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Distinctively Christian Engineering: Implementing Guiding Principles in our Civil Curriculum

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Abstract

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Keywords

holism, Christian principles, creation, educational objectives

Disciplines

Christianity | Curriculum and Instruction | Engineering

Comments

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Distinctively Christian Engineering: Implementing Guiding Principles in our Civil Curriculum

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At Dordt College, we work to make our motto, *Soli Deo gloria* (glory to God alone), the organizing principle for all activities. In the Engineering Department, it is our responsibility to continue to shape our program to be holistic and Christ-centered in order to equip our students to serve the Lord obediently in engineering. To direct the development and modification of our engineering curriculum, we established a set of five distinctively Christian guiding principles for engineering. Setting the direction for this work required a grounding point. Therefore, in a subsequent manuscript we evaluated the extent to which these principles were already emphasized in our civil engineering curriculum. This evaluation found opportunities for curriculum improvements, the most pressing of which was developing our students' understanding that that the world and everything in it was created for God's glory.

In this paper, we report on and critique our implementation of course activities that addressed the identified opportunities for curriculum improvement. This implementation included a common survey and targeted course activities. The survey provided an assessment of whether the guiding principles resonated with students at various points in their education. The activities were both linked to specific principles and course objectives and built upon activities in prior courses. Our critique of these early implementation steps provided evidence that the course activities helped our students understand and appreciate the guiding principles. However, further work needs to be done to translate this knowledge into a lifestyle where the principles guide all of our students' engineering work.

Introduction and background

Guiding principles for engineering
As Christians, we recognize that God made us "for his own glory" and therefore seek to honor him in everything that we do [1]. Like many others who attend this conference, we feel the Lord's call to serve in engineering education. There are many days that we find this calling daunting, but we trust that the Lord walks before us and leads us along a path that advances His plan for creation. As we seek to discern the Lord's direction for our work in engineering education, we recognize that it is our responsibility to continue to shape our program to be holistic and Christ-centered in order to equip our students to serve the Lord obediently in engineering. As we try to avoid straying from His path, we are continually reminded that shaping and refining a program is hard work! It requires thoughtful reflection to continually discern the Spirit's leading. It requires collaborative work to make plans envisioning what Christian engineering education could be. It requires focus

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to hold ourselves accountable to these plans. It requires practice to ensure that every class and every day point towards guiding principles for our curriculum.

In our 2013 paper, we took time to discern the Spirit's leading from God's Word as we considered what it means to do engineering for God's glory alone [2]. This thoughtful reflection led to a set of five distinctively Christian guiding principles for engineering (Figure 1). While the figure presents the principles in detail, we will refer to them briefly as: (1) God's Glory, (2) Develop e/Keep, (3) Creaturely, (4) Human/Non-human, (5) Already/Not Yet. These principles attempt to create a framework we can use to serve in our imperfect world while recognizing that engineering is just one part of a broader interdependent creation. Underlying these principles was a recognition that although the suffering introduced by humanity's fall impacted all of creation (Romans 8), through Christ's blood all things (both humankind and all other parts of creation) are being reconciled (Colossians 1:20). We know that sin permeates our work as well; therefore, we also recognize that these principles are not *the one and only* approach to Christ-centered engineering education. Instead, we characterize our work as *an* attempt to discern God's Word by finite sinful creatures.

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Guiding Principles for Engineering

Serving the Lord in His World

1. **The world (and <u>everything</u> in it) was created for God's glory.**
   - "For from him and through him and **for him** are **all things**" (Rom. 11:36).
   - "God's goal at every stage of creation and salvation is to magnify his glory" (J. Piper).
2. **God gave us dominion over creation and instructs us to develop and conserve it (at the same time).**
   - We give creation its proper due by treating it with care that brings healing and renewal **and** enables it to unfold and grow (L. Kalsbeek, Gen. 1:28, 2:15).
3. **We are creatures … always finite, currently sinful.**
   - Humans are the crown of creation, we have a unique role … but salvation does not come from the work of our hands (Ps. 8:4-6, Eph. 2:8,9).
   - We are not saviors. We are finite, sinful, and corrupted.
4. **Our sin caused creation's suffering. We have a responsibility to ease suffering by engaging the <u>human</u> and <u>non-human</u> creation.**
   - "For the creation was subjected to frustration, not by its own choice, but by the will of the one who subjected it … the whole creation has been groaning" (Rom. 8:20-22)
5. **We live in the already and not yet of Christ's kingdom.**
   - Christ's kingdom is already here, and one day it will be fully consummated!
   - We work out of gratefulness for Christ's saving work, and we trust Christ to use our work as He wills to fulfill His perfect plan
   - We work to continue the Spirit's sanctifying work in our lives.

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Figure 1. Summary of distinctively Christian guiding principles for an engineering curriculum.

Evaluating the emphasis of the principles in our current civil engineering curriculum
Developing the five guiding principles for engineering had an immediate impact on the *courses* we teach. It gave us a framework that helped us show our students how everything they do (engineering, work, life, etc.) is part of Christ's creation-fall-redemption story. However, we seek to use these principles to direct the development of an engineering *curriculum*. Facilitating changes at this larger-scale represents a substantial challenge and requires thoughtful coordination between faculty members. Coordination on this level cannot occur unless those involved can agree on a starting point. We established this grounding point in a subsequent manuscript that evaluated the extent to which the five principles were already emphasized in our civil engineering curriculum [3].

The method used to evaluate the emphasis of the principles was quantitative [3]. We began by using a course scorecard to gauge (on a 0–4 scale) the emphasis placed on each principle within a

particular course. This scorecard was applied to all courses (both engineering and other requirements) featured in the civil engineering curriculum. We aggregated the *course scorecards* into an appropriately-weighted *curriculum scorecard* using a method similar to calculating a student's grade-point average. Finally, we compared the curriculum scorecard to benchmark emphasis scores for each principle. The benchmark scores, while admittedly subjective, have been initially established based on our comparisons of the principles and best guesses as to what satisfactory scores will be. However, as we gather additional data, especially data from different subsets of students, we may refine the benchmarks as we feel is necessary.

Table 1 presents the comparison of our curriculum benchmarks to the civil engineering curriculum emphasis scores. In this comparison, a curriculum emphasis score that met or exceeded its benchmark was considered to indicate adequate emphasis of a principle in the program. As we used this method, we recognized that it had limitations, the most prevalent being the fact that we reduced the principles to a 0–4 emphasis score. Although a notable limitation, we reminded ourselves that it was our overall goal to create a starting point for implementation of the principles throughout the curriculum. For this purpose the method was sufficient and did not warrant additional modification because it would have drawn time away from the implementation work.

Table 1. Comparison of Dordt College civil-concentration curriculum benchmarks to principle emphasis scores [3].

Principle	Curriculum benchmark (0–4)	Curriculum principle emphasis score (0–4)	Difference between score and benchmark
1 (God's Glory)	3	1.8	-1.2
2 (Develop/Keep)	2.5	2.2	-0.3
3 (Creaturely)	2.5	1.6	-0.9
4 (Human/Non-human)	2.5	1.8	-0.7
5 (Already/Not Yet)	1.5	0.9	-0.6
Average	2.4	1.7	-0.7

The results presented in Table 1 provided a method for us to compare the actual emphasis of a principle in our curriculum to our overall goals. As we reflected on these results, we proposed actions that we should take to elevate the emphasis of the principles within the curriculum. Table 2 summarizes these proposed actions. Primary objections were linked to the greatest needs identified by the results. The sequence of these events does sound rather robotic, but recognize that this was an initial rating and an initial proposal for actions that are part of an ongoing process to continually improve the curriculum in the years ahead.

Table 2. Primary and secondary objectives to increase emphasis of guiding principles identified by evaluating civil engineering curriculum [3].

Primary objectives:

- All principles: increase exposure
- Principle 1 (God's Glory): increase emphasis
    Recommended actions: Readings, in-class discussion, personal reflections, develop closer ties between cohorts in which our older students help to mentor those who are joining our program.

Secondary objectives:

- Principle 2 (Develop/Keep): Help our engineers recognize *conservation*—the second part of our task.
    Recommended actions: Project- or problem-based activities that put engineering in context and consider broader impact on the natural creation.
- Principle 3 (Creaturely): Use targeted efforts to help students recognize that 'we are creatures' (finite and currently sinful).
    Recommended actions: When students have appropriate maturity and confidence, use case studies that demonstrate and reinforce the fact that our sinful nature becomes embedded in the things we create.
- Principle 4 (Human/Non-human): Leverage close ties to principle 2; recognizing a call to develop and conserve, it follows that efforts should be directed to easing suffering within creation caused by sin.
    Recommended actions: Demonstrate this principle alongside the project- or problem-based activities that emphasize principle 2.
- Principle 5 (Already/Not Yet): Carefully convey its relevance when students are likely to have needed maturity (e.g., the 7th or 8th semester).
    Recommended actions: Use reflective essays and class discussions because the principle is difficult to connect directly with engineering activities.

Methods

Flowing from the conclusions in Sikkema *et al.* [3], this paper reports on and critiques our efforts to address these identified needs by implementing a variety of course activities. To describe the approaches we used, this portion of the work features the following sections: (1) course activity selection and description and (2) course activity evaluation. The selection and description section documents the activities that were constructed and implemented in our efforts to address the conclusions from Sikkema *et al.* [3]. The evaluation section outlines how we evaluated whether the activities met their objectives.

Course activity selection and description
Our manuscript, which evaluated the emphasis of our principles in the civil curriculum, recommended increased exposure to all principles and an increased emphasis of principle 1 (God's glory) [3]. In concept, the activities we selected should primarily work towards these two goals. In practice, choice of activates was influenced by other factors as well (e.g., course content, current

events, opportunities to build on existing material). These activities and their relationship to the principles are summarized in Table 3.

Table 3. Course activities selected to improve civil curriculum emphasis of guiding principles.

Activity	Description	Reason	Principle(s) emphasized	Course(s)
Perspectives essay response	Students read short essays written by our department founder. Following the reading, students wrote a response.	These essays connected engineering and faith and shared themes with our principles.	1-5	EGR 115 (Introductory Engineering Statics & Structures)
Christian Renewal article response	Students read and wrote a written response on an article.	The article recognized the unfolding potential of technology and how it manifests God's glory.	1-3	EGR 212 (Mechanics of Materials)
Principles reflection	Students wrote reflections on the principles.	By reflection, the students became aware and developed an understanding of the principles.	1-5	EGR 317 (Structural Analysis)
Earthwise discussion	Students read and discussed chapters that related the cultural mandate to our place in creation.	The reading connected the principles to the care of creation and was relevant to course topics (environmental engineering).	1-5	EGR 319 (Environmental Engineering)
Lab activity project in context	Students designed lab activities and were challenged to connect this seemingly technical work to serving God.	This project developed the understanding that all of life is informed by our faith.	1, 2	EGR 319 (Environmental Engineering)
Principles survey	Students responded to a survey which gauged their understanding of the principles.	Completing the survey raised principle awareness and also a means to elevate.	1-5	EGR 115 (Introductory Engineering Statics & Structures)

Activity evaluation
As we considered appropriate means to evaluate the activities, we were presented with a variety of challenges. Overall, we sought an approach that evaluated each activity with a similar set of metrics. We looked for a means to keep the conclusions from Sikkema *et al.* [3] at the forefront of our minds to ensure that we did not stray from the prevailing needs in our curriculum. We also recognized that our effectiveness at implementing the guiding principles in our civil curriculum is not simply a matter of developing relevant activities; the activities must be both pedagogically effective and placed at an appropriate point in the curriculum.

As we thought through these considerations, we decided to use a standard set of guiding questions that encouraged us to step back and thoughtfully reflect on the impact of our efforts. The questions we used for this evaluation are displayed in Table 4.

Table 4. Guiding questions for activity evaluation.

Evaluation type	Guiding questions
Relevance	1. How did this activity work towards the primary objectives? 2. How (if at all) did this activity work towards the secondary objectives? 3. What ties does this activity have to the recommended actions? 4. How could you strengthen the ties between this activity and the principles?
Effectiveness	1. Did students' responses indicate that they understood activity's relevance? 2. How deep of an understanding was demonstrated? Did they simply paraphrase the activity's prompts or did they develop unique insights?
Curricular impact	1. Was the activity placed at a point in the curriculum that allowed it to both build upon prior learning activities and serve as a stepping stone to future activities?
Summary	1. Should this activity be retained, improved, or replaced? 2. If the activity should be improved, how could you make it more effective?

Results

The guiding questions provided a useful means to evaluate the activities we implemented in our curriculum. The results of this evaluation are provided in Table 5. This table includes the class activities (presented previously in Table 3) with responses to each of the guiding questions presented in Table 4. Discussion of these results is provided in the following section.

Table 5. Evaluation of Implemented Class Activities

Evaluation type	Essay response	Christian Renewal article response	Principles reflection	*Earthwise* discussion	Lab activity project in context	Principles survey
Relevance	1. Engaged students in reading that reinforces how God's glory shines through both the natural and developed creation. 2. Related to Principle 2…natural and developed creation. 3. Includes reading and personal reflection. 4. Could possibly provide the principles as background to the essay, or even have students reflect on principles 1 and 2 after reading the essay.	1. Engaged students in reading that explicitly talked about seeing God's glory in technology. 2. Indirectly related to Principle 3, recognizing man's creatureliness as opposed to God's glory. 3. Includes reading and personal reflection. 4. Could remind students of the principles prior to doing this reading reflection.	1. Challenged students to apply the principles directly to the specific course material. 2. Yes, used all the principles. 3. Primarily personal reflection, with brief reading. 4. It is tied directly to the principles.	1. Readings tied to all principles and challenged students to rethink their relationship with creation. 2. These reading in particular, worked toward the conservation aspect of Principle 2. 3. Used both personal reflections and in-class discussions. 4. Provide principles before reading as ask students to show where agreement or disagreement occur.	1. Activity helped students recognize connection that all parts of life exist for God's glory—even investigations that appear purely technical. 2. Activity equipped students to practice conservation. 3. As recommended, the activity put engineering in the broader context. 4. Discuss principles prior to assigning project to help make ties to principles explicit.	1. Increased exposure to the principles by asking one anonymous question related to each principle. 2. It asked questions related to Principles 2-5. 3. The activity was perhaps more of an assessment than really following the recommended formative actions. 4. It is tied directly to the principles with each question.
Effectiveness	1. Mostly. 2. Widely varying among the students (28% didn't get it, 54% got it, 18% owned it)	1. Mostly. 2. Again quite a variation. (17% didn't get it, 59% got it, 24% owned it).	1. Quite effective. 2. Served as a good way to evaluate whether students really were processing the principles and able to apply them directly to a specific course. (52.5% yes, 47.5% no).	1. Quite effective. 2. Overall quite deep, but reformulated questions could improve effectiveness.	1. Effective, but great opportunities exist for improvement. 2. The understanding is apparent in conversations, but communication in the project could be improved.	1. Marginally. 2. A few demonstrated a deep understanding. For the most part, the assignment didn't push deep enough to discern whether the students really resonated with the concept.
Curricular impact	1. Yes. (Primarily an introductory exercise, but that is the intention.)	1. Yes. (Built on freshmen year and increased focus on God's glory in technology.)	1. Yes.	1. Yes. Applied principles in specific area of engineering.	1. Yes	1. Not really, more of an introductory assessment exercise.
Summary	1. Retained. 2. Perhaps improved by tying it directly to the principles.	1. Retained. 2. Good as is.	1. Retained. 2. Good as is.	1. Improved. 2. Spread readings over longer period to allow thoughts to percolate. Strengthen explicit ties to principles.	1. Improved. 2. Strengthen ties to principles and facilitate student-led discussions.	1. Retained. 2. Should be improved by thinking carefully about the questions and modifying as needed.

Discussion

Relevance to primary and secondary objectives from our curriculum evaluation
We found that we were fairly successful in developing activities that worked towards the primary objectives from our curriculum evaluation (see Table 2). These primary objectives included increasing students' exposure to all five of the guiding principles and especially emphasizing the first principle (God's glory). However, our reflection also found that some of the activities we used would likely be a part of our courses even if we were not working to implement changes that increased the guiding principles' emphasis. This result should have been expected. When we developed the principles, we were not attempting to redefine what it means to serve as engineers who are Christians. Rather, the framework presented flows from the theological perspectives that have guided our department from its inception. This framework was helpful as we used the activities and discerned their usefulness. In some cases, explicit ties to the principles are not necessary, but we should take time to consider how to share this framework with the students so that they can also use it to discern the impact of their current and future work.

The activities were also helpful in working towards most of our secondary objectives (Table 2), particularly the objectives related to principles 2-4 (develop/keep, creaturely, and human/non-human). However, while a few of the activities touched on principle 5 (already/not yet) the evaluation process did reveal that these activities did little to really be formative or explicit.

Effectiveness of evaluation process
There are useful highlights to point out from the evaluation process. First, we discovered that even though we lacked a systematic rubric for rating the effectiveness of the activities, for most of the activities it was relatively simple to gauge the activities' effectiveness on the basis of the students' responses. For example, consider the first activity, "Perspectives Essay Response." This activity asked students to read an essay discussing the beauty of the *natural* creation, such as mountains, rivers, and trees and the beauty of *developed* creation, such as poetry, computer programming, or technological artifacts. The essay pointed out how the beauty of both nature and development point to God's glory, directly emphasizing one of our primary objectives. For the most part, it was surprising how easy it was to quickly skim a student's response and see if they "got it" or not. As Table 5 shows, we divided the student responses into three categories: "didn't get it," "got it," and "owned it." These ratings were made simply on the basis of a quick review of the written responses from the students. While upon first thought it may seem like this exercise is very subjective and relative, a quick read was all that was necessary to clearly see if students responded by recognizing God's glory in all things (getting it), passionately declaring God's glory in all things (owning it), or missing the point entirely and just talking about vacation or human endeavors and not reflecting on God's glory at all (not getting it). Since these categorizations of student responses felt meaningful and manageable, it reinforces to us that it is valuable to conduct such evaluations. Beyond simply providing data for assessment purposes, processing student responses in this way gives us a better picture of whether they truly are "getting it."

Deviations from curriculum evaluation conclusions
We did not carefully regiment the activities we discussed in this paper. Consequently, as we reflected on the implemented activities, and then went back and reviewed the conclusions from our curriculum evaluation [3], we discovered that we did not necessarily work towards this work's conclusions. While we indeed implemented new activities, many of which were quite effective,

these activities were not all directed to the objectives summarized in Table 2. For example, the readings from *Earthwise* were worthwhile and related to the principles. However, the activities constructed made no mention of the guiding principles. Creating a connection to the principles represents an easy opportunity to work towards the primary objectives in future years.

This apparent lack of focus in the activities we implemented may signify a need for greater planning on our part. However, on the flip side we can certainly see some benefit in activities like these not being carefully pre-planned and regimented. Oftentimes, the most valuable perspectival reflection activities are those which happen spontaneously based on current events or particular student interests. It is valuable to be able to take advantage of such opportunities and not feel so tied down to some preconceived plan. In fact, the relevance, effectiveness, curricular impact, and summary questions may show their true value in such situations, because they can be as readily applied to a pre-planned assignment as they can to a spontaneous one. As such, they serve as a good tool for evaluating student understanding of the guiding principles while still providing the freedom to change up the activities as the situation dictates.

Conclusion

As we reflected on this work, we found that the structure the guiding principles provided has helped us significantly in recognizing whether students are trying (and even desiring) to think Christianly about engineering. The principles provide a tangible framework that helps us see if students understand what integrally Christian engineering is really about. Perhaps even more importantly, the principles have helped us, as engineers ourselves, think more clearly and articulate more carefully what it means to do integrally Christian engineering. The guiding questions for activity evaluation were helpful in assessing the effectiveness of implemented activities, both carefully-planned activities and spontaneous ones.

In some cases we did get side-tracked. Since we did not carefully preplan the entire list of activities that we have implemented over the past academic year, when we went back and evaluated our activities we discovered that our activities were not evenly distributed in terms of addressing our primary and secondary objectives. However, we appreciate the flexibility that not carefully preplanning the entire gamut of activities provided, because it allowed us occasionally to incorporate timely current events that would have not been possible if we restricted ourselves only to a carefully regimented list.

By going through this process, we reaffirmed that these principles serve as a useful framework as we work to equip our students to serve the Lord obediently in engineering. We find real joy in using these principles because they offer clarity and direction to our work. We need to work harder to share this joy with our students. We need to describe these principles specifically and provide examples of how they guide our work. These principles have positively impacted our lives. We hope that they can help our students as they leave Dordt College and serve in a world clouded by sin but in anticipation of Christ's final reconciliation and consummation of his kingdom.

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