Integrating the humanities and engineering: The implications of an interdisciplinary-based learning module

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Abstract - A learning module entitled, The Water Module, was created to provide an instructional method of integrating the humanities into engineering courses. An interdisciplinary Model Teaching Team was established to determine what skills students needed in order to make this integration. The team collaboration resulted in the development of five guiding principles of essential skills, and the Water Module was created as a way to incorporate these principles into an engineering course. This module was implemented into a freshman engineering course. Interviews were used to gather students' reactions to this module and to evaluate the module's success in teaching students this integration. A control group was used to compare other instructional methods against the module. The results indicate that the treatment group had a clearer understanding of how the humanities are imbedded in engineering practice.

Keywords: integration, humanities, teaching module

INTRODUCTION

This paper presents a learning module for integrating the humanities into engineering topics to satisfy the Accreditation Board for Engineering and Technology (ABET) accreditation Engineering Criteria 2000 (EC2000). The purpose of this learning module, entitled The Water Module, is to provide an example for integrating the humanities and engineering topics in engineering courses. This Water Module is the result of the collaboration of an interdisciplinary Model Teaching Team who discussed what skills engineering students need to connect the humanities with engineering. Five Guiding Principles were established from the team, and the Water Module was created to satisfy the criteria of those five principles. The Model Teaching Team consisted of faculty members from

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the following fields: social work, art, English, health policy, curriculum, life sciences, etc. The Guiding Principles of this module are as follows:

- **Guiding Principle I:** Engineering must be viewed as a social process [Colon, 2], that is used to frame a problem, deals with social uncertainties and develops a range of potential solutions that could be of value to the target users.
- **Guiding Principle II:** Engineering education should provide opportunities that transform students into professionals who can identify problems, recognize conditions and constraints and can realize the consequences of their actions.
- **Guiding Principle III:** Engineering education should guide students through a holistic course of inquiry; this course of inquiry should include reductionist roles of inquiry for deep understanding [Adams,1].
- **Guiding Principle IV:** Engineering education should cultivate reflection and critical thinking to individual and group environments [King, 3].
- **Guiding Principle V:** Engineering education should view technology as an engagement, not application, between science and domains of society [wenk, 8].

Background

Changes in the ABET requirements now mandate for ethics and humanities instruction to be integrated into the engineering curriculum. In the EC 2000, "Criterion 3, Program Outcomes and Assessment," two new mandates assert, " [6] an understanding of professional and ethical responsibility…[8] the broad education necessary to understand the impact of engineering solutions in a global/societal context" [Schachterle, 6]. In today's global job market, students need more than sole technical knowledge. Students need a broader range of interpersonal and ethical qualities to compete, including communication and leadership skills, as well.

Globalization now necessitates that engineers are able to work on an international spectrum, which requires both interpersonal and intercultural skills (Riemer, 5; Shuman, 7]. In addition to ethical sensitivity and cultural enrichment, communication is becoming an important qualification in the engineering workforce. There is an essential need for more instruction on communication competency. Miller [4] emphasizes that clear and effective

writing is needed for any engineering project in which the engineer is explaining the concepts behind the design in order to sell that design to clients.

Moreover, when assessing students regarding their competency in humanities integration, faculty must evaluate students' critical thinking abilities. Schachterle [6] proposes that when solving engineering problems, students should be evaluated on the following skills: identification of issues, experimentation with issues, ability to gather more data on the issue, analysis of the data, suggestions of multiple solutions with supporting evidence, and appropriate implementation of the chosen solution. All skills begin with the process of being able to identify that an humanitarian problem exists, which students may struggle with initially. Humanities integration teaches students that all engineering design processes are multidimensional in which many factors must be considered, investigated, and defended.

METHODS

We implemented the Water Module into a new freshman engineering course, Principles of Systems Engineering. The module was used throughout the semester and served as the basis for connecting the theoretical lecture material to application. The individual topics of each section of the module were centered on the issue of gray water usage in Athens, Georgia, an area known for draughts, and students were to gather information and analyze constraints regarding the design/implementation of gray water systems at personal residencies. The project required students to research historical, cultural, and economical components both prior to engineering design and after the design process. We collected data through group interviews with the students about their experiences and opinions about the module/course. Two interviews for the treatment group were conducted in total: one interview following midterm and the other at the end of the course. All students in the course participated, and there were about 20 students in the course. Pseudonyms were used in place on students' real names, and a graduate assistant conducted the interviews to ensure confidentiality. The main objective of the interviews was to examine students' understanding of humanities and engineering integration and to gain feedback on the instructional module. Furthermore, a control group was used to compare the Water Module with other instructional methods and to determine if students in other engineering courses are receiving instruction on humanities and engineering

integration. The control group were not exposed to the module. Both the controls and treatment groups took similar freshman level courses such as engineering graphics, calculus, english composition. One group interview was conducted at the end of the same semester for the control group. Six students from the control class participated in the interview, and pseudonyms were used.

RESULTS AND DISCUSSION

Mid-term Interview- treatment group

Based on students' responses, many students understood that the instructor was teaching the students to investigate engineering problems thoroughly from both an engineering and societal perspective:

Stan: "He's [professor] pretty much making us think like engineers. It's pretty much phil…he says philosophy. He wants us to think like engineers and communicate with other engineers and other people to get as much information we can about a problem…"

Stuart: "…but as an engineer, you've been taught to look at all perspectives when considering a problem before even thinking about a solution…to gather the information from all perspectives and never to, you know, favor one side over the other."

Additionally, students were learning the importance of developing communication skills and that communication is a major component of engineering work.

Andy: "Dr. [name omitted] did say that engineering is like 60% communication. I could spend more time actually communicating and interacting with people rather than what you call sitting in a dark room like doing calculations and stuff, which you know, that's true. You have to learn more than just the math part of it…especially communicating and coordinating with other people."

Peter: "I agree that there's a lot of social interaction that's involved with it, I mean, it's not like he said, the math problems or whatever, I mean, you have to be able to communicate with a whole group, and it's not you sitting at a desk writing, solving something yourself."

When students were asked about their understanding of the course goals, students, in general, had a good understanding of what they were trying to accomplish. The instruction was different than the type of instruction in which most students were accustomed; however, most students indicated that they understood the method of teaching and the reason for particular instructional choices.

Hugh: "To learn the process of how we're supposed to do things. It's not focused on the end result. We're focused on the process of how we're supposed to do things like the constraints and all those different aspects that go into it."

End of Semester Interviews-Treatment Group

At the end of the semester, students still grasped the connection between the humanities and engineering; however, there were mixed feelings about the overall end result of the module. Most students agreed that the foundation for this connection was present, but some students wished that the project had expanded this concept further than what it did. Other students feel that the connection lacked clarity at the end of the process.

Anthony: "Because it doesn't really connect as well as I had hoped as far as like communication and that sort of thing. We did go into groups or whatever, and we did like break down a problem, but as far as that helped against humanities like you were talking about before, I didn't really…it was some connection, I could kind of see it, kind of see where we were going with it, but we didn't really get there."

Martin: "Because after we got into it, I thought that engineering had nothing to do with the humanities, and now I understand that there's a bunch of research and a bunch of other necessary BS that has to do with the work that we're delving into, but it is necessary that we have to do it, so like I understand that now. Was this overkill? Yeah. But do I understand that you have to research and stuff like that, yeah I do."

Billy: "Okay, as far as the humanities part of it, I mean I think that Dr. [name omitted] did a pretty good job of explaining like, yes, it's more than just crunching numbers and like staying in a room with no windows and stuff, but you know, how there's a lot of social aspects and different perspectives to take into account, but alright, that's what he started well, but I think laying that down, but we didn't…it wasn't as clear, like how it applied to specific projects we worked on, I guess."

Alex: "He applied it a little bit, just broadly. He never went into real depth. I guess he just wanted us to get a general idea."

When this course was compared to other engineering courses, students agreed that this course was more effective in connecting the humanities with engineering topics. All students claimed that this course was the only course they have taken that addresses this connection.

Anthony: "This definitely does more so than the other engineering course, which is just like how do you use autocad, which is like a computer course kind of. You just learn a computer program, and that one didn't really apply much, if at all, and this one definitely connected with communication and the humanities other than that, but again, not as well as I thought it should have."

Billy: "Um, I'm in 3…I think 3 other engineering classes. I mean this by far…the others are more…I have an autocad class and statics, um, which autocad could apply. I mean this one has been…I mean, as far as connecting to the humanities and seeing the bigger picture and the social side of things…this one has done the best job."

Horace: "I think it definitely is because it actually gives you like a perspective of how it works in the real world whereas your calculus class, you learn like the theology behind mathematics and no application to it…Um, so I think application for me is definitely better than any kind of theology you would learn in some of your chemistry classes or cal classes or in some of your engineering science classes, so…"

Students did have recommendations for improving the module. Most suggestions involved the inclusion of more opportunities to practice communication skills, more hands-on activities, more clarity in certain portions of the project, and the inclusion of an end result of some kind. Students understood the method of active learning in which they had to solve problems and learn processes independently; however, students wanted more guidance during the process from the instructor. Furthermore, students were aware that they were not going to develop a solution at the end of the semester, but students wanted some kind of end goal.

Victor: "Actually, you know, maybe if we had gone more in depth in like design or something. I know that's later courses, but like just to get a…like, the way I thought about it was, the way I thought about what he was teaching, the way I thought that that's how I should be thinking. I never really knew because the only thing I got judged on was taking a test. Like as we were doing our notebooks, like, we were just writing stuff in them that we thought was

important, and then we'd come in, and we'd discuss it. We discussed it like twice. And we figured out that some stuff that we were doing really wasn't that important, and some stuff was, but I think more of a, more of looking into that would have helped me understand what I really needed and what I didn't need better…I mean, I know we weren't going to solve it and actually build something, but if we could have gotten to the point where we came up with a final solution, that would have helped a lot more."

Anthony: "Yeah, I liked how he did, and always done, a lot of interactive stuff. That makes it interesting. It makes it more than us just sitting in there listening to a lecture, which sometimes he does, which are the days I like so much. When he's asking questions and making you get up and talk and go back and forth, it is really interactive. I like that the best. If he did more or if I had a teacher that did more of that, I would get more out of the class I think."

Billy: "Yeah, I think the scale of this project was too big, like it was just…well, for one thing, there were already teams, like professional teams working on it. I mean, another thing, us just being students, we don't have access to all the resources and stuff to do this project like accurately, we can all just shoot in the dark and get something down on a report, but um, yeah, I think it needs to be something a lot smaller and that you can actually see the results of at the end of the semester."

Anthony: "A little more guidance. I don't mind figuring things out as long as I know what I'm trying to figure out at least."

Carey: "I think he let us pick our own objectives so that we could learn to think of the objectives, so like, I mean, I don't mind that as long as he when he grades it, he doesn't like have something in mind, it is like philosophy, it is kind of vaguely graded like what he had in mind before, he didn't tell us really. It is kind of hard to know what he is looking for if he can't tell us. It is more of the way how we are thinking about the problem, so I hope he grades like that."

End of Semester Interviews-Control Group

In the control group, students did discuss the use of guest speakers to emphasize the importance of communication skills. However, communication appears to be the only humanities component incorporated into the course.

Frank: I think a lot of times there's a misconception that you don't need to be able to communicate with people, and that it's a very reclusive job, and in reality, you need to be able to convey what you're trying to design or

construct or recreate or fix, and I think that it was at least in some of our classes, in some of the guest speakers we had, that was actually mentioned, so that's good."

Todd: "I think we had six or maybe seven guest speakers, and probably at least half of them said that probably the most important class that they had was speech because they had a lot of times…I don't know if they public speak or just have to convey effectively, and so, I just remember that being mentioned a lot…"

However, despite that communication was accentuated in the course, students did not feel that they had adequate opportunities to learn communications.

Chad: "We have one speech class required, and I think four physics, three calculus, three biology, two chemistrys, and a ton of other things, so if they are looking to emphasize communication, having a 1:100 class ratio for speech, communications is not a good ratio I think.

Todd: "And the speech class is general. Like everyone at the university has to take it, so maybe a speech class or two in the engineering department…"

Gus: "Make more speech projects in the classes themselves, like…take those projects and make them where you have to speak in front of the class, you're not just turning in a piece of paper, and you can explain what you did."

When students were asked about their understanding about the humanities' and engineering connection, students had a broad conceptualization. The course's inclusion of the humanities in engineering topics seems rather superficial. One student, Sue, did not fully understand the meaning of the humanities, indicating that this concept is unclear to students.

Sue: "I do understand how they're [humanities and engineering] connected because he said earlier, you need to know how people feel and what people want in order to produce something that will affect them and that they'll be interested in, and I guess this class kind of gives you a step to like be able to present your ideas, but it is more like mathematically and on paper."

Frank: "It's not application…And I feel if we actually had something that we, you know, we knew how it worked, why it was important, and then had to draw it, or that would be more applicable…"

Johnny: "Yeah, but even the report, I mean, everybody can write a report…I think that being the only source of humanities in the class is dumb, it just kind of turns you off from the humanities even more because now it is just a pain to write a paragraph…"

CONCLUSION

The students in the treatment group understood the humanities application to engineering topics clearer than the control group. The control group limited the humanities to mostly communication and did not include aspects of societal influences, impacts, or conflicts. The students in the treatment group also recognized the importance of communications; however, they discussed the need to gather multiple perspectives and to learn the process of engineering work. The treatment group seemed to have more of a solid understanding of the course objectives, as well and seemed to find the activities useful to their learning. The module was the only exposure students had regarding the connection between the humanities and engineering; therefore, most students agreed that the course provided the foundation for this connection. However, students wanted more in-depth experiences and end goals in the module to improve the clarity of this connection. A limitation of this study is that it does not include any quantifiable measurements of students' understanding of the connection between the humanities and engineering. More follow-up studies are needed to assess students' learning gains and application regarding the humanities and engineering integration.

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BIOGRAPHICAL INFORMATION

Kerri Patrick Singer
Ms. Singer is a PhD candidate in Health Promotion and Behavior at the University of Georgia and has had over 5 years of experience teaching high school english. Ms. Singer's research interests include global obesity and health education with a focus on the social/cultural aspects of health and health education. Her current research focuses on obesity issues in urban China.

Timothy Foutz
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Maria Navarro
Dr. Navarro's main research focus is the enhancement of the Higher Education curriculum to achieve a more global, integrated, and socially conscious curriculum, with particular interest on STEM disciplines. From an outreach perspective, Dr. Navarro has extensive experience as a researcher, instructor, and facilitator of professional development programs for university teaching faculty (STEM disciplines), and has worked in the US, Latin America, Africa, the Middle East, and Western Asia. Her background in both agricultural engineering (B.S.) and education (Ph.D.), positions her well to address professional development of engineering faculty.

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Dr. Thompson is a Professor in the Department of Biological and Agricultural Engineering and Coordinator of Undergraduate Engineering Programs at The University of Georgia. Dr. Thompson received a Ph.D. in 1981 from the University of Kentucky in Agricultural Engineering. Dr. Thompson teaches undergraduate courses in engineering mechanics, engineering design and structural design. His research focuses on structural design, granular mechanics and also engineering education.