

Work in Progress: Assessing Change in Students' Value-Based Decision Making, through Case Study Analysis

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Abstract: This project was intended for the Integrative Design Studios (IDS), the mandatory design spine course for students in the Bachelor of Science in Engineering (BSE). An active research agenda was to answer the question: “How do students’ ability to engage in ethical behavior in design and problem solving change throughout the Integrative Design Studio (IDS) courses; before and after ethics lessons/activities (E/LA)?” Assessment from this iteration will be used to work on other E/LA in IDS and beyond. The E L/A was to fulfill the learning objective: to appraise the ethical implications of the products of the design process and employ social justice and ethical considerations in proposed solutions. Students reviewed a hypothetical case study in the beginning of the semester and were asked to evaluate ethical dimensions of the case. During the semester there were short learning modules (ethics insertions) related to value-based decision making. At the end of the semester students reviewed the hypothetical case study again and were asked to answer the same questions plus an additional question to further describe their approach. Hence the authors will report change in students’ perspective, through their responses to the case study, which were presented before and after the ethics insertions. As a team, students were also asked to apply what they had learned in value-based decision making in the final report on their respective engineering design projects. The Daniels Fund supports integration of ethics in our Mines engineering education curriculum. This project is a Daniels Fund initiative, since a couple of the authors have earned fellowships to participate in this endeavor.

INTRODUCTION

As part of the commitment to the Daniels Fund at the Colorado School of Mines, a cohort of faculty began to work on integrating ethics in our existing engineering curriculum [1]. One of the authors of this paper, Mirna Mattjik, worked on an ethics module for the Integrative Design Studios (IDS) course, whose instructor on record is Robin Bullock; the course is offered in the Engineering, Design, and Society Division [2]. Because of her experience integrating ethics in the First-year honors curriculum as a faculty fellow for the Daniels Fund, Toni Lefton is peer advisor to Mirna Mattjik; especially in respect to development of the module. The project is a collaborative effort with other parties beyond the Daniels cohort, including a senior assessment specialist in the Trefny Innovative Instruction Center, Megan Sanders [3]. There are also two McBride Honors [4] students involved as data reviewers, they are: Lazlo Stepback and Connor Smith.

IDS is the mandatory design spine course for students in the Bachelor of Science in Engineering (BSE). The purpose of the ethics module in IDS is to fulfill the learning objective: *to appraise the ethical implications of the products of the design process and employ social justice and ethical considerations in proposed solutions*. The general approach involves lessons/activities that provide gradual approaches to design and solving problems ethically. The active research agenda is to answer the question: “How do students’ *ability to engage in* ethical behavior in design and problem solving change throughout the Integrative Design Studio (IDS) courses; before and after E/LA?” Assessment from this iteration will be used to work on other E/LA in IDS and beyond.

CONTEXT AND BACKGROUND

Fall 2018 semester marked the inaugural IDS course; because of low enrollment, the class ran with second and third year students combined with the traditional second year design course at Mines. The assumed baseline for ethics in the IDS course is knowledge of ethical theory - which are learning outcomes in a required freshmen course titled Nature and Human Values that all Mines students have to take. In order to integrate ethics across the curriculum, students need continued exposure to real world problems that require more than an engineering solution. Mary Gentile in “Giving Voice to Values” suggests ethical problems today are complex in nature; hence the more tools given to understand/clarify values and articulate a position on an ethical dilemma, the better prepared students will be when put in this situation [5]. Therefore in IDS, EL/A is geared towards behavioral ethics or a suggestive critical view on values.

The EL/A is based on a hypothetical case study with an ethical dimension; the bookend activities of the semester consist of pre and post-survey on this case study. In between there are two short learning modules (ethics insertions) embedded in the design curriculum; these are tools that potentially allow students to make constructed value-based judgement on the case study. In July 2018, the Daniels Fund provided training for ethics integration in the engineering curriculum where considerations of ethics insertions were presented by Michael Davis, Senior Fellow at the Center for the Study of Ethics in the Professions and Professor of Philosophy,

Illinois Institute of Technology, Chicago. Davis suggests categories as a way to make clear distinctions on the purpose of these ethics lessons/activities; whether it is to raise ethical sensitivity (S), enhance ethical knowledge (K), improve ethical judgments (J), and/or increase ethical commitment (C) [6]. These categories are the basis of our analysis; especially whether the ethics insertions between the bookend activities had impacted change in students' responses on the survey.

While the training referenced above focused on professional ethics, this study focused on value-based judgement, which can be a challenge for students to think outside of their intuition as budding engineers. Inherent values in the engineering profession according to Ferguson, quoted by Davis are: (1) strive for efficiency, (2) design labor-saving systems, (3) design control into the system, (4) favor the very large, the very powerful, or the very small, and (5) tend to treat engineering as an end in itself rather than a means to satisfying human need [7]. Hence, with ethics insertions such as "Listening to Learn" and "Values & Persona Sketches" and a case study based on complications of mining engineering operations in Chile, the E/LA calls for additional values considered in decision making for engineers. To provide more context, faculty members from Pontifical Catholic University of Chile, Santiago were invited for an interview through Skype for Listening to Learn. Also, Chilean students at Mines were invited as discussants and source of reference for the Values & Persona Sketches lesson.

RESEARCH METHODOLOGY

It was important to establish rigorous and dependable rubrics for the case study responses, as a tool to review the data objectively. We had assigned data review to our two Honors students and had a couple of faculty as guide for generating the rubric and data interpretation. Conclusions to date is gathered by faculty and presented in the results below. This subset of our research team discussed different levels of performance on the three categories (sensitivity, knowledge, and judgment) and created rubric categories to reflect those levels of mastery for each of the first three questions in the survey. The case study and pre/post questions are included in Appendix A.

To eliminate any potential biases, students' pre and post responses to the case study questions were assigned a random number by a member of the research team not involved in the scoring. The responses were then reordered according to the randomly assigned numbers, effectively shuffling and blinding the pre-post responses.

To test the rubric, three members of the research team scored these blinded, shuffled responses. To further norm the use of the rubric, the three individually scored and then discussed their scores for the first five responses, coming to consensus.

The two data reviewers have individually scored the remaining responses. Scores from these two team members are compared in order to compute percentage agreement and to begin establishing the reliability of the rubrics [8]. Any points of disagreement were resolved through discussion. Data interpretation to date is discussed in the temporary results below. Next steps will involve review of question 4 or 5, which was intentionally taken out in the first round of data review.

RESULTS AND DISCUSSION

By time this paper was due, the research team was in the middle of data review; hence the work is still in progress. We have discussed results based on the first round of data review. Scores on case study responses were unshuffled and pre and post scores were compared for each participant. On the overall score, the average score increased from pre to post by 0.71 (pre = 1.26, post=1.97). We then broke down the scores by category; scores on sensitivity and knowledge were combined because the two were also combined on the rubric categories for two of the three questions. When broken down by category, there was a slightly higher increase in average judgment scores (change = .78; pre = 1.20, post = 1.98) than on the average sensitivity and knowledge scores (change = .67; pre=1.31, post=1.97).

Referencing the fact our focus is more on value-based judgement or applied ethics, it is important to note our interpretation of these categories. Sensitivity and knowledge are categories we found hard to separate when analyzing the responses, especially for questions 1 and 3. With reasoning that values, culture and context should be interconnected in the responses, we decided to combine them. In hindsight, we agreed this was done correctly. Question 2 was the only one we wanted for students to recognize the importance of environmental regulations for knowledge sake. Judgement was an important category to stand alone, because we wanted to discern student's reasoning in making the decisions. There are many interesting trends and nuances in the data to uncover, though in interest of succinctness for this paper, we chose the following to highlight.

An exemplary response for judgement on question 1, post survey:

“I think that COLDECO should be held responsible for payment. Though they claim to operate as a private company, the truth is that they have government ties. Since problems began, COLDECO has only done the minimum of what is required of them, which has led to more problems. I believe that this negligence on COLDECO's part and that this company, which has deep roots in Chile's history and current society, should be responsible for funding the rebuilding of the dam.” – This student had a .57 change in their average pre/post survey, with change of average judgement scores of .67 (below average).

An exemplary response for judgement on question 3, post survey:

“After talking with the Chilean students, I learned that they are hesitant to let in US intervention, after past occurrences. I also learned that family and national pride are large factors in the decisions. This makes the decisions difficult as I initially favored the US firm that has access to the capital and latest technology to do the job well. However, I am unsure if the Chileans would trust the US firm, so this may not be the best option. Although family ties are strong, I do not think that the inexperienced son of the mayor should get the job. This leaves my recommendation, which would be COLDECO.” – This student had a 1.71 change in their overall average pre/post survey, with change of average judgement scores of 2.33 (above average); change in question 3 was 3 points higher in the post survey for all categories.

An exemplary result for judgement on question 2, post survey:

“I would definitely consider implementing the foreign standard. The only reason not to would be that it could require more money to be spent up front for safer dams and other infrastructure, but that would only save the company and government money in the future, while also preventing the harmful substances from harming the public. Had a stricter standard been enforced when the tailings dam and diversions canal were built the first time, it may have prevented the need to repair it now, as well as the contamination of Ciudad Portuaria’s domestic water.” – This student had a 1.57 change in their overall average pre/post survey, with change of average judgement scores of 1.33; though change in question 2 alone was 3 points higher in the post survey for all categories.

Empirically we can see positive change in the categories, from pre to post survey. Though there a couple outliers that had gone the reverse direction. To date, no statistical analysis has been done, but it is reassuring that the answers grew in understanding values, culture, and context. Initially the contact with people from the area were through an online conference; the lesson, “Listen to Learn”, was intended for students to practice listening as a tool for inquiry. However the in-person contact, when working on the “Values & Persona Sketches” had helped students further develop understanding of the values, culture, and context, based on what we saw in the responses. It is important to note, the latter lesson was initiated by reflecting on their individual values. Hence, some responses would elude to what they (the student) prefer but still bearing in mind what the actors in the scenario prefers, given their values and culture. We did not have time to offer more learning discussions in developing skills for giving voice to values, prescribed by Gentile, so it was done in a flipped mode of delivery [5]. But these specific responses are indicative of awareness toward this practice. We might a different mode of delivery and/or discussion time for the next round of implementation.

Questions 1 to 3 of the case study gives students a platform to play scenarios in their minds about who shall pay, or who is responsible, or who are the actors, and why. We assume that question number 5 will provide further insights about how they made the decision; and this is yet to be explored. Also yet to be uncovered is the section in their final reports that speak to value-based judgement, in discerning level of learning mastery. In fact, this might provide challenge to the “inherent values in the engineering profession” as quoted by Davis [7]. We plan to have E/LA implemented once more in the EDNS291/391 course for Fall 2019, which will add to our data set for research.

CONCLUSION

The EL/A was implemented in the EDNS291/391 course during the Fall 2018 semester. Our research is still work in progress, though empirical data shows there are positive changes in the average scores from pre to post survey results in all categories. The categories are “Sensitivity, Knowledge and Judgement” of value-based decision making. More research is needed, especially to incorporate survey results on how students made the decisions (question 5). Another round of implementation will be done in the Fall 2019 semester in EDNS291/391. Through this first try we have established procedure to work on the research going forward.

Works Cited

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APPENDIX A

Well, I'll Be "Dam": A case of tailings mismanagement*

The Salado River in Chile continues to receive effluent tailings from the mineral-processing plant of the *El Salvador* mine, owned by the National Copper Corporation of Chile, COLDECO. In 1938 the mine was owned by a US firm that had filled the El Salvador tailings dam, and openly let effluent tailings into the Salado River. Under COLDECO's ownership in 1975 a canal was built to divert river water, including the tailings, into Calita Palitos bay which caused similar embankment issues. By 1989, these practices led to dumping of 330 x 10⁶ tonne of tailings into the river and the canal. Finally, the Chilean Supreme Court ordered COLDECO to build another tailings dam. This was instigated by Chanaral, an environmental group who took COLDECO to the Copiapo court in the late 1980-s. This case was unprecedented as practice of environmental policies were not historically strict, however due to ratification from the Chilean Supreme Court, it had set Chile to a different direction. In January 1994 Chilean Congress approved an environmental framework legislation, among the laws were new design concepts for tailings dams.

Fast forward to present day, COLDECO has established a symbol of national pride for Chile, but the tailings dam built for the El Salvador mine after the Supreme Court order is at 45 percent water recovery. When the new design concepts were proposed, it was too late to make any adjustments. However, reports from city officials show alarming levels of acid in the domestic waters in "Ciudad Portuaria", one of the port cities who receives their domestic water from Salado River. Thus the tailings dam is due for repair/rebuild/relocation, and an international call for bids have been initiated by COLDECO. Though stakeholders such as the artisanal miners downstream will also be affected, as they depend their livelihood on mining the existing copper that is left in the tailings.

Knowing the landscape decades ago, and in an effort to make amends, the civil arm of the US firm which formerly owned the mining company is interested in placing a bid; hoping to utilize and test new technology. "Presa Moderna" a local civil construction company owned by the son of Ciudad Portuaria's mayor, is also interested; though they have only been in business for less than 5 years. The government contractor that worked on the tailings dam post Supreme Court order has a lot of knowledge and experience in the environmental framework legislation, but they are lacking employees that have the entrepreneurial spirit to venture such a politicized proposal.

The city of "Ciudad Portuaria" is threatening to bring COLDECO to court again, if the issue of acid in their domestic waters is not resolved within a year. Ciudad Portuaria's mayor is a former member of Chanaral. You are the project manager tasked to make recommendations on this tailings dam. Considering all that are impacted and based on the knowledge you have, answer the following questions as best as you can.

*Inspired by true events -- Source: Warhurst, A. (1999) "Mining and the Environment: Case Studies of the Americas" for historical background and fictional case for current events

Questions

1. COLDECO is a national company, though operates as a private company. Capital expenditure like building a dam are covered through reinvestments or selling bonds, etc. Depending on the damages, COLDECO might need to fundraise more for the bid. Keeping all stakeholders' interest in mind, who should pay for the extra funds to repair/rebuild/relocation of the tailings dam, and provide reasoning for your answer?

2. Other foreign natural resource companies operating in Chile meet a certain environmental standard they abide by, which goes over and beyond the government's environmental legislation framework. To avoid future damages of the tailings dam, and/or to maintain its efficiency, would you consider using this foreign environmental standard (see sample of this below)? Why or why not?
3. Among the three companies in the narrative above who are involved in the bidding competition, which do you favor and why?

Answer one of the following questions thoroughly (Added for Post Survey):

4. The following bullet points are new design concepts for tailings dam that was proposed in 1994. You have seen most preliminary attempt to reach these goals have been done, but the problem is follow through and maintenance. What would be your idea for a maintenance plan? How would you propose this to COLDECO's management?
 - o The dam must be located where there is little likelihood of being affected by flooding;
 - o Any water eventually filtering from the dam should not pollute the groundwater;
 - o The dam should be located where there is little risk of earthquakes;
 - o Water from the dam should be channeled to agricultural or forest soils or to waterways able to withstand effluent without the quality of their water being affected; and
 - o The company should have plans to reclaim the land after the mine is abandoned.
5. Explain the decision making process above in #3, describe the steps as if you were to apply this process again and/or for someone else to replicate the steps. If you are applying a certain framework, approach, and/or theory/code of ethics, in addition to your own, please cite it in your explanation.

Additional reference:

EXXON's Environmental Policy Implemented in Chile

- To comply with environmental regulations or, if such regulations do not exist, to apply responsible standards;
- To prevent incidents and to design, run, and maintain installations with this purpose;
- To react quickly and effectively to incidents resulting from mining operations;
- To promote the development of appropriate environmental laws and regulations;
- To carry out and promote research on the impacts of operations on the environment, to improve environmental-protection methods, and to increase the capacity to make operations and products compatible with the environment; and
- To audit operations to ensure they comply with this environmental policy.