Responsibility in University Ecosystems and Challenge Based Learning

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***Abstract* — Universities introduce real-life stakeholders in their courses as challenge based learning (CBL). We argue that the literature has not yet discussed the role of responsibility for universities, their students and their ecosystems in this new format. This paper explores this gap by using Niklas Luhmann's concepts of structural differentiation, structural coupling and irritation. It studies how the focus of CBL on responsibility influences the structural couplings of the subsystems education, research and economy in society. We expect that responsibility in students and universities could be promoted by creating structural couplings between these subsystems. The paper shows why practice-based education may be undersupplied at universities and how novel education formats can be understood to fill this gap.**

Keywords — Challenge based learning (CBL), ecosystem, engineering education, responsibility, Luhmann

I. INTRODUCTION

Engineers are increasingly expected to contribute more than mere technical expertise to society. Grand challenges, such as climate change, force us to view engineers as actors who take more responsibility and interact with others to develop societal solutions [1]. Universities need to motivate students for this part of the education. In this context, [2] and [3] propose to address this need with *challenge based learning* (CBL), an education format where external stakeholders (from industry, or other parts of society) join the classroom and introduce an open, real-world challenge to students. To support this transition, a growing literature focuses on the pedagogical aspects of CBL ([4], [5] and [6]). However, introducing CBL in a university implies new and far-reaching organizational needs, such as other forms of collaboration with its ecosystem partners and other ways of linking education and research. These aspects of CBL curriculum redesign are currently missing in the literature. As such, we want to explore the question of the changes in the role of universities when implementing new educational methods for responsible engineers of the future.

Niklas Luhmann's work is one of the most sophisticated theories of systems, offering insights for academic disciplines beyond sociology, as well as practical problems. His theoretical insights about the differentiation between systems in society and the about need to address these make his theory a fruitful starting place to consider the role of universities in society. This paper uses Luhmann's account of functional differentiation in society to understand the need for educational changes in universities that ensure students engage with real world problems during their studies. CBL aims to achieve such engagement by placing open-ended, real-world challenges at the centre of student education. The paper argues that Luhmann's concepts of *structural coupling* and *irritation* are the crucial leverage points in his theoretical framework to conceptualise the possibility of — as well as the need for — universities to play this inter-systemic role.

We argue that CBL is an ideal educational format to integrate the university, its education, research and innovation activities into the wider ecosystem and thereby make responsibility a central value in engineering education. We aim to answer the following two questions:

First, how can we understand the interaction between students, teachers, universities and ecosystems in CBL? This question focuses on how to best conceptualize the systemic integration of the universities and its sub-institutions into society and other systems with which the university interacts (its *ecosystem*).

Second, what is the nature of the type of responsibility that emerges from this interaction between universities and their ecosystems? This question asks whether the integration of the universities into societal subsystems achieved by CBL will lead to increased concerns for societal responsibility. This question is relevant in the context of educating engineering students and engaging with the university ecosystem.

Section II and III introduce the relevant conceptual ideas from Luhmann's work. Section IV connects Luhmann's ideas to CBL and Section V addresses the nature of responsibility arising from CBL and section VI concludes.

The paper makes two contributions to existing scholarship. On the one hand, it goes beyond existing discussions of the implications of Luhmann's thought on education and shows its relevance for considering a concrete proposal for education in the context of contemporary universities. On the other hand, it aims to situate discussions about responsibility and CBL within a wider theoretical debate about how to understand the university as connecting various social systems.

II. Luhmann on Structural Differentiation

One of the core parts of Niklas Luhmann's systems theory is his theory of functional differentiation [7]. Contemporary societies consist of subsystems which serve different functions. For Luhmann, this functional differentiation is getting more pronounced and it can account for a range of theoretical and practical problems. Examples of such functionally differentiated subsystems are education, politics, law, economy and science. To explain the reasoning behind this theory, let us quickly introduce the basic tenets of Luhmann's systems theory.

Luhmann's account of systems consists of two parts: First, systems maintain a boundary to their environment and a system is defined as a process of "how the difference between a system and environment can be maintained" [8]. The second major part of Luhmann's account of systems concerns the concept of *autopoiesis*. Systems reproduce and maintain themselves by creating new elements and these elements are in turn parts of the system. In this way, autopoietic systems continue to maintain their structure and boundary to their environment. He takes the concept of autopoiesis from biology, where it was first applied to explain the reproduction of living cells by interacting with their environment [9].

In addition to the idea of autopoiesis in organisms, Luhmann expands the concept to two further types of systems, namely psychic systems and social systems. These types of systems differ according to how their process of autopoiesis occurs. Social systems reproduce themselves through communication. These social systems (communications) are distinguished from psychic systems which reproduce through thoughts. The subsystems of society (law, politics, etc.) are social systems. As a result, Luhmann understands them as communications and for Luhmann social systems are based on binary codes which are their internal logic. In the example of law, the binary code may consist of the dichotomy between legal/illegal, in politics it is powerful/powerless and in the case of science true/false.

Luhmann held that these social systems are autonomous: the subsystems of society resulting from functional differentiation do not "directly engage" or "communicate" with each other. Each social system is only able to reproduce according to its own code, they are operationally closed. The legal system, for instance, is unable to account for the difference between progressive or conservative politics. For each system, other systems are part of that system's environment. The precariousness of the relationship between systems and environment is a central theme in Luhmann's work (see especially [10]). The idea of functional differentiation of subsystems — along with Luhmann's idea of the relationship between system and environment — constitute a problem for understanding how the various subsystems of society coordinate.

This question of inter-systemic relationships is a fruitful field for scholarship on Luhmann's thought. Luhmann's theory has the ambition of being applicable to the whole subject area of sociology and Luhmann himself has written extensively on the various subsystems of society. The theory of structural differentiation has led Luhmann to be skeptical of planning: "systems theoretical analysis […] divert our attention to the self-steering of systems" and "those seeking hope for society usually think first of politics and its ability to steer. However, this idea collides squarely with the fact of functional differentiation" ([11]).

There are several publications that explore and aim to overcome the seeming gap between different social systems. For example, [12] explores the scope of planning: "Because of society's functional differentiation, the different systems involved in spatial organization (politics, economy, architecture, etc.) are subject to their own different logics and they are driven by their coding. They consequently cannot be controlled or steered directly by planning actors, which have to rely on indirect forms of steering". Similarly, and more relevantly for our present concern of education, [13] reconstructs Luhmann's concept of education. Here the problem is not a gap between different social systems, but rather "a sharp distinction between social systems and psychic and organic systems (or human beings)". Education is the attempt to "realize effects within psychic systems" [13].

Luhmann was aware of this problem created by his theory of functional differentiation: "If we were to describe modern society as merely a multitude of autonomous functional systems that do not need to take one another into consideration but only to obey the reproductive constraints of their own autopoiesis, the picture would be very one-sided. It would be difficult to understand why such a society is not on the verge of exploding or collapsing." [14]. In the next section, we will consider other areas of Luhmann's thought which ameliorate the tension created by his theory of structural differentiation.

III. LUHMANN ON STRUCTURAL COUPLING AND IRRITATION

Luhmann's concept of *structural couplings* allows that some organisations or institutions in society can constitute a coupling (*Kopplung*) between different sub-systems of society. For Luhmann, his concept of structural coupling replaces previous sociological concepts, such as *integration*: "In the classical sociological discussion from Durkheim to Parsons, *[the problem of functional differentiation]* was handled with the differentiation-integration schema. The task of sociology was to find forms of integration compatible with functional differentiation. We replace this schema by the distinction between autopoiesis and structural coupling" [14]. It is this notion of structural coupling which dissolves much of the theoretical rigidity created by the thesis of functional differentiation: "In fact, all functional systems are interlinked and held in society by structural couplings" [14].

For Luhmann, structural coupling is "intensifying certain mutual irritation channels with a high degree of indifference toward the environment" [14]. In other words, two systems are structurally coupled with each other if there are established forms how they can regularly irritate the workings of each other. Irritations are the next idea that Luhmann introduces. Luhmann states that the increased differentiation in society results in higher sensitiveness towards the environment, combined with the sacrifice of coordination. Irritation is caused by the appearance of something new, a deviation from what was expected, by an exception. "Irritation is accordingly a state of the system that stimulates the continuation of the system's autopoietic operations, but which, as mere irritation, initially leaves it open whether structures have to be changed for this purpose" [14].

Luhmann advances several examples for structural couplings. For example, the systems science and education are coupled "by the university organization form" [14]. The systems remain separate with their own logic, but the fact that they are carried out by the same people (the university researcher as the university lecturer) has an impact on both (Luhmann refers to the idea that one person can be part of various systems as "interpenetration" [7]). Further examples are the coupling between politics and science (in the form of scientific or policy advice) and the coupling between economy and education in the form of educational certificates.

In this context of the structural coupling between education and science, Luhmann identifies a reason why contemporary university education might be too theoretical: "The systems remain separate but operate, as it were, in personal union; they have an effect on scientific publication that is difficult to determine and, perhaps even more strongly, bring a certain overemphasis on science and lack of practical relevance to university education" [14]. In other words, Luhmann acknowledges the role of universities and researchers in coupling the systems of education and research as it is one and the same person doing both. However, as the quotation shows, that concrete coupling does not seem to deliver enough, especially because it does not include connections to other parts of society.

These ideas on the role of universities in coupling different sub-systems of society should be understood as abstract — systems theoretical — reasons for expecting universities to deliver education that has too little practical application. Luhmann's theory of systems is abstract and general and not primarily designed to measure empirically the difference between universities in their ability to fulfil the function of coupling subsystems. In particular, Luhmann's theory is "functionalist" and therefore describes a system from the role it fulfils in society. Understanding the changing demands on universities and differences among universities in how well they accommodate these demands requires supplying Luhmann's theory with accounts of how the role of universities has changed in recent decades, as well as their future challenges.

IV. CHALLENGE BASED LEARNING AS STRUCUTRAL COUPLING

After this review of Luhmann's concepts of structural coupling and irritation we can now sketch how Luhmann's systems theory might account for changes in education that bring about greater engagement with problems that come from outside the narrow bounds of the university and make students shift their learning towards application.

CBL as an educational model has been discussed for some 20 years. No single account and definition have emerged yet and there is a plurality of practices within this umbrella term. However, the definition in [15] has received most attention. Here, CBL is an educational format where learning takes place "through the identification, analysis and design of a solution to a sociotechnical problem. The learning experience is typically multidisciplinary, takes place in an international context and aims to find a collaboratively developed solution, which is environmentally, socially and economically sustainable".

In our characterisation of CBL at the beginning of this paper, we start with the presence of external stakeholders from industry or other parts of society who introduce the students to a real-world challenge. While external stakeholders do not feature in the definition in [15], their focus on sociotechnical problems implies the same concern of introducing students to problems from outside the university system. The idea that teachers — their lectures and other educational inputs — should be seen as instrumental in devising societal solutions is reflected in the definition through the multidisciplinary nature, as well as the requirement that solutions are collaboratively developed.

The recent literature review in [16] surveys the various goals that have been associated with CBL. The two central ones they identify are "transversal skills and competencies" and "industry and community collaboration". However, we argue that these goals do not full justice to the potential of CBL as an educational format, especially regarding the potential role of future engineers in society and in societal challenges. [1], for instance, explicitly links the idea of CBL with the role of engineers in solving grand challenges and having a wider societal impact. For students, the introduction of CBL is hoped to result in greater awareness of the students about societal and moral issues.

We now have the background to formulate an answer to our first research question, namely, how to understand the interaction between students, teachers, universities and the ecosystems in CBL? For the university, the introduction of CBL might result in a more structural revamping of the orientation of the university from education for its own sake towards being sensitive towards the problems of other societal actors and better understanding how universities can contribute. We might start to view the introduction of CBL as the effort of universities to bring in societal aspects, especially from economy and — depending on the nature of the challenges — also politics or law.

Introducing such a structural coupling — so we might translate the hope into Luhmann's terms — would allow possible irritations between these subsystems of society and the system of education, which is principally represented by the university. Unexpected developments in the economy or other parts of society might be registered by universities more directly and faster. In this way, such developments may incite the continuation of autopoiesis of education, but opening the possibility that (structural) changes in the curriculum are required.

V. Responsibility and Engineering Students

The previous section started to identify the ways in which CBL can couple education with other parts of society. In this section, we want to go further and explore the idea that CBL makes students develop an attitude of responsibility for societal problems to which they may have been introduced as part of CBL. In this way, we hope to highlight a further aspect of CBL, namely its potential of teaching students central ethical concepts (on CBL and ethics, see [4] and [5]).

We are unable to enter debates here about Luhmann's relationship to ethics (see [17]), but we can sketch an account of responsibility for engineering students that is broadly in the spirit of Luhmann's analysis of functional differentiation of systems. There are roughly two avenues of how we can introduce the concept of *responsibility* into a systems theory like Luhmann's. First, we might focus on the way that social systems condition individuals to think or act in certain way. The concept of *conditioning* is Luhmann's way of explaining how social systems, such as culture or education can have an impact on the development of psychic systems. The alternative route is to look at the systemic conditions for the successful exercise of agency and responsibility. The broad idea is that the coupling of the interests of sub-systems of society with those of the engineering profession is a way towards understanding and achieving responsibility in this domain.

Remember that according to Luhmann's theory of social systems, they should be understood as types of communications operating with their own (internal) logic. Such systems therefore have only limited ability to make sense of problems in their environment. Unless a system has a certain concern built into its code, it is unlikely that that system will respect that concern. As mentioned before, the system of law will not (on its own) possess the resources for making sense of problems in its environment, which are the other subsystems of society.

Socialising or educating (future) members of such a system, such as future engineers who will form part of the wider economic system, into the concerns and operational logics of other systems may allow them to take account of the concerns and problems occurring in these other systems.

Luhmann's idea of structural coupling and irritations can be used to conceptualize CBL as a way towards achieving greater sensitivity between education and other subsystems of society (economy or law) in general and responsibility in particular. By bringing people and challenges from outside the university into the educational curriculum, greater sensitivity can be brought into its education and research activities. Making individuals sensitive to a broad spectrum of problems and considerations can enable them to be responsible agents aware of societal problems and their role towards their solution.

However, the role of universities has expanded in recent decades and we may wonder how CBL can affect these other roles of universities. There is consensus in the literature that universities have come to assume roles in addition to education and research in previous decades. [18] illustrates the "entrepreneurial role" of universities: Researchers are increasingly encouraged to create spin-off companies from the knowledge generated from their research activities.

The exact nature of the third, entrepreneurial, mission of universities [18] is subject to discussion: [19], for example, argues that the role should be understood more broadly and the focus should be more on responsibility, namely as "the contributions of the university to industry and society".

Given this account of the new roles of universities, we may say that they nowadays sit at the interface of (at least) three systems, namely education, research and economy. Given this new set of tasks of universities, we may return to

CBL and ask about its relationship to these other roles that universities are fulfilling.

As for research, CBL may constitute the regular institutional arrangement through which university researchers engage with industry, thus facilitating the exchange of communication about industry needs, possible collaborations and the developments in science. Let us start to explore this idea by focusing on the way that responsibility can be introduced through CBL in research, innovation and companies.

First, CBL may be hoped to bring greater responsibility in research. CBL is motivated by the ideal of preparing engineering students to become actors in addressing societal grand challenges. A focus on responsibility is therefore an integral part of this education format. Researchers and teachers engaged in CBL can incorporate their ongoing research "in action" in the classroom. This means that they may not merely discuss their results in class, but incorporate it in teaching more hands-on. In this way responsibility in the context of grand challenges is structurally coupled with the research/science system. It is our hypothesis that researchers engaged in this kind of education will pursue research in a different way. To illustrate this, consider their researchers' choices about next steps in research design and implementation. It is plausible to expect that the society and responsibility aspect will become more important as a result. An important further question — beyond our scope — is whether this can be expected to impact all types of research (natural science, social science, humanities) equally.

Second, concerning the entrepreneurial function of universities, the connection between CBL and the economy receives its most pronounced form in the case of student entrepreneurship. Here it is possible to identify a very similar connection to responsibility and university ecosystems as in the case of research. Societal grand challenges are the starting point and solving these challenges serves as an alternative motive for engaging in entrepreneurship to the usual monetary motive.

Finally, companies acting as stakeholders in CBL will be questioned by students about their social responsibility and their actions towards socially responsible outcomes. This means that the effort to tackle grand challenges through responsibility is coupled with the economic system. It is our hypothesis that companies engaging in CBL partnerships will make different business decisions. For example, when making choices about business, the societal responsibility aspect might become much more prominent.

This idea that CBL goes beyond linking education to industry and connects a whole university with other subsystems draws attention to what is meant by a university's ecosystem. Luhmann's technical machinery also allows us to define this notion. The idea is that those systems which are directly connected to a university by structural couplings are its ecosystems. It is these other systems that universities have mostly directly an impact or are impacted by (in the form of irritations). Those subsystems which are further removed from a university, are not part of its ecosystem (but there will perhaps not be a sharp boundary). For example, university X has a structural coupling with company Y because that company acts as a stakeholder in CBL. In this sense, CBL is one (among other) way how universities can define and maintain their ecosystem.

VI. Conclusions

The proposal to introduce CBL in technical universities is ambitious and relevant given the challenge to rethink the role of engineers in society. To fully evaluate this proposal, we must take a lens that includes the perspectives of both systems theory and ethics. This paper aimed to advance our understanding of the implications of systems philosophy in the context of education. We sketched how bringing in real-life stakeholders via CBL pedagogy (1) has an influence on the structural couplings of education, research and entrepreneurship and (2) that this structural coupling has consequences for how responsibility plays out for students, teachers, researchers, universities and their ecosystems. We used Niklas Luhmann's theory of systems to show how this theory can be relevant in the context of university education. While Luhmann's systems approach has been discussed in the context of education, this has usually not been in the context of his systems-theoretical views on society.

We saw that a systems theoretical approach shows why practice-oriented education may be undersupplied by universities. It describes how such a coupling between different subsystems can occur and it gives us some insights into what successful couplings might look like.

The improved understanding of responsibility and the systemic integration of universities will form the basis for further empirical research. This will consider the more specific differences between technical universities in their approach to including considerations of responsibility in their education and in their attempt to integrate into their ecosystem through educational changes. The greater theoretical understanding will help us study the different perceptions, practices and developments of responsibilities in these contexts.

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