

Fostering Learning Communities in Engineering Design Education - A Critical Discourse Analysis of Engineering Syllabi

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Abstract - This Research paper presents results from a Critical Discourse Analysis of ten engineering design courses' syllabi from an undergraduate engineering program that would like to foster a learning community through their design courses. The analysis found the syllabi are giving mixed and incoherent messages to students in becoming contributing community members. The syllabi as a tool should be able to motivate and prepare students to collaborate and thrive within a learning community.

Keywords—learning communities, syllabus, engineering education, engineering design

I. INTRODUCTION

The present research is situated in a four-year engineering program at a large urban Canadian university, in which students engage in design courses across all four years of their undergraduate journey. Through program evaluation - particularly graduate attributes analysis - the program has identified two key concerns related to this "design spine." First, students expressed that they see few connections amongst their design experiences, even though they are being exposed to different perspectives on the field. Second, third-year students cannot articulate the purpose of their experience and connect it with their chosen major. The present research aims to improve the quality and efficacy of the program and with it the undergraduate student's experience by introducing a learning community approach that will help students to learn about design, build disciplinary connections and develop a coherent understanding of problem-solving within their field.

The study adopts the theoretical perspective of learning communities, informed by two frameworks: The Fostering Communities of Learners (FCL) program and the Knowledge Community and Inquiry (KCI) model. FCL transformed inner-city classrooms into science learning communities and engaged students in conceptually rich domains of scientific inquiry [1]. KCI expanded on FCL, adding the notion of a curricular "script" that specifies activity sequences, materials, student groupings, and technology elements. In KCI designs, students work together as a community, building upon each other's knowledge and cultivates a shared epistemology [2]

The purpose of this study is to explore how design engineering courses may be suited to foster engagement within a learning community. We examined a corpus of existing course syllabi using a framework that looks at student learning outcomes, course activities, assessment methods, language used, and particular methods of establishing social and teacher presence. The syllabi provide critical insight into the expectations and requirements of these courses, which can contribute to fostering a learning community by creating opportunities for student engagement. We performed a critical discourse analysis (CDA) to analyze the syllabi for educational engagement, following the tasks of relating function to language from Paul Gee's tools who describes critical discourse analysis as a means of uncovering structural regularities and affordances, by examining the language used within the syllabus. Our approach adds to this methodology through its unique approach of analyzing syllabi in terms of a set of key metadata significance, activities, identities, relationships, politics, connections, and sign systems and knowledge ontologies. The syllabi reflect the underlying pedagogical narratives and epistemic commitments held by their respective professors and are potent sources for analysis because every word serves a function. The syllabi can represent the social norms a professor expects in their classroom, which may reflect the belief-system of the institution. We will present findings related to the application or conversion of these courses into a learning community model. The findings include limitations of pedagogical commitments and course structures, as well as particular affordances that could lend themselves to elements of KCI, like knowledge bases and curricular scripts.

II. BACKGROUND

A. Design philosophies

The design philosophy of an engineer can influence their conceptualization of the problem and rhetorical structures to justify a design. Researchers and designers express various schools of thought with regards to what design is, might be, or how it should be carried out. The first school of thought believes that the design process has to be chaotic and creative, the second school of thought emphasizes that the process needs to be

systematic and disciplined, and the third group believes that no design process should be obligated to the designer [3]. Wallace argues that the engineering design process needs to be systematic and not left entirely to chance - making the process easy to comprehend for contributors and transparent where the inputs have any value [4].

The design philosophy is perpetuated in the community through the use of a certain dialect, discourse, and the judgments or consensus made by the instructor [5]. Undergraduate engineering students, through their design courses, learn how to operate within a context, influence their audience, and develop an intuition to balance their position and the needs of the users. Designs are commonly conveyed through representations, and Galle postulates that the role of these representations is closely tied with the design philosophy practiced [6]. Faculty members teaching engineering design may come into the classroom or studio with their design philosophy, and students may notice the elements of design emphasized are different from a previous design course. The design models employed by the faculty exhibits how the design is and can be done, is a representation of their philosophies [7]. Furthermore, the faculty's philosophies of design may influence the design goals and the variety of design problems allowed in the course, such as – routine designs, redesigns, and non-routine designs [8].

B. Engineering syllabi

The syllabus is one of the first forms of formal communication artifact meant for students, outlining important information about course expectations, instructor information, and schedule. Often, for courses that are electives, students' first impression of the course is through the syllabus, which can influence their willingness to enroll. Syllabi also serves as a permanent academic history that may show the progression of the course in incorporating graduate attributes [9]. The syllabi can contain general information of the course and may not contain essential strategies required for student success [10]. This may occur as syllabi had traditionally used for contractual and communication purposes designed to block policy loopholes [11][12] with a primary focus on performance and grading [13]. Many scholars argue that the function of the syllabus should be of a learning tool [14]. A learning-focused syllabus can orient students towards more mastery-based learning through the description of the learning objectives and assignments [15].

C. Affordances of Design Education

Faculty members who teach design courses are often not trained to develop a pedagogy for design learning and may lack experience in working and understanding other disciplines [16]. Professors who are domain experts may adhere to instructional techniques familiar to their field and may present concepts isolated from other disciplines. Apart from pedagogical and content aspects of design courses, teaching members need to be comfortable with unpredictable and chaotic behaviors and situations in the classroom.

D. Learning Communities

Knowledge Community and Inquiry (KCI) is a learning community model developed in the mid- 2000s. Students in a KCI classroom work together as a community, building upon

each other's knowledge and nurturing a collective epistemology. An essential aspect of KCI is the design of curricular scripts [17], which specify the activity sequences, materials, student groupings, and technology elements that serve to guide the inquiry toward particular learning goals. A KCI script typically begins with a brainstorming activity in which students explore and investigate their own ideas with respect to a broad inquiry topic. Knowledge artifacts that are generated during this process (e.g., notes, wiki pages, multimedia files, or discussion comments) are aggregated into a shared community knowledge base, which serves as a persistent referent and resource for further inquiry. The contributions to the knowledge base give rise to emergent themes, challenges, or interests that represent the "voice" of the community. The "community voice" subsequently informs the design of scaffolded inquiry activities that address specific content expectations and curricular learning goals, including assessable outcomes. These activity scripts are co-designed with the teacher and are tailored to meet the unique needs of his/her students.

In a learning-communities approach, the aim is to foster a culture of learning among students and their community. Community members contribute their individual expertise and efforts in understanding a problem under study. Students, working together in learning communities, learn to synthesize multiple viewpoints, utilize each other's expertise to solve problems collaboratively and discover new ways of thinking and understanding [18].

III. METHODOLOGY

A. Purpose of the Study

This study was conducted as part of an evaluation process of the current standing of a four-year undergraduate program, specifically the student experience that plays a role in the identity formation of graduates. The evaluation includes document analysis of course material and curriculum to inform future work on incorporating a learning community approach to curriculum design and pedagogical strategies. The leadership team has proposed to take approaches so that students experience the benefits of thriving in a knowledge community – one where community members rely on each other's experience and expertise to understand the world around them. The insights found in this study through a critical discourse analysis will inform a faculty development strategy. Through a survey conducted for students in the department, it was revealed that students found little connection with foundational design courses with the design courses offered in their chosen major stream. The findings will allow the design instructors to find common tenets of engineering design education that could be reflected in their course syllabi as a way to showcase coherence in the design spine.

B. Overview of Syllabi

The syllabi chosen for this study are from engineering design courses run in an engineering department of a large urban university in Canada. The design courses in the first two foundational years are mandatory for the students. Depending on the major chosen, students go into different design courses

in their third and final year. The syllabi were retrieved from the department office and are deemed as the latest documents for the course for the academic year 2019-2020. As the course syllabus is one of the initial documents prepared by instructors to organize content and learning objectives – it gives a glimpse of the initial pedagogical intentions of the course. The syllabus impacts students' decision-making process in choosing their courses [19]. However, in the context of this study, all the courses are mandatory for students in their foundational years and the major they chose.

C. Critical Discourse Analysis

In this study, critical discourse analysis (CDA) was used to examine the links among language and discourses in (re)producing authority, social relationships, and practices. CDA is an approach to analysis that allows the researcher to illuminate the way language is used to construct policy issues in ways that uphold the status quo or challenge it. The sources of data can include mission statements, textbooks, transcripts of meetings, representations of policy in the media, etc. [20][21]. CDA is particularly well suited for drawing attention to how current discourses shape the way issues are constructed and the responses that become available [22]. Critical discourse analysis has been used to evaluate syllabi in previous research [23][24][25] as a means to uncover how the language used within the syllabus relates to power dynamics in university courses.

D. Document Analysis

This study looked at the engineering syllabi produced by engineering design instructors to communicate course expectations to their students. Documents broadly defined refer to the range of written, visual, digital, and physical artifacts [26]. They are situated within "systems of reality," and their status as documents depends on how these objects are integrated into "networks of action," including particular structures and discourses [27]. According to Lindsay Prior [27], they "express and represent a set of discursive practices" and can be mobilized for different social, political, and cultural purposes." Documents are agents and are open to "manipulation by others." This method allows for addressing questions related to the intersections of power across systems and institutions in an unobtrusive manner [28]. Instead of focusing on human beings as objects of data collection, social structures and institutions become the subject of the research [29]. Data collection and analysis of documents are heavily dependent on the researcher. Prior contends that in social science research, the focus is often on the content of documents, but interpreting these documents required careful attention to the content, as well as the way that language was being used [27].

IV. DISCUSSION

A. Instructor information

The instructors took different approaches to introduce themselves and their teaching team through their syllabi. In syllabi 1,2, and 10, the instructors, along with their full names, choose to provide their academic qualifications such as having a Ph.D. in a topic. Stating one's credentials is a norm in academia; however, when unpacking how the syllabus is read and decoupling oneself from taken-for-granted perceptions

suggests this practice sends messages that expertise and authority are deemed crucial in the courses [30]. In syllabi 8, along with credentials, the instructor shared their years of experience in the field and explicit viewpoints on how engineers should interact with the design. In all the syllabi, the teaching assistants were listed in a separate section with their contact details. These explicit practices imply that there is a hierarchical structure in which instructors, teaching assistants, and students are related to knowledge transmission [31].

In syllabi 4 and 5, the teaching team chose to provide their contacts and what their expert functions were in teaching the course. The division of expertise showcased to students that the instructors were part of a team, and they each brought in their unique perspective – showcasing a learning community in action during course development. This sets expectations for students to form groups that bring diverse opinions into their design projects.

B. Course Narratives

As the syllabi in this study were of undergraduate engineering design courses, each instructor chose to emphasize on why design was necessary for the engineering profession. However, the emphasis was backed up with different narratives. In syllabi 1,3 and 9, the importance of design was to solve real-world problems. In syllabi 6,7, and 10, the course objectives were presented and mapped with accreditation board guidelines and institutional graduate attributes. The various narratives of the purpose of a design education presented in the syllabi show that students need to comprehend the implicit expectations of the instructor. The real-world-problem narrative allows students to bring in their viewpoints of the world around them and present what they perceive as a problem. The syllabi with the mapping of attributes and definitions provided by accreditation boards indicate that the instructors have a precise idea of what design artifacts and processes should look like.

C. Course Policy

The most prominent component was course policy in every syllabus in this study. Penalties regarding late submission, often in bold emphasis, was prevalent in all syllabi. In syllabi 2 and 8, the instructors used the document to convey strict rules regarding page limits and headings to be used in documents. The semiotic structures of all the syllabi, project that rules and standards are of immense importance in designing engineering artifacts.

D. Design Philosophies

Through the syllabi analysis, it was evident each instructor communicated their philosophy of design through definitions, types of deliverables, and project descriptions. In syllabi 4 and 10, the instructors express their design ideologies by writing out their documents in the first person. An engineer can design and implement designs by probing into the unknown and inventing new knowledge [5]. Students need to be exposed to various forms of design ideologies and be able to develop their own understanding of the world. Sections in the syllabi in this study barely mentioned the nature of assignments, course purpose, course rationale, and teaching philosophy. Also, it is useful to

inform students how the course can introduce them to critical dialogue and key arguments in the field [32].

E. Engineering Syllabi

The syllabi serve as a contractual document between the teaching team and the student. This may have led the instructors of the syllabi in this study to focus their document on the expectations of each deliverable and the consequences of not following the expectations. However, design courses are avenues for students to make meaning of highly structured courses they go through each semester. The contradiction may be due to instructors' orientations towards writing in certain genres [33]. The instructors may have wanted to develop a syllabus based on certain formal conventions and unmindful of what may have been perceived by a student – a novice in academia. Therefore, adhering to conventions may lead to perpetuating institutional structures [34]. A well-written course syllabus can highlight the instructor's philosophy in connection with the content and activities.

F. Affordances of Design Education

Design courses in engineering schools are offered at different stages of the program. The courses need to build on foundational courses and showcase the student is becoming rigorous and sophisticated as a designer. Apart from syllabi 4,5, and 7, other instructors did not show how their courses build upon design principles and experiences from prerequisite courses. These explicit connections are necessary to show students that these courses interact, and their learning journey is coherent. The authors in [34] posit that "desirable program coherence is found where students can build connections among various areas of knowledge and skill, but where loose ends remain, inviting a reweaving of beliefs and ties to the unknown." Hence, instructors should find ways to show connectedness, especially at the beginning of their course – when students read the syllabus.

G. Learning Communities

In all the syllabi, in this study, there were recommendations on how to interact with team members and the appropriate protocol to follow when a dispute arises. There was an emphasis on the reader of the syllabi to contribute to team activities and deliverables. A learning community forms when members of the community start seeing the benefit of depending on each others' expertise and sharpen their own skills. The recommendation would be employing a more encouraging tone to welcome the expertise of the new student and show ways how students can contribute to the community and explore new skills to pick-up. In syllabi 2, 8, 9, and 10, students are expected to form their groups, which may be done based on working experience in other courses or based on informal relationships. Learning communities' approaches can help students to experience members' expertise through various performances such as shared reports, presentations, which can lead to making more informed choices when they need to pick team members.

Expectations in syllabi 2 and 3 inform students need to work with team members in designated spaces and present team

progress in class. It is not clear whether these activities' outcomes are shared with the broader class or just with the instructor. According to the FCL approach, knowledge needs to disseminate within the community, within the physical classroom through interactions and exchange [35]. Becker and Calhon, in their article on "How Students Use the Course Syllabus," indicated that students use syllabi throughout the course to keep track of deliverables and associated expectations [36]. This provides an opportunity to prepare student mindsets before activities during class and share pedagogical intentions [37]. The syllabi can help prepare students' mindsets before they enter the classroom, especially if the syllabi move away from an individualized grading policy with high stakes and towards one that supports collaboration and dialogue among community members [38].

From the document analysis, it seemed that instructors did not require student teams in their design courses to share their deliverables with the class. In syllabus 8, there was a demo session to showcase the project outcome with the other teams at the end of the semester. The KCI learning community approach requires all community members to aggregate findings and learn from each other's' contributions from a shared knowledge base. Therefore, through curriculum changes, the syllabi need to showcase through their learning outcomes and deliverables that a community is to be developed by creating a knowledge base.

V. LIMITATIONS AND FUTURE DIRECTIONS

This study, as mentioned in an earlier section, was conducted as part of evaluating the current status of the program through document analysis. Therefore, a limitation is that the findings do not include observations of how instructors introduce their course in class and exhibit their design philosophies. While the discourse identified from analyzing these syllabi is critical, a richer understanding could be gained from interviewing faculty and students. It is important to examine students' and faculty members' perceived importance of the syllabus components and the other forms of information that students receive that play a role in forming an impression of the course before the first lesson.

VI. CONCLUSION

Fostering learning communities within an undergraduate engineering program helps students embark on a professional journey that transcends the four-year relationship they have built with peers. The engineering design courses offer ill-structured problems to students, which affords them to form their professional opinions and apply the tools they have learned from their theoretical courses. This means changing the learning outcomes and the nature of deliverables. As the syllabus act as the first interaction between a student and the course, there is an opportunity to motivate, plan, and prepare students to become contributing community members ahead of the first class.

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