Creating a Significant Learning Experience through a Real-Life Design Project

Capstone Project for the Faculty Teaching Certificate Program

by

Deborah K. Nykanen, Ph.D., P.E.

Minnesota State University, Mankato
Department of Mechanical & Civil Engineering

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This project was motivated by our FTCP session on “Integrated Course Design: Creating Significant Learning Experiences”. At the beginning of the session, Dr. Ross asked us to participate in what he called a Dreaming Exercise. We were asked to imagine that we had a perfect class and then answer the question: If you had a class that could learn everything you want them to learn, what would that be? What would you want them to be able to do a year after graduation because they were in your class? My mind drifted to CIVE350 (Hydraulics and Hydrology), a required course for our Civil Engineering majors that I teach every spring. The dream that I wrote down was:

*A year after graduation, I would want them to be able to set-up a watershed model for a project their company is working on and be able to understand all the components and data required for the model. I would want them to be able to design a detention pond or a culvert for that watershed.*

During the session, we discussed situational factors, criteria for good course design, and how to formulate significant learning goals. In the past, I have found that significant learning happens in my courses when I integrate the introduction of new concepts with real life applications and/or visual demonstrations of these concepts. The session on integrated course design took that idea one-step further with Fink’s Taxonomy of Significant Learning which highlights six kinds of learning shown in Figure 1. In the past, I have focused on the *Fundamental Knowledge* and *Application* pieces of the pie, with some attempts at *Learning How to Learn* and *Integration*. As shown in Figure 2, it is when these different types of learning interact that significant learning happens at a deeper level.

For the past several years, I have been loosely implementing the ideas of Fink’s Taxonomy in my courses through open-ended design projects. The students are given an application-based problem that integrates the fundamental knowledge they have gained over several different topics in the course. However, the design projects have typically been made-up problems with my best attempts to make them typical of real-life situations. I left the FTCP session with a strengthened resolved, that although the visual demonstration, photos of real-life applications and the design projects are good, they are not enough to ensure that significant learning is really
achieved in my courses. I can not assume that Learning How to Learn will fall out naturally from this process and that the students are really developing critical thinking skills. I was motivated to think more deeply about Fink’s Taxonomy and what Dr. Ross called Holistic Active Learning which combines information and ideas (new concepts) with experience (observing or doing) followed by reflection (writing). How can I be assured that my dream of the perfect student for CIVE350 being able to develop a watershed model and design a detention pond or culvert in a real-life application where there are not spoon-fed all the background data and information required for the various components?

It was April, about a month after the FTCP session, and it was time to start putting together the HydroCAD® design project for the CIVE350 class. HydroCAD® is watershed software package typically used by consulting engineering firms for storm water management and detention pond design. For the past couple years, I have given the class a design project intended to give them experience in HydroCAD® and in modeling a detention pond for a watershed. However, these have typically been artificial projects with most the required input data for the model given in the assignment. I wanted this year’s project to be different – designed with significant learning at the intersection of the different areas of learning (see Figure 2) as the primary goal, rather than simply exposure to a software package as the goal. I was driving west on Hwy 14 from Mankato towards home. I had seen the development south of Hwy 14 and just east of CR-41 progressing over the past couple years, but on this particular drive home I saw it from a new perspective. They were building a detention pond at the site, and there were large concrete pipes sitting on the ground waiting to be installed for conveying the development’s storm water. I started brainstorming on how I could develop this year’s HydroCAD® project based on this real-life application that was local to the students.
The goal was significant learning and integration of all six of the different areas into the project. Table 1 lists the six areas of learning and how this real-life design project achieved them. Some of them were specifically built into the assignment, and some of them (e.g., Human Dimension and Caring) were a fortunate by-product of the students digging for the information required to complete the assignment.

Holistic Active Learning was also achieved through the project by combining information and ideas (new topics learned in the course) with experience (observing a real-life application in the local area) and then reflection by writing a report on the project which summarized their detention pond design and how it meet the required constraints and performance goals. The project was presented to the students as a letter from a client explaining the project, permit regulations, and performance goals (see Appendix). The students were required to write a 1~2 page response letter to the client and also submit a written report including: cover page; table of contents; restatement of the problem and objectives; discussion of pre- and post-development hydrology of the area; recommended location, size, and construction detail for their detention ponds and outlet structures; detail on connection of pond outlets to the city’s storm sewer or natural stream at the bottom of the ravine; discussion and documentation on how the MPCA permit requirements were met; performance of the detention ponds to the 50-year and 100-year storms; and citation of references used. This written report was critical to the integration of the various areas of significant learning that were taking place in the project. It was also important to developing their skills in writing professional documents and reflecting on the design process.

Overall, the project was successful in achieving significant learning. The Dreaming Exercise posed by Dr. Ross at the FTCP session helped me to articulate one of the goals of my course and motivated me to think about what is really needed to achieve the desired outcome. The local, real-life application that allowed the students to visit the site and experience first-hand the types of information and data that need to be collected and design decisions they will be required to make as engineers helped motivate the students’ interest and develop their critical thinking skills. Changes that I will make to the project in future semester will be to require the students to search out the MPCA permit regulations on detention pond design rather than providing that information in the assignment and also to shift the project due date to 1~2 weeks before the end of the semester (rather than the last day of class) so that there is time to return the graded projects and discuss them in class. I also think it would be beneficial to require a short (5-10 minute) presentation by each group to help them develop their presentation skills.
Table 1. Fink’s Taxonomy of Significant Learning applied to the Detention Pond Design Project

<table>
<thead>
<tr>
<th>Learning Goal</th>
<th>How it was achieved</th>
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<tr>
<td>Fundamental Knowledge</td>
<td>The students used fundamental knowledge from several different topics covered over 7 weeks of the semester including: design storms, drainage basins, unit hydrographs (developing rainfall-runoff relationships for a watershed), detention pond design, and flow routing through detention ponds.</td>
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<tr>
<td>Application</td>
<td>The students were required to apply the fundamental knowledge to a real-life design project in the local area. They were supplied with a location map, aerial photos and topographic map of the development area. The background data and information on the watershed was not given, which made it necessary for the students to go to the site and walk around to record observed data and make decisions on the best location for the detention ponds. They also needed to contact the city or local consulting firms to obtain additional information on the storm sewer system in the area. They gained experience with HydroCAD®, which is a software package commonly used by in the industry for studying watersheds and designing detention ponds for storm water management.</td>
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<tr>
<td>Integration</td>
<td>The project required the integration of fundamental knowledge in a variety of topics listed above into a real-life situation. They were also required to meet various constraints on their design imposed by permit regulations and achieve performance goals for their detention pond design. Meeting the constraints and performance goals required an iterative approach to solving the project. They would make design decisions, develop their model, and then run it to see the effects of their decisions on the pond performance. They modified their design and model until all the constraints and minimum performance goals were achieved. They also needed to consider the downstream impact of the discharge from their ponds and protect against stream erosion.</td>
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<td>Learning How to Learn</td>
<td>Since the project was open-ended and the background information on the watershed was not supplied, students needed to discover what data they needed to collect in order to build their model and decisions they had to make in order to located and design their detention ponds. Several of the groups went back to the site multiple times as they discovered they needed additional observed information. Since one detention pond was currently under construction at the site, they were able to observe first-hand what a detention pond and its outlets look like before it is filled with water. Some groups also took the initiative to contact the consulting engineering firm responsible for the design of that pond in order to gain additional information on typical pond design. This process of self-discovery of information, applying and integrating knowledge from various topics, making their own design decisions and modeling the effects of these decisions develops critical thinking skills.</td>
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<td>Human Dimension</td>
<td>Since the detention ponds will be placed in a residential development, they needed to consider the human dimension in determining the locations of their detention ponds and what the effects would be if a storm larger than the design criteria of their pond were to occur. To minimize flooding of homes, many of the groups recommended that parks and recreational areas be located next to their detention ponds. The students worked in teams of three. As the instructor, I assigned groups with the specific intent of forming teams with students that don’t typically hang out together. I explained to the students that my motivation for doing this was to help them learn how to work with different people. In the workplace, they will have to work on teams with people that they may not know very well or that they may not get along with. The dynamics of overcoming these personality differences and working effectively as a team is an important skill that their employers will expect from them.</td>
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<tr>
<td>Caring</td>
<td>This learning goal was the one that I was unsure how it would be achieved by the project. However, I was very pleased with the by-product that it was met through the students own initiative and developed interest in the project. Some of the groups talked to local residents on their site visit and discovered their concern of erosion. The residents commented on their concerns about ongoing erosion in the ravine from storm water runoff. Several of the groups discussed this in their project report and recommended various erosion control measures to protect the ravine. Several of the students also commented to me on how this project has changed their perspective of detention ponds. As they drive around, they are constantly noticing all the detention ponds in the area and thinking about how the pond and its outlets are designed.</td>
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Appendix A

Design Project Handout
Dear Hydrology Consultant,

ABC Developers have purchased farmland to the west of North Mankato and are planning a two phase development project. An aerial photo with the location of the two phases denoted is attached. The MPCA requirements state that if more than 1 acre of land is disturbed and converted into impervious surface, that we are required to build detention ponds to treat the water before releasing it into the natural surface water or City storm sewer system. We will be developing over 150 acres, thus we will need an extensive detention pond system for stormwater management in the development.

Both phases will be residential districts. Phase 1 will be 20% townhomes, 75% ¼-acre residential lots, and 5% parks. Phase 2 will be 45% ½-acre residential lots, 50% 1-acre residential, and 5% parks. You may use the attached maps and other resources available to estimate areas, elevations and slopes for the development.

We request that you design a system of detention ponds (one or more) for each phase of the project. We have received permits from MPCA and the City of North Mankato to discharge from our ponds into the stream at the bottom of the ravine (on either side of the development) or into the City storm sewer system. However, our permit restricts us to releasing no more than 20 cfs from Phase 1 and 20 cfs from Phase 2 for a 24-hour, 50-year storm. This is the combined total from all detention ponds in each development phase area. The pond is also required to not overtop during the 24-hour, 100-year storm, and we are required to report our outlet discharge and pond elevations for this design storm. The MPCA permit requires side slopes of no more than 1:3 in the permanent pool (dead storage, below primary outlet) and 1:10 in the live storage (above primary outlet). We are also required to have a depth of 4 – 10 ft in our permanent pool.

Please provide us with the location, size, and construction detail (geometry and elevations) for all ponds and outlet structures. For the outlet structure, we also need you to specify how the primary outlet will connect to the city storm sewer or the natural stream at the bottom of the ravine. For erosion purposes, we are not allowed to free discharge from our outlet at the top of the ravine and allow the water to flow naturally down the ravine slope. The outlet pipe must by buried and connect the detention pond to the bottom of the ravine so that it will exit the pipe and flow directly into the natural stream bed.

Sincerely,

Bob Jones
President, ABC Developers
Design Project Guidelines

You will work in teams of 3 students per team. Teams will be assigned.

Deliverables:

♦ Formal response letter (typed) to the client summarizing your design recommendations and referencing the written report for further details. In the response letter, include answers to the client’s questions and highlight your recommendations. (Approximate length is 2 pages.)

♦ Written report
The written report must be typed. All graphs must be drawn using computer software. When presenting your results, choose graphs over tables. A plot of a hydrograph is easier to interpret than a table of runoff vs. time.

The report must include:
→ Cover page and table of contents.
→ Restatement of the problem and objectives.
→ Discussion of pre- and post-development hydrology of the area
→ Recommended location, size, and construction detail (geometry and elevations) for all ponds and outlet structures. Provide detail on connection of outlet to city storm sewer or natural stream at the bottom of the ravine.
→ Discussion and documentation on how the MPCA permit requirement were met.
→ Response of the detention ponds to the 50-year and 100-year storms.
→ HydroCAD solution to the project, include routing diagrams, graphs and tables of results. (Use tables only when you cannot display the data with a figure. For figures, click on the “2D” button.)
→ References (if any).

Note that a portion of your grade will be based on correct use of grammar and spelling, so make sure you PROOF READ your report.

♦ HydroCAD project file saved into D2L Dropbox before due date. Note that submitting this file is supplemental. I should not need to open this file in order to understand your report.

Due Friday May 4, 2007 at 4:00 PM.