion for the coders. One of the coders had several scores that were “ties” between the other category and one of the other three categories. This indicates that this category may have to be better described and attributed in order for coders to properly employ it. In reviewing the individual coder results, it is clear that better correlation of scoring would probably result from refinement of the “other” theme definition.

In reviewing the overall importance of each theme, the content analysis with stance indications revealed that students were transformed mostly by the learning community at each site (Table 3). The quantitative data indicate that on average 38% of the key words used in the analysis were scored in the “engaged by learning community” thematic region. This was followed by “other” with 31% of the key words. The “engaged by place” theme scored at approximately 26%. The “engaged by the course” had the lowest score at approximately 6%. In the 2010 assessment, the engaged by course theme also scored the lowest score. In 2010 the highest scoring theme was “engaged by place” while “engaged by learning community” rated second, tied with “other”. Table 3 provides a direct comparison between the two course assessments.

<table>
<thead>
<tr>
<th>Course Assessment</th>
<th>Students engaged by place</th>
<th>Students engaged by learning community</th>
<th>Students engaged by course or course content</th>
<th>Other – Nonacademic needs</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>37%</td>
<td>22.5%</td>
<td>18%</td>
<td>22.5%</td>
</tr>
<tr>
<td>2012</td>
<td>26%</td>
<td>38%</td>
<td>6%</td>
<td>31%</td>
</tr>
</tbody>
</table>

**RESEARCH LIMITATIONS**

The proposed hybridized methodology appears useful to assess written student artifacts but does appear to suffer from some limitations. Similar to shortcomings of the 2010 assessment effort, for the 2012 course, only 8 student journals were used to develop the initial word screening list. A larger student group would provide more definitive results and perhaps a wider variety of words to use in the quantitative analysis. Second, the composition of the students was not a mix of STEM majors, it only included engineering students. This class demographic could lead to bias in the journals and therefore in the quantitative analysis. Third, the coding method did not consider any additional demographics such as student gender or age. Lastly, the actual coding activity is somewhat subjective since using humans to determine the stance may not be perfect. This is reinforced by the coder actions themselves. The
interpretation of words or word groups that may fall into the “other” category was inconsistent between the two coders possibly skewing the results for the 2012 assessment effort. The assumption of the authors is that humans can do a better job attributing stance than a comparable computer algorithm; perhaps this is not true. In the future, the research team would like to investigate this hypothesis further.

DISCUSSIONS AND CONCLUSION

The degree of the transformational learning was measured using a quantitative analysis methodology developed from student journals for two separate away courses. The new methodology provided a better understanding of the critical thinking skills and deeper learning gains achieved by the students. Overall, the 2012 summer TLO course was a great success. The students learned a substantial amount about sustainable design as well as the natural environment in the American Southwest. The students were transformed by the course through immersion in the amazing landscapes along with the interaction with the learning community at each field site. Quantitative analysis of student journals concluded that the most important learning theme for the 2012 course was the impact of the “learning community” itself. In 2010 the “place” was ranked as the most important theme. Prior to both courses, the faculty team anticipated that the place and learning communities would impact the students at the highest level. This was confirmed through the assessment process.

REFERENCES


