Appraising the Impact of Dialogical Pedagogy and Curriculum Co-Design: A Conversation Between the Humanities and Engineering

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Abstract

The central problem addressed in this work-in-progress paper is the divide that is there between engineering studies and the humanities in the current engineering curriculum design and pedagogy. Although it has been accepted that the engineering curriculum needs to be complemented with courses in the humanities, in practice, however, the humanities courses are mostly offered as electives. They are taught by humanities faculty who have no background in engineering and are completely isolated from the rest of the engineering curriculum, resonating with the idea of NOMA (Non-overlapping Magisteria) between the humanities and engineering, a view advocated by the palaeontologist, Stephen Gould with regard to science and religion. It has been argued that this separation of the humanities from engineering, has made it quite difficult for the engineering fraternity to meaningfully contribute to our twenty-first-century society and its needs. The engineering problems of our age have a strong component concerning human traits, values, and ideals. Thus, engineers need to be trained not only in the technological and experimental education concerning the engineering curriculum but also in social and human knowledge and practices. This would enable engineers to understand, empathize with, and respond to the needs of humanity and build solutions that would cater to the sustainable and developmental goals of our planet. In the past, elective courses in the humanities have been offered as part of the engineering curriculum, however, even these attempts do not solve the problem as the humanities and engineering courses continue to be siloed and there is no conversation between the engineering and the humanities faculty. To have a synergy between the humanities and engineering, there is a need for joint curriculum design and adopting collective pedagogical approaches.

This work-in-progress paper showcases a pedagogical innovation that was employed in a course for engineering students. It introduces a new transdisciplinary course which has been co-designed by faculty belonging to the humanities and technology domains respectively and is also being co-taught using a dialogical teaching model in which a live conversation between both the faculty becomes the medium of course delivery. This paper demonstrates how this change in pedagogy has brought about a change in the engineering students' perception of the course as well as has exponentially increased their participation in the course. We also show how the use of statistical tools and data from the technology domain to put forward arguments in lectures can go hand-in-hand with the philosophical and theoretical structures provided by the humanities. We establish that the traditional curriculum and pedagogy used by the faculty to teach humanities students will be ineffective in training the engineering students in humanities courses. A reimagination of both curriculum and pedagogy in collaboration with the engineering fraternity is necessary if engineering students are to be effectively and meaningfully taught courses in the humanities.

Keywords

Anthropocene, Dialogical Pedagogy, Co-designing, Engineering education

Introduction

Many of our planet's most pressing problems—overpopulation, climate change, biodiversity loss, air pollution, and others—arise partly due to the chasm between problem-solvers and policymakers. While engineers and scientists diligently try to find solutions to these problems in their labs, it is the bureaucrats and the leaders who grapple with the immediate task of implementing the solutions in communities [1]. However, there is a crucial disconnect between them which hinders finding the most optimal solutions to our planet's complex challenges. This lack of synergy and presence can be attributed to the echo chambers created by our education system itself [2]. The requirement of in-depth specialization has been a defining characteristic of the modern higher education system. Over time, this has led to the fragmentation of the curriculum along disciplinary lines, thus creating silos. These silos are often an artificial separation of academic disciplines [3].

Particularly in engineering education, these silos are explicitly visible. The engineering curriculum is dominated by courses on science and technology with very little representation of humanities courses. Even the limited humanities courses are taught in isolation using the conventional theory-based curriculum design and pedagogy. Therefore, there is a rift within the engineering curriculum due to the lack of synergic integration of humanities courses alongside the mainstream engineering courses.

One way of overcoming these siloes is to deliver a multi-disciplinary course which can help engineering students integrate humanities courses within their technological studies. Especially when a course seeks to understand the nature of diverse planetary challenges, such a course needs to draw from all forms of human knowledge—scientific, humanistic, artistic and the various intersections and connections that arise from them. Neither the scientific expertise nor the humanistic debates alone can holistically formulate solutions [4].

This multidisciplinary approach is particularly useful to solve the multidimensional challenges of our planet which requires an integration of curricula from the Arts and Humanities with STEM as opposed to a general curriculum. Scholars argue that the present planetary grand challenges cut across various dimensions of human experience—social, economic, environmental, political as well as moral [5]. For instance, the shift to a less carbon-dependent economy in the face of climate change is as much a technological problem as it is a socio-economic one since rapid, dependable, and affordable access to energy has been ingrained in social life's routines and conventions. If we try to solve these issues with a narrow conception and understanding of these problems, the solutions may be similarly constrained [3].

Plaksha University, a technological university located in Punjab, India, has been recently established to reimagine technology education with a focus on solving the grand challenges of our planet. Plaksha university offers four highly interdisciplinary undergraduate degree programs in engineering, Bachelor of Technology (B.Tech), which are i) B.Tech in Robotics & Cyber-Physical Systems ii) B.Tech in Computer Science & Artificial Intelligence iii) B.Tech in Biological Systems Engineering iv) B.Tech in Data Science, Economics & Business. The university has incorporated key humanities courses within its curriculum so that its graduates are equipped to closely work with communities to ensure that solutions are human-centric, in line with cultural norms and economically and environmentally sustainable.

While the intention of this integrated curriculum has been appreciated, the reception of the humanities courses by engineering students has faced certain resistance. In the first year of the university, the humanities courses were taught by humanities professors using conventional humanities pedagogy and this did not fare well with engineering students as they found it difficult to access the content of these humanities courses.

In the second year of the university, to address this problem of reception, we experimented with a mandatory one-credit course titled "*Entangled Worlds: Technology and the Anthropocene*". This course's curriculum was co-designed and co-taught by two professors—a humanities and a technology professor who used a novel dialogical pedagogy to deliver the course to first year and second year engineering students.

The objective of the course was to enable the students to understand the relationship between humans, technology, and the well-being of the planet. According to a growing consensus amongst geologists and earth system scientists, the human [*anthropos*] has now become the most influential and overwhelmingly destructive "geoforce" of the planet and will therefore be the crucial factor determining the future fate of the earth's biosphere [6]. This is being called the "Age of the *Anthropocene*" [7]. With the *Anthropocene* officially recognised as a formal geological epoch [8], the purpose of the course was to navigate the complex interplay between humans, technology, and the planet, and come up with *Planetocene* technologies. The term *Planetocene* is a concept that envisions an era where the primary focus is on prioritizing the needs and well-being of the planet Earth as a whole, in other words, considering the planet as the primary stakeholder.

To achieve the course objectives, the two professors (from the humanities and technology field respectively) combined their distinct expertise to deliver a curriculum that examined:

1. The driving forces behind the *Anthropocene* from a humanities perspective: This lens analysed the dominant human ethos that led to this era.
2. The role of technology in propelling the age of the *Anthropocene* as well as how technology can be reimagined with the planet as a stakeholder.

Through this work-in-progress paper, we wish to explore the effectiveness of co-designing a humanities course to bridge the humanities-engineering divide in an engineering education context. Furthermore, we wish to examine the value of a dialogical pedagogy, where the two professors from technology and humanities respectively delivered the sessions by having a live conversation on stage.

Background

In his lecture "The Two Cultures," CP Snow [9] contended that the root of numerous issues lies in the educational system's failure to adequately prepare future leaders and scientists to comprehend and respond to the consequences of advancing technology. The lecture focused not only on the divide between sciences and humanities but also on the gap between technology and humanity. Snow believed that the intellectuals and scientists alike failed to grasp the implications of the Industrial Revolution on the world's future and the moral responsibilities towards the planet [9]. The result therefore was the failure to foresee the changing responsibilities required in the educational system.

Recent research challenges the idea that today's problems are fundamentally technological. Instead, scholars like Eubanks [10], Powell [11], and Hicks [12] emphasize that the global

challenges such as climate change, deforestation, water scarcity etc. we face are arising from the ever-present but often denied entanglement of technology and culture. The siloed approach in education and the disconnect between STEM knowledge and historical and cultural knowledge further hinder the understanding of these connections. This leads to producing engineering graduates who are unprepared to grasp the social and ethical implications of their technological work [13].

It is generally acknowledged that educating engineers to be creative and inventive is essential to address the current and future challenges faced by our society [14]. In order to contribute to solving complex and highly interconnected problems, every engineering student must graduate with a well-rounded education that includes skills ranging from engaging in complex thought, analysis, quantitative and qualitative reasoning, and effective communication [15].

The suggestion made by Nobel laureate and physicist Murray Gell-Mann is that "we must rid ourselves of the notion that careful study of a problem, based on a narrow range of issues is the only kind of work to be taken seriously, while integrative thinking is to be relegated to cocktail party conversation" [14]. Some scholars maintain that employing an integrative curricular approach prepares better graduates for the workforce as well as engaged citizenship. Furthermore, many other scholars also note that an integrative approach increases students' enjoyment, engagement, and relevance to the material being learned.

Several scholars [16]-[17] advocate for alternative pedagogies for STEM fields, specifically to incorporate epistemologies from humanities, arts, and design. Historically, there have been attempts to re-invent STEM education, particularly engineering education [18], however, the movements to develop deeper integration of humanities into engineering pedagogies have not succeeded and the dominant curricular strategies have remained siloed. The recent STEAM movement represents a renewed effort, emphasizing creativity and artistic intervention within STEM education.

Markauskaite et al., [19] highlight the challenge of designing effective interdisciplinary courses. Their research explored co-design, where students and faculty collaboratively develop courses fostering interdisciplinary innovation. They identified key design principles, including: i) Student agency: highlighting students' ability to contribute meaningfully to knowledge creation and engage in real-world projects; ii) Open-endedness: acknowledging the inherent flexibility of interdisciplinary learning and the need for ongoing course development; iii) Dialogue and transparency: emphasizing continuous communication between students and faculty throughout the design process. These principles challenge traditional, pre-designed approaches and advocate for flexible, co-developed curricula. Inspired by the work of Markauskaite et al. [19], the experimented course at Plaksha University was co-designed not by students and professors but by two professors belonging to different streams.

A recent study in the UK demonstrated the effectiveness of dialogical pedagogy in university seminars. Poore [20] found that using dialogic teaching methods led to increased student engagement and learning through richer academic discussions and participation. Dialogical pedagogy refers to a wide range of teaching approaches that emphasize the power of dialogue in learning. Although rooted in the Socratic method used thousands of years ago, this approach has seen renewed interest in recent times, partly as a reaction to "neoliberal technicism" [21]-[22].

While all these approaches value dialogue, they differ in how they define it within education. For instance, Lefstein and Snell [23] see dialogue as a critical exchange of ideas between

teachers and learners, encompassing various perspectives. Therefore, they argue that dialogue is inherently present in all forms of pedagogy, whether explicitly promoted or not, as "meaning is inherently dialogical" [24]. However, what has been rarely if not ever observed is a dialogue between teachers that takes place in the presence of students. This model of professors from different disciplines conversing on a single theme from different disciplinary perspectives with the students listening in to this conversation has been implemented as a novel pedagogical approach.

In the context of our course, this dialogical pedagogy took place between the two professors as well as between the professors and students. This allowed learners to reach a conversational understanding of a complex subject matter and enabled them to actively engage in the process of learning as they listened to the different perspectives of both professors as well as their peers.

Methodology

Participation

A total of 220 engineering students (140 from the first semester and 80 from the third semester; 147 male, 73 female) from Plaksha University in India participated in this course. The students were randomly assigned to small groups of three, each of which undertook the project. The participants in this study were engineering students who had not taken humanities courses since middle school. This lack of recent exposure may have influenced their initial understanding of the relevance of humanities to their engineering curriculum.

Course Pedagogy

One of the pedagogical options to deliver the course "Entangled Worlds: Technology and the *Anthropocene*," was to take alternative sessions from the humanities and the engineering disciplines on the same theme. However, the unique pedagogy that was implemented for delivering the course was not only to co-design a single integrated curriculum but also to co-teach the sessions in the form of a dialogical conversation between the two faculty—one from humanities and the other from engineering. This collaboration ensured that the curriculum integrated both the social and technological understanding of the *Anthropocene*'s origins, challenges, and mitigations.

Dialogue formed the key component of the teaching experience. Both professors actively co-taught each session, engaging in live conversations exploring the nature of technology and its impact on our planet and society. For example, on the one hand, the humanities professor talked about definitions of the *Anthropocene,* the historical debate on its emergence as well as the relationship between the *Anthropocene* and capitalism. On the other hand, the STEM professor took forward this conversation by discussing the role of technology in the making of the *Anthropocene*, the transformation of technology from the Pre-Industrial to Post-Industrial age and highlighting its impact on the planet.

The students were not merely passive recipients of information but were also co-participants in their learning experience. They actively participated in the course by responding to the dialogue by working on an integrated project following each session. The final submission of the project included a 3-minute multimedia presentation based on the following questions:

1. *What Planetocene technology would you like to work on and how does it take the planet as a stakeholder?*

2. *How does this technology solve the problem of the Anthropocene?*
3. *What human values and traits does this technology capture and embody?*
4. *How does this technology critique destructive human values?*

Course Module Outline

The course consisted of 8 sessions over 4 weeks.

Week	Theme	Objectives
1	Beyond the Status Quo: Critiquing *Anthropocene* Technologies	• Understand the concept of technology as a dynamic and ever-evolving force • Trace the role of technology in contributing to the grand challenges of our planet
2	Critique of the Tech-Subservient Human	• Analyze how technology has controlled and influenced human behavior, perceptions, and experiences • Discuss the implications of humans being shaped by their technological creations
3	Beyond the Machine – Rise of New Humanity	• Explore the emergence of a new human paradigm where individuals gain greater control over technology • Consider the implications of this shift for human agency and responsibility in the *Anthropocene*
4	Creating Tomorrow's World: A Vision for New Technologies	• Engage in a critical examination of the relationship between the new human and the development of new technology • Explore the potential for technology to be a tool for positive change in the face of ecological challenges

Table 1: Outline of the Weekly Sessions

Data Collection

The efficacy of the Dialogical Pedagogy and Curriculum Co-Design approach was assessed based on i) a subjective evaluation of the multimedia submissions and ii) an end-of-course online feedback survey. This survey was primarily designed to gauge students' feedback on how they perceived the co-teaching and dialogical pedagogy component. The survey had both qualitative and quantitative questions. It was filled by 159 out of 220 students.

Results and Discussion

Project Submission Evaluation

Based on the evaluation utilizing a pre-defined rubric of videos submitted by the students as part of the final project submission, it was evident that the students critically engaged with the course and were able to understand its central ideas. It was evident that the engineering students not only learned to reimagine sustainable technologies but also realized the importance of reimagining a new human paradigm required for creating responsible technologies for the *Planetocene*. Some of the ideas that the students explored were how ocean fertilization can be used to stimulate phytoplankton growth and enhance carbon sequestration, bio-plastics from algae, eco-mesh use in wall cladding, hydrogen fuel cells, and plant sound detection to develop empathy with nature for solving issues like de-forestation.

Qualitative Data Analysis

The students' response in the feedback survey to the co-designing and co-teaching of the transdisciplinary course by two faculties from different fields was mostly positive. They valued the unique combination of humanities and technology perspectives, finding it "interesting," "enlightening," and "informative." They commented that the co-teaching approach enabled "engaging" discussions and "diverse opinions."

Some students desired broader topics ("It could have been better if we could have had broader topics..." - Student F) and improved pacing to avoid redundancy ("...sometimes we spend too much time on certain topics, making the class feel a little redundant." - Student G). Opinions varied on the feasibility of envisioning new technologies in a short timeframe ("It was a fun thing but to imagine a new technology in such a short time would be a bit hard" - Student J). Some desired deeper exploration of specific topics related to the transition from the *Anthropocene* to the *Planetocene* ("It is more about how exactly we can stop the *Anthropocene* and make the shift into *Planetocene*." - Student K).

As for the use of Dialogue based-pedagogy, students enjoyed the conversational and debate-like approach, preferring it to traditional lectures. They appreciated the "two-way learning" facilitated by discussions and felt it aligned with their learning styles ("Having a conversation or dialogue, was a great way to do the class, as it seemed like a debate and discussion rather than directly giving us data. I feel that this cycle of discussions and talk meshes quite well with how we as students wish to learn" - Student L, Student M).

Engagement levels varied, with some finding discussions less effective ("Not many people respond so it isn't very effective" - Student N) while others appreciated their stimulating nature ("dialogical pedagogy made us connected and alive with the course." - Student O).

Overall, students found the integration of disciplines beneficial, praising the course for providing a "bigger impact" than a purely philosophical approach ("Yes, the connection between science, philosophy, and statistical data enriches the course by providing a practical and evidence-based context for philosophical concepts, making it more impactful than a purely philosophical course." - Student P). Some suggested using case studies for deeper understanding ("I think you could delve more into case studies and study them in a more detailed way so as to get a broader scope of human ideologies, history and perspectives" - Student Q).

Many students reported that they overcame their initial negative views of humanities which they used to previously find “monotonous” (Student R) or irrelevant to engineering. “I thought humanities wasn’t very related to science and engineering, but I realise now that as an engineer it is very important to be aware about all these topics” (Student S).

Quantitative Data Analysis

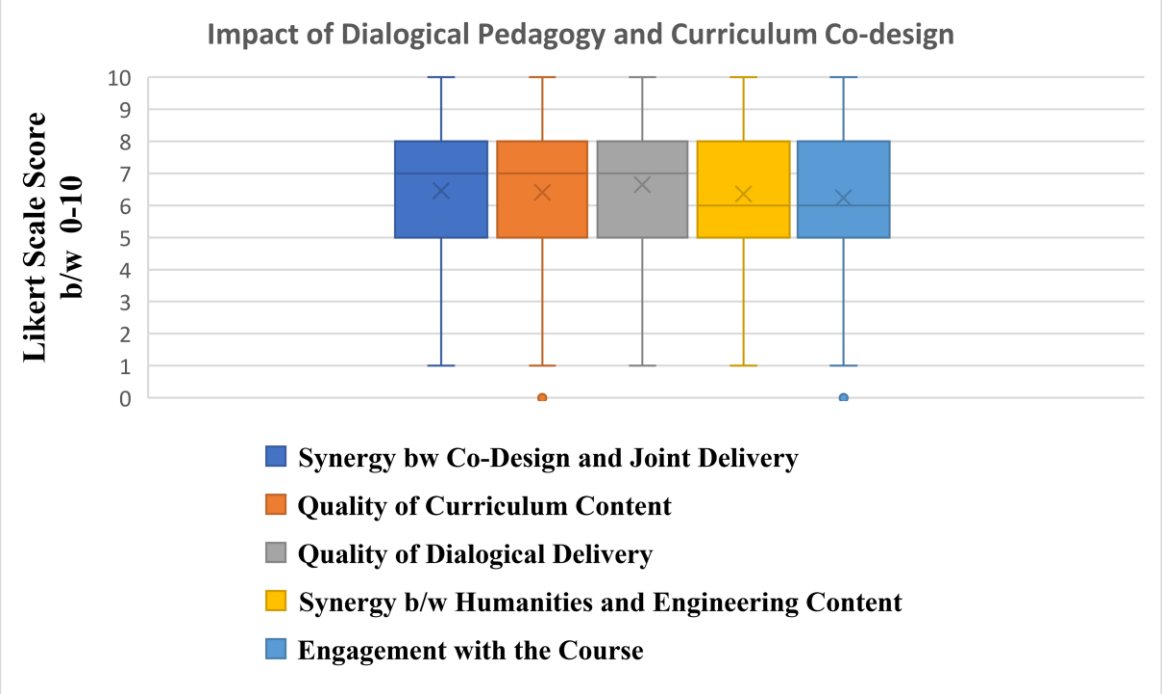

Figure 1: Box plot for Survey Questions

Student Evaluations: The course was piloted for the first time with engineering students who had limited recent exposure to the humanities. Despite this, the student feedback survey (n = 159, response rate = 72.3%) yielded generally positive results. Students reported favorably on the co-design and co-delivery approach (mean score = 6.45, median = 7.0), the quality of course content (mean > 6.4, median = 7.0), and the use of dialogical pedagogy (mean > 6.4, median = 7.0).

Areas for Improvement: On the question of whether the humanities content and engineering content were effectively integrated, the mean score is 6.35 and a median of 6.0, suggesting room for improvement. The perceived student engagement impact was unclear since this received a lower mean score (6.23) and median (6.00) compared to other parameters.

Addressing the Response Rate: While the response rate (72.3%) is acceptable, it is important to acknowledge this limitation when interpreting the strength of the positive response. Future iterations of the course may benefit from incorporating additional methods of gauging student perception and student learning.

Key Findings and Interpretation

Even though this course was co-designed and co-delivered for the very first time, the student feedback suggests a positive acceptance of both the transdisciplinary curriculum and the dialogue-based pedagogy. There is evidence that this novel pedagogical approach engaged the students and promoted a deeper understanding of the complex interconnections between

technology and the *Anthropocene*. While some areas for improvement have been highlighted, such as expanding the depth of the subject-matter and having more discussion activities, the overall student response signifies that this was a valuable pedagogical innovation in engineering education.

Limitations

Our data only represented a specific student population and course context, so generalizability and transferability may be limited. Since students self-reported their experiences based on which our impact evaluation of the course was done, there will be a certain degree of personal bias and interpretation. The quantitative measures could have been further refined to capture the nuanced aspects of the student experience.

Conclusion

This is a start of a critical study on the value of co-designing curriculum for teaching of interdisciplinary courses in engineering education and the co-delivery of curriculum by professors from different fields using dialogical pedagogy for effective student learning experiences. The findings attest that there is significant value in this approach. Therefore, future research on such pedagogies should be conducted to ascertain the efficacy of these pedagogies on student learning outcomes, career choices, and their ability to bridge disciplinary divides in their professional practice. We also can use different measurement tools and methodologies to capture student engagement more effectively in future studies.

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