New Engineers for a Bright Future: Deconstructing the Promises of Challenge-Based Learning

STUDIES IN ENGINEERING EDUCATION

New Engineers for a Bright Future: Deconstructing the Promises of Challenge-Based Learning

EMPIRICAL RESEARCH

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ABSTRACT

Background: While engineers are pivotal to technological innovation and societal problem-solving, traditional engineering education often inadequately prepares them for societal engagement. Challenge-based learning (CBL) is a pedagogical model that promotes engagement with authentic, sociotechnical, and societal challenges, promising to produce a more socially responsible engineer. Given that CBL is advanced as central to reforming engineering education, it is crucial to understand how the relation between engineering and society is conceptualized in these initiatives.

Purpose: In this paper we analyze CBL as a reform discourse in order to scrutinize what assumptions about engineering are reproduced when CBL is promoted, focusing on the relationship between reformed engineering education and engineers' societal responsibility.

Method: We investigate recruitment material from a reform initiative that aligns with the tenets of CBL. We utilize discourse analysis to analyze the rationales and interpretative repertoires the reform initiative draws on, as well as the ideological consequences of these discourses.

Results: We find that the reform initiative promises students the opportunity to be, simultaneously, societally important, professionally successful, and technically proficient. Students are not promised much opportunity for critically interrogating established engineering practices. In the process, engineering is mostly separated from sociopolitical concerns and society is equated with industry.

Conclusions: The investigated CBL initiative appears to reproduce rather than renegotiate dominant ways of thinking about engineering. As such, we argue that challenge-based learning as a reform discourse does not necessarily live up to its overarching promise of creating a new and more societally beneficial engineering profession.

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INTRODUCTION

A central concern for educational policymakers, researchers and educators alike is the role engineering professionals play in society, and how their education prepares them for contributing to societal development (Bourn 2018; Cech 2014; Eidenskog et al. 2023). On the one hand, engineers are typically seen as highly important, because they contribute to technological innovation, which may in turn drive economic growth and offer solutions to important societal problems. On the other hand, it is often argued that engineers do not live up to this potential because of inadequate training. One common concern is that engineering programs emphasize theoretical skills and decontextualized problems to the detriment of professional skills and capacity to deal with problems that include societal dimensions, such as sustainable development (Guerra 2017; Lönngren, Ingerman & Svanström 2017).

In this context, challenge-based learning (CBL) has recently become a key concept in discussions of how a new kind of engineer can be trained (Kohn Rådberg et al. 2020; Gaskins et al. 2015). CBL sets itself apart by emphasizing that students should be engaged with particular types of problems in their educational programs, namely, "challenges." These challenges should be authentic, sociotechnical and societal (Gallagher & Savage 2023). The idea and promise of CBL is that through working on such challenges during their education, students will develop capacity and willingness to take on important societal concerns in their future professional engineering practice.

However, we argue that training engineers to tackle "challenges" does not guarantee a uniformly positive societal engagement. First, what is defined as a legitimate challenge for engineering is political, as it reproduces particular views of the role and responsibility of engineers in society as well as what societal developments are especially prioritized (Herkert & Banks 2012; Mitcham 2014). Furthermore, students' understanding of engineering in society does not only depend on the type of problems they encounter, but also on the frames of reference they are supplied with to make sense of these problems. Engineers can in many ways be seen as political actors, for instance developing weapons technology (Philip et al. 2018) and making design decisions that uphold transport infrastructure prioritizing cars over mass transit (Winner 1980). Still, it is common in both engineering education and practice to talk about technical issues as separate from political or societal issues (Cech 2014; Faulkner 2007; Lagesen & Sørensen 2009) delimiting the "realm of responsibility that engineers carve out for themselves" as separate from "socioeconomic inequality, history, and global politics" (Cech 2014, p. 48). In engineering education, this demarcation of the social has been shown to work as a "depoliticization" that socializes engineering students into a "culture of disengagement" (Cech 2014) from issues that are deemed "non-technical." In the terminology we adopt in this paper, this separation of concerns can be denoted as a discursive ideology production, constructing certain roles and relations as appropriate in society (Wetherell & Potter 1988).

CBL engages students with the entanglement of society and technology, carrying the promise to produce a more responsible kind of engineer. As such, we argue it is crucial to examine what ideas about engineering in society these initiatives communicate to students and faculty. Still, the rapidly growing research on CBL in engineering education focuses mainly on benefits and practicalities of CBL as an educational *format* (Doulougeri et al. 2024; Gallagher & Savage 2023), giving little attention to what understandings of engineering are privileged in CBL initiatives and what alternative understandings may be crowded out. To understand its ideological consequences, CBL also needs to be studied as an educational reform *discourse* (Sen 2022; Staton & Peeples 2000), drawing on specific arguments and rationales concerned with the nature of engineering and its relationship to societal development.

The aim of this paper is to investigate CBL as a reform discourse, analyzing what assumptions about engineering in society it is based on and reproduces. We analyze material used to recruit students to a recently launched pedagogical CBL reform initiative at a Swedish university of technology, scrutinizing what is explicitly and implicitly communicated to students in trying to recruit them to participate in CBL. Drawing on discourse analysis and denoting coherent configurations

of discourse as "interpretative repertoires" (Potter & Wetherell 1987; Potter & Wetherell 1994; Wetherell & Potter 1988), we study information texts that describe the proposed benefits of the full CBL program as well as individual courses. We read this material in relation to literature on CBL as well as other engineering education reform discourses. In our analysis, we consider the material as representing both promises made to students regarding the benefits of participating in this particular CBL initiative and promises of the wider CBL reform discourse. Our research questions are:

1. What promises does the recruitment material make to students regarding their future as engineers if they participate in CBL and what interpretative repertoires are invoked to do this?
2. What are the ideological consequences of this discourse in framing the relationship between reformed engineering education and engineers' societal responsibility?

LITERATURE REVIEW

This section frames CBL within the context of engineering education reform and contemporary developments in society and education. We start with a background on reforms and reform discourse in engineering education, then describe contemporary developments in education policy discourse, and conclude with situating CBL initiatives against this background and the discourse of "challenges" that it invokes.

REFORMS AND REFORM DISCOURSE IN ENGINEERING EDUCATION

Pedagogical reforms always entail making prioritizations between multiple educational and professional aims (Edström 2018; Stonyer 2002). However, the assumptions underpinning these prioritizations usually remain implicit (Hagvall Svensson 2021). Since the formalization of engineering education in the 19th century, reform ideas and initiatives have abounded, often formulated in relation to imagined futures. Two large-scale shifts are usually considered when describing the development of engineering education over time (Froyd, Wankat & Smith 2012). First, following the Second World War, many countries invested considerably in strengthening the analytical and scientific ability of the engineering workforce to achieve international technological and economic competitiveness. Second, around the turn of the millennium, calls for globally competitive engineers equipped with professional skills resulted in such skills being included in accreditation frameworks and educational reforms focused on outcomes-based educational design (Felder & Brent 2003).

Educational reform initiatives such as these are generally presented and legitimized through various constellations of reform discourse, including specific narratives and metaphors through which they can be understood as timely and appropriate (Sen 2022; Staton & Peeples 2000). In the engineering education context, reform initiatives are often put forth as responses to changes outside of engineering education. This includes technological changes, changes in professional practice and, more generally, changes in society. A particularly common argument is that there is an increasing speed of technological change that engineers need to learn how to manage, and that many engineering programs fail to develop appropriate skills because of their overly "traditional" curriculum (see for example Díaz Lantada 2020). Discourse theorists have emphasized that such narratives and arguments need to be critically scrutinized, because reform discourse constitutes a powerful form of governance (Bacchi 2000). For instance, Dishon (2021, p. 166) points out that framing educational reforms as unavoidable responses to changes in society "conceptualizes education mainly in instrumental terms [...] at the expense of education's traditional role of shaping society." Similarly, Hagvall Svensson (2021), reviewing the literature on reformed teaching methods in engineering education, argued that the framing of these initiatives risks obscuring value judgements and prioritizations underpinning educational reforms. In short, there is a need for critical interrogations of how reform initiatives in engineering education are legitimized, supported by specific discourses and underpinned by specific normative assumptions.

PROFESSIONAL SKILLS, EMPLOYABILITY AND THE NEW ENGINEER

During the 1980s and 1990s, Western education policy increasingly emphasized "generic skills," in addition to traditional disciplinary knowledge. This was done with the argument that these skills would better prepare students for a changing labor market. This developed into a discourse of "21st century-skills," in response to a supposedly increasingly uncertain future (Dishon & Gilead 2021). In engineering education, this led to "professional skills" being encoded in accreditation frameworks and qualification systems (Akera et al. 2019; Lucena et al. 2008). This trend was connected to repeated calls for educating "the new engineer" (Beder 1998).

Conlon (2008) identified two different and potentially competing visions of engineering contained in the demand for "the new engineer;" as focused on either employability or social responsibility. Conlon argued that a narrow focus on professional and social skills with the goal of employability may fail in the important task of developing engineers' sense of responsibility for a socially just, equitable and sustainable world. Berge et al. (2019), in a study of how engineering education is marketed on Swedish university websites, found that both these visions were promoted alongside the traditional "technicist" engineer. Faulkner (2007) showed how professional boundary work in engineering often involves a tension between the technical and the social, for example in the (problematic) distinction between "hard" and "soft" skills. This "social/technical dualism" is at the heart of engineering identity (Faulkner 2007, p. 332).

Another way of understanding the focus on employability and professional skills is that they reflect a neoliberal turn in the goals and nature of education, commodifying education (Southwood 2017) and additionally putting the responsibility of (un)employment on individuals (Moreau & Leathwood 2006). The policy discourses promoting professional skills and employability may mark a shift in the power to define what knowledge is seen as valuable, from the institutions and professions, to the state and the market (Boden & Nedeva 2010). Consequently, critical analyses of how employability and professional skills are framed in engineering education have outlined how curricula focused on employability harbors what can be called a "neoliberal hidden curriculum" (Nudelman 2020), visible also in student recruitment materials (Berge, Silfver & Danielsson 2019).

CHALLENGE-BASED LEARNING AS A PEDAGOGICAL APPROACH

CBL is a pedagogical approach where students work together in project form to find solutions to "challenges" (van den Beemt et al. 2023). It has roots in developments in the early 2000s in higher education biotechnology (Birol et al. 2002) and as part of Apple's project "Classrooms of Tomorrow–Today" aiming to meet the needs of the 21st century workplace (Gallagher & Savage 2023; Leijon et al. 2022; Nichols & Cator 2008). Malmqvist et al. (2015, p. 1) defined CBL as learning experiences where "the learning takes place through the identification, analysis and design of a solution to a sociotechnical problem. It is typically multidisciplinary, takes place in an international context and aims to find a solution, which is environmentally, socially and economically sustainable." As such, CBL is well aligned with education for sustainable development (ESD), which calls for students to develop skills in cross-disciplinarity, perspective-shifting, critical thinking, emotional skills, and the merging of social and technical perspectives (Högfeldt et al. 2019; Lönngren et al. 2023; Martínez-Acosta, Membrillo-Hernández & Cabañas-Izquierdo, 2022; O'Flaherty & Liddy 2018; UNESCO 2021). The connection to sustainability has been emphasized in several CBL initiatives in engineering, focusing on for example cross-disciplinary collaboration and sustainability (Kohn Rådberg et al. 2020), North-South collaboration (Högfeldt et al. 2019), sustainable development in local communities (Martínez-Acosta, Membrillo-Hernández & Cabañas-Izquierdo 2022), and ethics and epistemic uncertainty (Martin et al. 2022). In other fields such as communication, CBL has been explored as a feminist pedagogy where students are engaged as change agents (Cruger 2018).

Studies of CBL in the context of engineering education have mainly focused on understanding its implementation as an educational format. For example, Dolougeri et al. (2024) in a review of CBL in engineering found that most studies find positive student-reported measures of competence development and also highlight practical challenges of CBL concerning workload and assessment.

CBL is overall positioned within a narrative of positive change, but the broader implications of the discourses underpinning CBL have not been studied to any significant extent in previous literature.

THE CHALLENGE REPERTOIRE

Distinguishing CBL from other similar pedagogical approaches, such as problem-based learning and project-based learning, is the use of the word "challenge." What a challenge is, and how working with challenges is different than working with problems or projects is thus central to the appeal of CBL. Commonly, the CBL-literature describes challenges as not pre-defined, but as defined by students, stakeholders and teachers together. A challenge should be authentic, sociotechnical, and relate to broad societal questions of sustainability (Gallagher & Savage 2023). However, the conception of what constitutes a "challenge" varies and Gallagher and Savage urged researchers to approach the question with clearer definitions.

We argue that the use of the word "challenge" in CBL needs to be understood as part of a larger global discourse of grand challenges. Kaldewey (2018) described how scientists and policymakers over the last 50 years have increasingly used the term "challenges" instead of "problems" and that this represents a conceptual shift in how science and technology is framed in relation to society. This challenge discourse is highly visible in policy and public discourse and well established in engineering education. One example is the "grand challenges" for engineering, where fourteen grand challenges that "await engineering solutions" were identified by the US National Academy of Engineering (Malmqvist et al. 2015; National Academy of Engineering 2008, p. 2). These challenges state a desired direction of (the American) engineering profession and can be understood as a "project of professional self-definition," marking a particular and very optimistic understanding of the role of engineers (Slaton 2012). This particular discourse has been criticized as reproducing the social/technical divide when societal problems are made into technical problems, while questions of social justice are ignored (Nieusma & Tang 2012).

Characterizing the differences in how the terms "challenge" and "problem" are used to describe the concerns of science, Kaldewey (2018) argued that "problem" appears to denote something smaller, well defined, and contained within the disciplines. In contrast, "challenge" places emphasis on the interaction between science and society, where scientists are increasingly expected to be motivated not by intra-scientific problems but by what is urgent and societally important. The shift towards (grand) challenges is further characterized by a positive "ideology of feasibility" carrying the implicit assumption that challenges are "ambitious but achievable" (Kaldewey 2018). It is illuminating to compare this with the simultaneous increase in the use of the term "wicked problems" (Rittel & Webber 1973), which has also informed discussions of how engineering should engage in societal problems such as sustainability (Lönngren & van Poeck 2021). Wicked problems are characterized as lacking unambiguously good solutions, as they are embedded in normative systems with competing values and objectives (Lönngren, Ingerman & Svanström 2017). Kaldewey (2018, p. 168) suggested that the difference between wicked problems and challenges is "one of framing: today, most participants in the GC [Grand Challenges] discourse adopt the optimistic futurological stance [...] and conceive of challenges as solvable." The positive role of engineers in the NAE grand challenges combined with the "ideology of feasibility" represents an ideology of *futuristic techno-optimism*, the idea that technological development in itself leads to positive future outcomes (Danaher 2022).

To conclude, CBL holds a position within engineering education as a contemporary and innovative, "state-of-the-art," pedagogy well in line with best practices (Graham 2018). This pedagogical approach is discursively positioned to fulfill the increasingly urgent demands on reforming engineering education to address global challenges and develop professional skills. CBL thus holds the potential to frame what sustainability and societal engagement is taken to mean in reformed engineering education. However, it is still unclear what assumptions about engineering in society CBL initiatives are based on and reproduce. In this paper, we therefore investigate what is explicitly and implicitly communicated when CBL is marketed to students.

METHODOLOGY

THE STUDIED CASE

This paper is part of a larger research project focused on ideological dimensions and dynamics of a recently launched pedagogical reform initiative at a Swedish university of technology. For brevity we call this initiative NCCP (New CBL Course Package). NCCP is the outcome of a 10-year undertaking to develop and test a new model for engineering education built on CBL. It involves the development of new courses where students work in cross-disciplinary teams on project topics of relevance to engineering researchers and societal and industrial stakeholders. Apart from being inspired by CBL, the program design was guided by local studies of what motivates students and what they miss in their education.

At the time of the study, the NCCP courses were an elective for students in some bachelor programs from year two, most engineering master programs, as well as alumni. Courses were given in English and the goal was to have a range of students from different programs in the same course. The courses were project-based and organized within areas, chosen to be current and relevant to researchers and students from varied backgrounds. Students worked together on a range of "new and cross-disciplinary societal and research challenges" (info on student main portal webpage). A new learning environment was connected to the initiative, offering facilities to design, build and test artifacts as well as areas for group work.

The program and courses were advertised to students and other stakeholders through a student portal and the university website. Since courses within the initiative were offered to students from year two, recruitment occurred primarily from within the university, even though the initiative was also promoted in the university's external recruitment channels.

MATERIALS

In informal interviews with the NCCP management and the university's communication department, three main communication channels about NCCP were identified. These were the university's official webpage, a student portal functioning as the university's main way of posting information to students, and through the university's learning management system from which emails with information about NCCP were regularly sent out. All documents available through these channels were collected, spanning between 2019 and 2021. A search in these channels for documents and web pages mentioning NCCP resulted in 180 documents and web pages that were collected in qualitative data analysis software NVivo 14. Two kinds of information were available through these platforms, general information about the program (the "program information"), and course specific descriptions detailing each course. Both the program information and the course descriptions contain pictures as well as written text. While the main object of analysis was the written text, the pictures were viewed together with the text during analysis and influenced our interpretations. Included in the final analysis were:

> **The program information**: The main web pages of the three communication platforms where NCCP is mentioned, the information in emails sent to all students and three news articles that describe NCCP and that are linked from the main platform.
>
> **The course descriptions:** 25 course posters, one to two pages long, available on the main web pages, each presenting a course within NCCP. Most posters consist of two parts, the first presenting and motivating the course theme and content, and the second giving practical information about how the course is run and how to apply.

The program information describes NCCP, motivates why it is implemented at the university, why students should apply, and informs about the practical details of applying for courses. Even though it consists of a large number of different documents with slightly different purposes, the material is rhetorically uniform. The tone of these documents is well in line with the discourse used by university management in both internal and external communication, which can be recognized as a particular kind of "technical university jargon" also used by other technical universities. For the

sake of this study, we regard this discourse as an official communication by the university, rather than the output of individuals, even if some of the materials has a specified author.

The analyzed material has the double purpose of bolstering the brand of the university and recruiting students. It should be understood in light of how university policy and communication, in response to the marketization of higher education, increasingly serves a promotional and branding purpose (Fairclough 2010; Feng 2019; Xiong 2012). These texts are products of, and limited by, a complex field of recruitment discourses, university branding, discourses in vogue in higher education and the reproduction of the engineering/technical research community by "the selection and formation of newcomers" (Andrée & Hansson 2014). Program leaders and university communicators are bound to use these forms of communication, in order to fulfill the multiple functions of providing information, advertising courses to students as part of a unique university experience and promoting the university brand (Askehave 2007). Since the material does not include personal information, no ethics approval was required for this study, according to Swedish law.

THEORY

We use the theoretical approach espoused by Wetherell and Potter (1988), called "discourse psychology." Central to this approach, is the social constructionist notion of language as not only *describing* but also *constructing* the world that is perceived and interpreted by people (Gee 2014; Wetherell & Potter 1988). That our view of the world is socially constructed does not mean that it is arbitrary, but rather contingent on history. Discourse is structured and limited by previous uses of language; we have to use already established meanings for our language use to make sense. Potter and Wetherell (1987, p. 138) outlined an approach for interpreting such patterns of continuity in discourse, denoting them as "interpretative repertoires" that are "drawn upon to characterize and evaluate actions and events" in a certain social setting.

Central to the notion of interpretative repertoires is that they represent both the fixity and malleability of discourse. People have to use established repertoires to be intelligible to others. At the same time, there is agency and flexibility in choosing to use one repertoire over another or combining multiple repertoires. Drawing on a certain interpretative repertoire in a social situation has consequences for how that situation is interpreted, and what social interactions appear reasonable. This means that discourse in practice "does things," it is "action oriented" and never neutral (Wetherell & Potter 1988). The action of discourse can be explicit, such as suggesting it is time for dinner or answering "yes" to a proposal. Language is then directly performative, but actions can also be more implicit and indirect, when particular forms of discourse have consequences that may not be intended or comprehended by the speaker. Discourse thus always has a "function," intended, unintended, direct or indirect:

> We can think of a continuum from more "interpersonal" functions such as explaining, justifying, excusing, blaming and so on, which define the local discursive context, to the wider purposes discourse might serve — where, for instance, a social analyst might wish to describe an account, very broadly, as having a particular kind of ideological effect in the sense of legitimating the power of one group in a society. (Wetherell & Potter 1988, p. 169)

This discourse psychological approach is helpful for analyzing a range of functions of language use. This includes paying attention to the function of silences as what is not said and left out of discourse, is as important as what is said. Discourse can also have the function of *not* producing the effects that it names. Such "nonperformatives" are not necessarily failures, but as Ahmed outlined in an analysis of institutional commitments to equality, such commitments "work" by not bringing about their effects while appearing as if they do (Ahmed 2006). We use nonperformativity to understand not only the functions of the NCCP discourse in productive terms but also to analyze what the material fails to do and why.

We intend to analyze what meaning is produced in the NCCP recruitment material, in terms of the explicit functions of recruiting students to the courses, but more importantly also in the wider

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implicit functions ("ideological effects") of how the material is presented. Importantly, these wider functions, which we will henceforth describe as *ideological consequences*, are not explicitly available to the analyst, but are conclusions drawn from an extensive analysis process. This process involves interpreting the material in the context of the broader interpretative repertoires in which it is situated (Wetherell & Potter 1988, p. 170).

We understand the information about NCPP available to students as having (at least) two general implicit functions. First it communicates a message about what a good engineering student is, signifying what could be called idealized engineering identity positions (Berge, Silfver & Danielsson 2019). This is in line with an understanding of identities as enacted through discourse (Gee 2014). Second, it makes certain futures and roles for engineering, in relation to society in general, imaginable and desirable. As the NCCP material employs CBL to promote the university as committed to reforming engineering education, it also produces assumed promises of a wider CBL reform. The configuration of these promises has ideological consequences by constructing certain futures as important and desirable (Ahmed 2010), thus defining a positive (promising) direction for engineering and engineering education.

ANALYSIS

In order to study the meaning communicated in marketing the NCCP program, we use the analytical toolbox outlined by Potter & Wetherell (1987; 1994) as well as Ahmed (2006). We explore both the discursive configuration of the material and the functional role of it. This includes looking for how interpretative repertoires are flexibly used and combined, what silences remain, and how these configurations serve to define identities and socio-political relations.

Potter and Wetherell (1987) suggested discourse analysis as proceeding from open and inclusive coding of extracts possibly pertaining to the research question, to looking for regularities and irregularities in language use. Hypotheses about interpretative repertoires as well as the functional role of these repertoires, can then be formed. This central analysis phase is iterated multiple times, moving back and forth between the data, the interpretations and the literature to look for coherence, alignment and possible fruitfulness of the proposed interpretations. Therefore, in the final report, interpretations are presented together with data excerpts as well as supporting literature.

The first phase of the analysis aimed to answer the research question of what is promised to students applying to NCCP. The analysis started with open coding (Flick 2009) of all the collected material, looking for "selling points" and focusing first on the program information and second on the course descriptions. This resulted in a large number of positive characteristics that were re-read and sorted with a look to any "recurring organizations" in the material (Wetherell & Potter 1988, p. 177). These recurring patterns were summarized according to their explicit function as a number of *rationales* that can be said to be answers to the question of why a student should choose this program or this course.

In the second phase, to shift the focus to the implicit functions of the texts, we identified the interpretative repertoires the material drew on in order to make sense. This involved analysing the terms and metaphors used, how they are invoked and which wider societal meaning these terms have. One example is the word "challenge" and what it signifies in an engineering education context, for example which qualifiers are used for described challenges (see analysis below). Delineating different interpretative repertoires was done by identifying this type of variation in language use (Wetherell & Potter 1988, p. 172), and relating it to previous research. Attention was paid not only to what is written but also to what is not communicated in the material.

The third analysis phase involved exploring how rationales and interpretative repertoires are configured in the material to address the second research question focused on the ideological consequences of the texts as a whole. To understand how the repertoires are blended and fused in the material we use the concept "boundary repertoires," that is, "plastic" repertoires that work "across discursive practices in order to construct recognizable justifications of actions" (Andrée & Hansson 2020, p. 556).

RATIONALES, REPERTOIRES AND PROMISES IN THE PROMOTION OF CBL

In this and the following section we present our analysis of the NCCP material. Our interpretations of the material are presented and related to the previous research needed for analyzing the function of the interpretative repertoires invoked. As in all discourse analytical work, the results must be seen as analytical categories that could be partitioned in other ways but serve to illuminate the general structure of the material (Gee 2014).

This section presents our analysis answering research question 1, what promises are made to students in recruiting them to the CBL initiative. The analysis resulted in 12 rationales, organized within three clusters of meaning, and drawing from six interpretative repertoires. See Table 1 for an overview. Overall, the rationales within the first and second clusters are more commonly invoked in the program information, while the rationales in the third cluster are almost exclusive to the Course descriptions. The three clusters each communicate a promise: the *Promise to be societally important*, the *Promise to be professionally successful*, and the *Promise of sated curiosity and important knowledge*. These promises suggest what should be desirable to students, while at the same time defining the NCCP-program practice and motivating its significance. While the promises are analytically separated, their messages are not presented separately in the material, but are seamlessly fused together, sometimes in the same sentence. For clarity, we present and describe the three promises separately. In the next section, focused on research question 2, we come back to the ideological consequences of the interconnectedness of these discourses.

Table 1 Summary of rationales, associated interpretative repertoires and the promises promoted in the material for recruiting students.

PROMISES	RATIONALES	MAIN ASSOCIATED REPERTOIRES
Promise to be societally important	• Solve real challenges • Work on sustainability • Contribute to society • Work cross-disciplinarily • Learn to critically examine the role of technology in society	• Challenge-based learning • Sustainable development and ESD • Futuristic techno-optimism
Promise to be professionally successful	• Learn professional skills • Become employable • Individualize your education • Flexible education for society	• The new engineer • Employability
Promise of sated curiosity and important knowledge	• Learn specific content knowledge • Learn topics that are important in industry or research • Learn topics of personal interest	• Inherent value of science and technology • Passionate interest in science and technology

THE PROMISE TO BE SOCIETALLY IMPORTANT

Five rationales for choosing NCCP promise students to be societally important: *Solve real challenges*, *work on sustainability*, *contribute to society*, *work cross-disciplinarily* and *critically examine the role of technology in society.* This cluster of rationales motivates NCCP by drawing on ideas of a new kind of engineering education and practice that is closer to society. It paints the state of the world as in urgent need of intervention by engineers, and the NCCP program as answering to that need.

Solve real challenges

The rationale of *solving real challenges* is central to the whole material and our analysis, and we will therefore discuss at length how this rationale appears in the material and how the concept of challenges is used and situated within greater societal discourses. The way that challenges

are described in the program information aligns well with the general meaning and use of challenges in the challenge repertoire, as discussed in the literature review. A challenge appears to denote a situation that is not under control, where there is work in progress and where coming to a solution implies a positive impact on the future. Challenges are mentioned a large number of times and modified in terms of the domain they focus on, their temporal properties and a number of other properties describing the size, complexity and place of challenges, see Table 2.

Table 2 Words used before the term "challenge" in the text, modifying its meaning.

Domain	societal, scientific, deep research-related, reality-based.
Temporal	new, contemporary, recent, future/of the future, current
Other	global, grand, large, broad, complex, cross-disciplinary, real

The domain modifiers describe challenges as focused on either society or science while connections to companies, industry or engineering practice are absent. The temporal modifiers further place challenges in the present time or future, thus excluding problems that are old, persistent or still in need of solving. This is interesting, as for example, sustainability could be argued to be an old problem, present at least since humans first started affecting the environment by growing crops and changing water courses. The portrayal of challenges as new further positions the engineer primarily as an innovator, while the material is silent on challenges of maintaining our current infrastructure.

Challenges are further described as global, grand, large, broad, complex and cross-disciplinary. Finally, challenges are described as "real." Students will work with real problems, real stakeholders, close to reality. NCCP is thus positioned as different from other, "traditional," supposedly less real, courses or programs at the university.

While specific challenges are not described in the program information, there are a few descriptions of areas that courses and challenges are placed within, for example: the health sector, developing sports technology, sustainable transports, AI and emerging technologies. These areas of challenges are mentioned together without further specification of why they are important, or any prioritization between them:

> "We create an arena to train students to solve the major global challenges," says [one of the leaders of NCCP]. And there are plenty of global challenges, in areas such as sustainability, transportation and infrastructure, energy, global systems and vehicle safety. (program information)

These general area descriptions, together with the sweeping nature of the words used to describe challenges, create an impression of challenges as well-defined, non-political and unproblematically shared between global contexts, stakeholders, students and teachers. It is uncertain whether this harmonious picture of the challenges faced within for example the health sector would be shared by all stakeholders, including students with various backgrounds and identities (see e.g. Cech 2012).

A large proportion of the course descriptions align with this rhetoric of challenges through presenting a narrative where the course content is crucial to creating solutions. A striking difference between the program information and course descriptions is that the latter in many cases describe challenges as industrial or connected to engineering practice, something that is entirely absent from the program information:

> Task 1) Present a report on: What makes a materials thermoplastic and why is cellulose fibers not? How can thermoplasticity be determined? Make an interview with predefined companies around their experiences and challenges using thermoplastic materials Task 2) Identify one challenge with the lack of thermoplasticity for lignocellulose materials and present how this challenge can be overmastered Task 3) Perform work (lab or theoretical) to master this challenge Task 4) Write and present orally a summary report for industrial partners (course description)

In this course description, the challenge is entirely the concern of a predefined company and the written report is to be presented only to the industrial partners. While not every course description is this specific, we interpret this pattern as a possible failure of the individual courses to live up to the more grandiose (global, societal, complex) ambitions of the program information as "society" becomes equivalent to industry and grand societal challenges are reduced to sustainability adaptations in industry.

Work on sustainability

Working on sustainability is the only challenge that also explicitly functions as a separate rationale for why students should choose NCCP. It is the only specific challenge not just briefly listed but also expanded upon in the program information. In general, this rationale draws on an interpretative repertoire of sustainable development, including its many positive connotations.

> Sustainable development requires collaboration
>
> In [year], the first pilot round of [NCCP] started and now the courses are in full swing. [University] students from [a majority of] master's programs were represented in the [NCCP] courses last year, and the idea is for students to meet across program boundaries and take on current and reality-based challenges together. "I believe that many young engineers today want to contribute to sustainable development and the problems we face require systemic changes. Therefore, we must be prepared to work across borders if we are to contribute to a sustainable transition," says [a NCCP student] (program information)

In this quote, students are expected to be motivated by working with sustainability, which in turn demands cross-disciplinarity. This is in line with how cross-disciplinarity is seen as an important skill in the literature on education for sustainable development (UNESCO 2021). It is noticeable that other skills discussed as crucial in this literature are absent here, such as critical thinking, the merging of social and technical perspectives (O'Flaherty & Liddy 2018), and the emotional capability to act when no single good solution can be identified (Lönngren, Ingerman & Svanström 2017). Overall, sustainability plays an ambivalent role in the material, where some quotes, like the one above, frame the whole program as a sustainability effort, while others place sustainability as just one challenge on equal footing with others.

Contribute to society

In the quote above, sustainability is described as of particular importance to students who want to contribute. The *contribute to society* rationale states that students should choose NCCP because they want to contribute to society during and after their studies. Apart from the quote above, there are two further places where contributing is mentioned explicitly:

> Why should you choose [NCCP]? You want to be part of the latest research and contribute to solving current societal issues as part of your degree programme (program information)
>
> We create opportunities for students who have a need to commit. If they are interested in climate change they can choose courses close to real up-to-date problems and learn how to solve them through their education. (program information)

While contributing is thus only mentioned a few times in the material (and only in the Programme information), it is explicitly expected to be motivating for students. The opportunity to contribute and a sense of social responsibility can also be understood to be implied in the more general talk about solving societal challenges. This, as well as the focus on cross-disciplinarity, is in line with the repertoire of the new, more societally responsible, engineer (Berge, Silfver & Danielsson, 2019; Conlon 2008). However, the extent of this societal responsibility remains vague in the NCCP material.

Work cross-disciplinarily

That students will *work cross-disiplinarily* is mentioned a large number of times in the material but not explained or expanded upon. In general, the need for cross-disciplinarity is motivated by the nature of the challenges that are to be solved:

> Engineering and architecture programs are usually organized by discipline: mechanical engineering, chemical engineering and so on. Deep subject knowledge is necessary for quality engineering work, but engineers also need to develop interdisciplinary skills, as broader systems thinking is required to solve the challenges of the future. [The NCCP] courses bring together students with different skills and backgrounds to work together on current societal challenges. (program information)

> The very nature of our predicament requires trans and interdisciplinary collaborations between experts in all fields, therefore, this course brings students together from various disciplines to collaborate and solve real-world challenges through 'live, smart building projects' (course description)

In these quotes we see how cross-disciplinarity is placed in the middle of narratives of societal need, connected to images of a current or future society. It is also contrasted with traditional engineering education that is assumed to provide deep subject knowledge while being organized within disciplinary bounds (Berge, Silfver & Danielsson 2019). New engineering skills, on the other hand, are to be achieved by working across disciplinary boundaries. This association between single-disciplinarity and old or outdated pedagogy is further indicated as cross-disciplinarity is connected to the "challenges of the future." The opportunity to work cross-disciplinarily is strongly promoted in the NCCP material.

Critically examine the role of technology in society

Critical perspectives have been argued to be central for societally relevant, sustainable engineering (Conlon 2008). Two course descriptions, which we characterize as social science topics taught by non-engineers, differ from the rest of the material by explicitly drawing on such content and rhetoric. The first involves discussing technology and ethics based on science fiction and aims to "establish habits of ethical reflection." (course description) The second is a course on technology and politics, drawing on science and technology studies. The rationale for choosing these courses is that students will *learn to critically examine the role of technology in society* and it cites critical and social science-oriented interpretative repertoires. The skills of ethical reflection and critical examination are aligned with the more social responsibility-oriented side of the repertoire of the new engineer (Conlon 2008). While these skills are well aligned with the *Promise to be societally important*, the rhetoric with which they are discussed is not: no challenge, future, cross-disciplinarity or skills vocabulary is used. Furthermore, ethics, social responsibility, and political perspectives are overall absent from the rest of the material.

The five rationales discussed in this section (*solve real challenges, work on sustainability*, *contribute to society*, *work cross-disciplinarily* and *critically examine the role of technology in society)* draw from a cluster of interconnected ways of talking about engineering and engineering education that we see as having the function of promising students to be societally important. This is well aligned with CBL, and NCCP is largely positioned as a CBL-initiative. To be attracted to NCCP by this promise, students should be motivated by the chance to contribute to a better world by engaging in cross-disciplinary work and learning on real, urgent, societal challenges. This is an idealized identity position in line with the discourse of the new engineer (Berge, Silfver & Danielsson 2019). Here, learning is not neutral or intrinsically justified but should contribute to the betterment of society. However, tensions between different perspectives, different dimensions of sustainability and between stakeholders, often emphasized in CBL, are largely absent in the *Promise to be societally important*. Social responsibility and critical perspectives on engineering are suggested by two course descriptions, which substantially break the rhetoric of the rest of the material by not drawing on the challenge repertoire. These two exceptions work to emphasize the absence of

critical perspectives from the overall repertoires invoked here. Largely, the *Promise to be societally important* communicates a straightforward "promising" direction, where technical solutions to a multitude of (grand, global and industrial) challenges can be expected to move society towards a bright future.

THE PROMISE TO BE PROFESSIONALLY SUCCESSFUL

Four closely interconnected rationales for choosing NCCP promise students a successful career: *Learn professional skills*, *become employable*, *individualize your education* and *flexible education for society*. These rationales are primarily employed in the program information, and much less in the course descriptions, with a few exceptions that we will come back to at the end of this section.

Learn professional skills

Students should choose NCCP because it will help them *learn professional skills* that engineers need:

> The interdisciplinary teamwork offered within the [NCCP] courses develops your knowledge and skills in areas such as teamwork, ethics, communication and entrepreneurship—so-called professional skills—without compromising the more in-depth subject knowledge that each course provides. (program information)

> When I was [a student at the university] you were often given a lab assignment to complete from A to Z. Deep and narrow subject knowledge is very important in working life, but through [NCCP] students also get the opportunity to develop their professional skills, such as working in teams, networking, working independently and solving abstract tasks together with others! This is a different kind of knowledge that employers really want today. (program information)

In these quotes, "professional skills" are associated with a shift from how engineering traditionally has been taught. We have already described how cross-disciplinarity distinguishes new engineering from old, and here a further difference is created when NCCP is set apart as providing authentic experiences of "real" engineering practice, supposedly not provided in old engineering education:

> The [NCCP] courses use a team-oriented and project-based way of working that is similar to what awaits students in real work life. (program information)

By using teaching approaches that mirror real engineering practice, NCCP purportedly provides the skills engineers need and industry is asking for. The emphasis on the realness, or authenticity, of the problems the NCCP students work with runs through all the Program information.

We recognize this professional skills rationale as also drawing on the familiar repertoire of the new engineer. However, just like Berge et al. (2019) noted in their study, new professional skills are in these quotes mentioned together with an emphasis on "traditional" deep subject knowledge. While in the previous section we saw how these skills are motivated by sustainability and social responsibility, here they are made desirable by being what employers wish for (see Conlon 2008).

Become employable and individualize your education

NCCP courses are claimed to give students an advantage when applying for future jobs, a rationale that they will *become employable:*

> Why you should apply for a [NCCP] course!
>
> - You are looking for a unique educational opportunity that can kick-start your career
> - You want to gain experience of working in a team with mixed backgrounds and skills, as a preparation for your future working life
> - You want to improve your CV (program information)

Similar to the *learn professional skills* rationale, this draws on the repertoire of the new engineer. It also draws on a repertoire of employability, part of a neoliberal turn where the main purpose of education is to enable students to create an attractive professional profile (Berge, Silfver & Danielsson, 2019; Moreau & Leathwood 2006). In general, the idea of generic or professional skills and employability is intertwined with discourses of commodification of education that frames students as products that the university is producing for the industry (Boden & Nedeva 2010; Southwood 2017). In the material, this is visible in how the sought-after skills are commonly argued to make students competitive on the job market rather than well-prepared to participate in engineering practice (even if these two also sometimes go together):

> The industry representatives that [the University] collaborates with believe that [NCCP] gives students a great competitive advantage in their future careers. The experience of working in mixed teams is requested by many companies. (program information)

The logic constructed in the material is that students participating in NCCP will be competitive because the education is up-to-date, involves realistic practice and gives students networking opportunities. Flexibility and individualization are also put forth as competitive advantages. Students are described as wanting and expecting such individualization:

> [NCCP] is a new educational initiative that consists of elective courses, and developments to the educational system and [the university's] learning environments at [campus]. [...] One important purpose of [NCCP] is to cater to the students' wishes for a more individual and flexible education. (program information)

In this way, the engineering student is assumed to desire to make individual choices to maximize their attractivity on the job market. The rationale *individualize your education* thus goes hand in hand with professional skills and employability. It serves the function of being one of the main reasons to implement NCCP, because the university needs to "'[m]eet the students' expectations and need for a more individualized study plan."

Flexible education for society

The last rationale of this promise is *flexible education for society*. Since NCCP lies outside the ordinary course system it is possible to create new courses within a few months, dealing with current topics or responding to industry need for a particular skill set. This is emphasized as a purpose of NCCP in the program information:

> To develop the education including flexibility, interdisciplinary knowledge and capabilities for faster adaptation to new situations—exemplified in the spring of 2020—everyone needs to practice managing uncertainties, to adapt to the situation and to create new solutions with limited information about the future. (program information)

In contrast to the other rationales, this rationale does not seem to speak directly to students but rather appears to be about university branding. Since society is changing at a fast pace, the university needs to be flexible, and the offered courses need to be up to date and relevant. This is in line with a view of education as responding to the accelerating change in society (Díaz Lantada 2020; Dishon & Gilead 2021).

The four rationales, *learn professional skills*, *become employable*, *individualize your education* and *flexible education for society*, which are primarily invoked in the program information, together communicate a *promise to be professionally successful*. These rationales all draw on neoliberal repertoires where education is an instrument for producing a flexible workforce ready to adapt to the needs of the market. The course descriptions contribute little to this promise, with a few exceptions. One course for example aims to develop "communication and teamwork skills to successfully integrate key roles" and another aims to equip students with a "professional toolbox." (program information)

THE PROMISE OF SATED CURIOSITY AND IMPORTANT KNOWLEDGE

While the program information and course descriptions share many rationales for students' applying to an NCCP course, there are a few rationales that are only invoked in the course descriptions, and these draw on other interpretative repertoires than the rest of the material. As can be expected, the course descriptions discuss the specific content knowledge that will be gained through the courses, but are also less focused on skills. These descriptions of specific knowledge serve as motivations in three rationales.

First, in *learn specific content knowledge,* the content of the course is described but not motivated and thus expected to be sufficient reason for the well-informed student to choose the course. Second, in *learn topics that are important in industry or research*, the content is described as important for being able to take part in emergent areas of industry or in ongoing research. It involves arguments for the authenticity of the topics that students will learn by explicit references to current industrial practices or scientific advances.

> The course aims to provide the students with fundamental knowledge about data science (including AI and ML) as well as skills in applying data science techniques for improving production systems and product development. (Course description)

> [The university] is now building a quantum computer and you can contribute to this development! Quantum computers are machines first envisioned by Richard Feynman to solve numerical and simulation problems that would take millennia even with the fastest supercomputers. Quantum algorithms make use of spooky quantum phenomena such as superposition and entanglement to reach this speedup, and this is why blue chip companies, such as Google, Microsoft and IBM and several research institutes are now investing in quantum computation. (Course description)

While this appeal to research or industry-relevant knowledge could be argued to align with the focus on employability in the *promise to be professionally successful* discussed above, it is different in its focus on specific knowledge rather than on general skills. The rationales *learn specific content knowledge* and *learn topics that are important in research or industry* thus do not primarily draw from the new engineer repertoire but rather from a more traditional repertoire of the value of techno-scientific knowledge in engineering education.

The third rationale of this promise is *learn topics of personal interest*. For example, the marketing for the quantum computing course builds on the relevance of current industrial practices and scientific advances, as well as students' expected interest in fundamental physics (and its heroes). This illustrates a simultaneous appeal to the importance of the area and the students' expected strong interest in the subject, whether it is quantum algorithms making use of "spooky quantum phenomena," or, as in another course, the fascinating properties of ceramic materials:

> Have you ever wondered what makes ceramics and hard materials so special and why ceramics can be found in so many different applications? Have you wondered if these materials can be part of the rapid change in technologies in today's and tomorrow's society and how they can become key players in future sustainable solutions in the fields of energy, communication, engineering, and consumer products? If you are interested in these topics, then join [the course]. (Course description)

In this quote, the content of the course (ceramics) is framed within a narrative of rapidly changing technology, sustainability and the future in a way clearly aligned with how the NCCP program is advertised. What is different is the direct appeal to students' sense of wonder and desire to learn.

Overall, the three rationales (*learn specific content knowledge, learn topics that are important in industry or research,* and *learn topics of personal interest)* communicate a *Promise of sated curiosity and important knowledge.* This is specific to the course descriptions, and draws on repertoires of traditional engineering in close connection with industry and on the identity of the deeply interested, passionate or even nerdy science/engineering student that is well documented

in earlier research (Johansson 2020; Ottemo et al. 2023). Drawing on these "old" repertoires is thus used for attracting students to particular study areas. In contrast, the program information, in painting the program as a whole as contemporary and for the new engineer, shies away from such nerd stereotypes, similar to the university marketing documented by Berge et al. (2019).

IDEOLOGICAL CONSEQUENCES OF THE PROMOTION OF CBL

In this second part of our findings, we address our second research question focused on the ideological consequences of the discourse in the material. This analysis draws on previous research to frame and contextualize discursive ideology production in relation to engineering. As several of the examples already presented show, the rationales found in the analysis are not separated in the material but appear together within the same logics of recruitment. The arguably quite different promises of being societally important, professionally successful, and having one's curiosity sated are invoked together, as promises that could all be fulfilled simultaneously. We argue that this intermingling is made possible through the characteristics of the interpretative repertoires invoked in the texts; they can be said to function as "boundary repertoires" meaning that they have the plasticity to contain conflicting meanings and make sense across discursive practices (Andrée & Hansson 2020). In the following two subsections, we elaborate on the consequences of the plasticity and intermingling of the repertoires for framing the relationship between reformed engineering education and engineers' societal responsibility. We do this by looking first at how engineering challenges are defined and demarcated, second at how engineering identities are constructed.

THE DEFINITION AND DEMARCATION OF ENGINEERING CHALLENGES

In the NCCP material, we see how a "challenge" can mean both a puzzling problem of industrial production and a global threat to human persistence on the planet. Within this plastic discourse, no explicit negotiations between these meanings are needed for the text to make sense. In particular, framing challenges as being "of the future" affords a general noncommittal air of sustainability and an optimistic promise of progress. Here, opposing interpretations can be harbored without tension. As there are no discriminating factors excluding things from this repertoire, almost any problem could seemingly be cast as a challenge.

How challenges are understood is defined in part by how cross-disciplinarity is manifested. The terms inter-, cross- and multi-disciplinary collaboration are all used a large number of times but are not motivated or explained further than that. There is no discernable pattern as to when each term is used or a difference in meaning attached to them. This is in stark contrast to the many, and detailed, distinctions often made between these terms (Klein 2017). This interchangeable use of terms can be taken to indicate that the function of cross-disciplinarity is not so much to describe a particular intended practice of collaboration, but rather to create a distance to traditional engineering education where disciplines (supposedly) do not interact. The brevity with which cross-disciplinarity figures in the texts does not allow us to distinguish between these possible meanings, and even less to ascertain what is going on in the practice of the courses. What we can say is that cross-disciplinary collaboration is portrayed as contained within the technical university, which means engineering disciplines working together. This mode of collaboration has been called "narrow interdisciplinarity" (Klein 2017) and its persistence has been identified as a common problem in implementations of CBL (Gallagher & Savage 2023). It perpetuates the framing of solutions to "societal challenges" as technical or industrial in nature, melding the concerns of society with the concerns of industry (Slaton 2012).

We interpret this melding of concerns within *the Promise to be societally important* as serving the function of obscuring potential conflicts or tensions between stakeholders. When the concerns of local communities, the technical university and industry are fused together in this way, the main obstacle to solving challenges is understood as students' lack of professional skills. This picture stands in contrast to the growing understanding of many societal and sustainability problems as "wicked," lacking simple solutions achievable without conflict between different actors (Lönngren,

Ingerman & Svanström 2017). Grand challenges discourse can misframe "wicked" problems as "tame," and thus legitimize dominant instead of critical and nuanced responses (Ludwig et al. 2022). The complexity of wicked problems is however marginalized in the NCCP material, which rather communicates a kind of technocratic and post-political picture of doing "what needs to be done," where consensus is assumed to be achievable, or even already achieved (Mouffe 2005). While encouraging students to engage in societal issues, CBL discourse may in this sense still reproduce the traditional ("depoliticized") notion of engineering practice as providing rational conflict-free solutions (Cech 2014). Furthermore, this techno-optimist framing of challenges, together with the connection of employability to innovation and grand narratives of desirable futures, frames sustainable development in terms of continued technological expansion.

STUDENT- AND PROFESSIONAL ENGINEERING IDENTITIES

The NCCP discourse functions not only to produce certain relationships between society and engineering, but also to produce expectations and idealized identity positions for a certain type of engineering student and engineer. Which students can feel a personal connection to the supposedly shared narratives of the future portrayed in the NCCP discourse? The engineering student addressed by the NCCP material is positioned as someone who is motivated by its promises. Given the intermingling of these promises, the ideal student is committed to changing society for the better while hungry to individualize their education within a flexible course structure. When the *Promise to be societally important* melts together with becoming *professionally successful* and employable, students' passion for contributing becomes a means to provide industry with skilled workers, directed towards a limited number of professional skills. By learning these professional "soft" skills through "authentic experiences", students sharpen their CV, prepare for a successful career, and save the world. We argue that this asks for a sort of optimistic willingness to ignore conflicts or tensions, and to perform an unproblematizing passion for problem solving that excludes critical thinking or ethical reflection.

This is interesting in light of research pointing out the importance of emotional skills such as empathy and critical awareness for sustainable engineering practice (Lönngren et al. 2023). Such skills are not used to promote the program, and this absence in the NCCP discourse seems to call for another kind of emotional capability in students: to be able to work together in teams without asking difficult questions. The ideal NCCP student is thus positive (in line with the ideology of feasibility, Kaldewey 2018) and (uncritically) engaged in society and in their own career. They are excited to engage in challenges, without needing to evaluate involved stakeholders or overcoming (supposedly non-existent) conflicts. The new engineer identity constructed in the NCCP discourse thus seems focused primarily on employability and on social responsibility only in a circumscribed manner (Conlon 2008). The neoliberal employability repertoire further makes every student individually responsible for their employability, where the NCCP courses are cast as an opportunity to get ahead. Such discourse may encourage students to disregard other parts of their identity, like gender or race, and to understand struggling, or not finishing, as a personal failure (Moreau & Leathwood 2006). This lack is especially interesting if we consider the call within the wider CBL literature for challenges to connect to local communities and students' identities (Gallagher & Savage 2023).

A final point regards the role of engineering education in relation to the profession and the industry. Students do not seem to be recruited to NCCP on the basis of the possibility to change companies for the better from within, to become change agents in industry (Cruger 2018). In contrast, for the teaching profession, similar ambitions are often very explicit, both in teacher education policy (Saka et al. 2013) and practice (Larsson et al. 2020). The idea that new engineers could be equipped to subvert, challenge, and change the industry is curiously absent in this pedagogical initiative even though it is explicitly promoted as creating change. Perhaps, this change is not expected to come from engineers within companies as the boundaries of traditional engineering ethics expect them to "work, objectively, on projects, with a humble gratitude to their employers" (Paul et al. 2023, p. 7). This also reflects the status afforded by recognition from the industry in engineering education (Nordvall 2023).

CONCLUDING DISCUSSION: KEEPING THE PROMISE OF CBL

In state-of-the-art engineering education, CBL is primarily used to reform the pedagogy and curriculum of existing programs (Gallagher & Savage 2023). It promises to educate responsible engineers that can act for society in a time of gloomy scenarios of future disaster. This involves teaching students to respond to wicked problems that lack unambiguously good solutions (Malmqvist, Kohn Rådberg & Lundqvist 2015). By combining technical knowledge with an understanding of the interconnectedness and tensions between science, technology and society, CBL may teach students to practice these balancing acts. By breaking the "culture of disengagement" where engineers are absolved from responsibility by an understanding of technology as neutral, CBL promises to produce sociopolitically responsible "new" engineers.

But does this promise hold, when analyzing the reform discourse of CBL as used in the communication of specific reformed engineering education programs? We found that CBL, in the case we studied, is advertised to students drawing on narratives of bright futures and grand challenges, calling for engineers to work together to find solutions. Students are recruited based on promises of being, simultaneously, societally important, employable and deeply knowledgeable. In this context, the ideal engineering student is passionate, optimistic and ready to take on grand engineering challenges together with others. CBL has often been described as a way of attending to sustainable development (Kohn Rådberg et al. 2020). However, the discourse in the recruitment material communicates an ambivalent relationship to sustainability and melds societal issues with industrial concerns. Here, a kind of post-political, consensus picture of sustainability is implicitly assumed, making explicit discussion of tensions between stakeholders superfluous. This allows for "challenges" to take on diverse meanings while still communicating a positive air. The plasticity of the CBL discourse thus allows for critical, political discourses to coexist and fuse seamlessly with more post-political techno-optimistic discourses.

In the NCCP material, the promises of saving the world and creating employable engineers meld together painlessly and seamlessly by the way CBL is presented. By replacing traditional notions of problem solving with a rhetoric of challenges, and by letting students work in interdisciplinary projects, the university can claim to work towards sustainability without having to change radically. We would argue that this CBL reform discourse works as a nonperformative commitment, similar to many institutional commitments to equality (Ahmed 2006). It is nonperformative as it works by failing to bring about the changes it names, reproducing the depoliticization of engineering, while portraying the university as doing the opposite. This paints a picture of a CBL that, paradoxically, breaks its promise of transforming the technical university, while still functioning to release the university from this responsibility.

Our findings suggest that communication around CBL initiatives—both in and out of the classroom—could benefit from explicitly acknowledging that working with societal challenges involves tensions and value-conflicts that students, teachers and external stakeholders need to navigate. On the one hand, CBL initiatives like NCCP need to adhere to current ways of marketing education to be intelligible in the world of the technical university, and to possibly attract students. On the other hand, CBL initiatives could work more actively with trying to renegotiate powerful ideas about engineering in society. In this way, CBL could live up to the promise of more wide-ranging and radical changes.

Our findings further suggest that research adopting a critical approach would complement extant research on CBL, especially when it comes to understanding the ideological consequences of CBL as a reform discourse. Our analysis is limited to recruitment discourse and does not involve actual program or course practice, where we are convinced that dedicated students and teachers learn and create together, and where various ideas and perspectives meet. An important further question is how students and teachers interpret, reproduce and potentially renegotiate this reform discourse in practice. Such work could for example include analyzing students' identity work in the context of CBL or investigating how students relate to elements of CBL reform discourse in developing an understanding of their roles as engineers in society. Seeing as our analysis is

limited to one technical university situated in a particular national and industrial context, further work could also investigate CBL reform discourse in other settings. Such work could detangle how conditions such as university characteristics (young or old, vocational or research-intensive) and national educational policies may shape specific instances of CBL reform discourse.

Our analysis highlights how CBL initiatives are at a crossroads, occupying a strong position in discussions of how engineering education should be developed, a position where there is a critical potential and many openings for "challenging" the status quo. This critical potential needs to be nurtured with care, which includes daring to be uncomfortable.

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The authors have no competing interests to declare.

AUTHOR CONTRIBUTIONS

The paper presents ideas that the authors have developed together. The first author did the data collection, led the analysis and coordinated the writing. All three authors discussed and developed the analysis and collaborated on writing the final draft.

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