Teaching Ethics As Practical Reflection In A Project-Based Engineering Course

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ABSTRACT

The implementation of ethics in engineering courses often faces several intertwined problems. For example, there is widespread moral relativism, ethics is often confused with moralism on the one hand and with pro-contra discussions on the other, there are difficulties with the degree of abstraction being too high, or ethics is relativised as one method for decision-making among many others. Furthermore, in many cases, ethics is suspected of being artificially introduced into engineering.

In the context of a project-based course at a German university, we took up these challenges and developed an innovative teaching format whose focus is not on theories and methods. Instead, we implemented ethics education as a practical

exercise of reflection. Based on situations in students' project life, we engaged in open conversations addressing aspects of their practice that tend to be overlooked under conventional conditions: boundary conditions of their engineering actions, preconditions of their judgements, and criteria for justifying their decisions. Instead of reacting to problems reflexively, and thus blindly accepting them, we wanted to enable students to examine problems critically. In this way, we aimed to enable the students to adopt a (reasonable and therefore) responsible attitude toward their actions and their boundary conditions.

In our contribution, we first discuss the preconditions: the project-based four-month full-time course with an industrial partner. Second, we explain and justify our philosophical approach. Third, we describe the implementation of our approach followed by the evaluation. Finally, we conclude our findings and outline next steps.

1 INTRODUCTION

1.1 Motivation

In their paper on phronesis and the role of values, Frigo et al. (2021) highlighted the need for teaching ethics in engineering and discussed a potential application. However, the responsibility that engineers bear in their professional activities has not been reflected widely as part of engineering education, especially at German Universities (Frigo et al. 2021). The central role of engineers in finding technological solutions to fundamental societal problems (Frigo et al. 2021) thus leads to the necessity of teaching ethics in engineering education. Courses that are more practically oriented can provide a particular purposeful opportunity (Frigo et al. 2021). Based on the preliminary considerations of Frigo et. al. (2021), this practice paper develops and implements a detailed concept for teaching ethics in engineering education at a German university and reflects on its evolution over two years.

1.2 Our mission

Within the framework of a German excellence promotion program, we pursue the goal of building reflective competence among students in ethical and social issues. The overarching approach chosen can be described as teaching "ethical literacy" and is characterized by teaching ethical-reflective competence instead of principles and theories. For this purpose, our interdisciplinary team led by philosophers offer a variety of services, including online courses, co-teaching events, and challenges to realize the above-mentioned goal. The course presented in this article is part of this offering.

1.3 The project-based engineering course

In the course IP - Integrated Product Development in which we are implementing our pilot project, a selection of master's students from the fields of mechanical engineering, industrial engineering, and mechatronics work in teams through a 4-month product development process from strategic foresight to prototype construction. The problem definition for the development project is provided by an industry partner. During the project the students independently develop product profiles, alternative solutions, and prototypes, which they present to the industry partner and invited guests from research and industry at a final event (Albers et al. 2018). As the main stakeholder for the solutions developed by the students, the industry partner is pivotal to the practical learning environment.

The coordination of the development process and the methodological coaching of the students is carried out by scientific staff of the IPEK - Institute of Product Engineering, who are themselves mechanical engineers. Decisions as well as feedback on the intermediate results takes place through the industry partner at multiple milestones. Between these milestones the students independently decide how they spend their time and balance efforts. The course can be associated with challenge-based and project-based learning methods (c.f. Membrillo-Hernández et al. 2019). Fundamental to the course is the understanding of product development according to the Karlsruhe School of Product Development (KaSPro) specifically in relation to demand- and benefit-driven innovation (Albers, Düser and Burkhardt 2006).

Due to the students' freedom of choice, its implications, and the courses' nature as preparatory for the students' entry into work (as part of the master's degree), the course offers a well-suited opportunity for our mission and the obligation to address responsibility in engineering education. While there have already been preliminary conceptual considerations, the development of a consistent teaching concept and its

implementation remained open. Therefore, this contribution justifies and proposes a detailed concept for teaching ethics as a practice while acknowledging the complexity of engineering education. Moreover, the concept is implemented and evaluated with two cohorts in the winter terms 2021/22 and 2022/23.

2   TEACHING ETHICS AS A PRACTICAL EXERCISE IN REFLECTION

In both teaching and being taught theoretical content, we are accustomed to viewing this content as retrievable pieces of knowledge. Examples include the fundamentals of engineering mechanics, mathematical methods, functional principles of machine elements and many more. In engineering courses, we teach many such things, which are undeniably important. Alongside this kind of knowledge, we also teach and learn methods which are instructions or procedures that help us to contribute to a solution of a given (technical) problem under certain circumstances. A good engineer is characterised not least by the fact that they are able to choose the most appropriate method for the problem from their arsenal of methods. In this way an engineer demonstrates the competence to understand the problem as well as the function and mode of action of the chosen method to be able to apply it purposefully. The interaction of theoretical knowledge, knowledge of methods, and the understanding of problems makes engineering a lively activity—especially when engineers become creative and have to work out new ways of solving unprecedented problems. This lively activity can be called "practical skills".

Whoever wants to teach knowledge, methods, or even practical skills is faced with the question of the best way to do this. Under certain circumstances, one must also ask oneself the definition of "best" here. Of course, we also had to ask ourselves what it could mean to teach what we wanted to teach.

We knew we wanted to enable students to act in a responsible way. Assuming what it means to act responsibly would be a kind of theoretical knowledge, we could have taught our students a theory of responsibility and tested this knowledge in an exam. While this might be possible, the concept of responsible action does not describe knowledge about the world or about how people are but addresses their actions. Having an idea of what it means to act responsibly enables one to identify and evaluate one's own actions or those of others as such actions accordingly. But then one does not have theoretical knowledge, but a norm for a way of acting. And with norms, you have to justify why they should do in this way. To understand responsibility as a kind of theoretical knowledge seems at least problematic.

What would it mean instead to understand responsible action as a method? If so, we could have told students to follow a procedure and their actions would henceforth be responsible. But we did not want to teach one method among other methods, or even the most important method of all other methods. We wanted students to be able to make responsible use of their arsenal of methods in case of doubt. The ability that we wanted to make accessible to our students concerns the *how* of their actions–not just the *what*–and it seemed to us that whatever was connected to that ability lay to be beyond the choice of method. Because this ability is neither theoretical knowledge nor a method, but is expressed in people's actions, we ultimately had to understand it as a kind of practical skill–namely the practical skill to act responsibly. Approaching our concept of responsibility in this way raised another question: how must we understand our mission based on this understanding of responsibility so that we can seek options for its realisation that do justice to the matter of responsibility?

However as often happens in philosophical practice, the questions are initially unsettling: instead of providing support and finally a solution, they seem unnecessarily

complicated and endless. Couldn't we have simply defined responsibility somehow and then taught this definition to the students? But wouldn't responsibility then have remained merely a piece of theoretical knowledge again instead of becoming a practical skill? And would it have been responsible at all to simply define the concept of responsibility in that way or to adopt it from others without reflection? What are the criteria for us to act appropriately in each case?

Therefore, the question of how we would understand responsibility not only affected what we wanted to teach, but also our own actions. As we have said, the easiest approach would have been to simply presuppose a given understanding of responsibility and tell the students how to act in the future. Then we would have solved the problem that we need a concept of responsibility. But we would have left the context unconsidered and thus already accepted the conditions under which the perceived problem appears as a problem. Consequently, just because the problem-solving mode is possible does not mean it is appropriate.

When we are responsible for teaching others what it means to act responsibly and why they should act that way, then we firstly have to be able to justify why this is a good concept of responsibility. And secondly, if we don't want to get tangled up in contradictions, we must do justice to our responsibility both in the rationale for it and in the way we want to convey it. This means that whatever concept of responsibility we choose, it reflects on us and on our actions. When we think about how to teach responsibility, we have to look at what we do while thinking about it.

What did we do? First, we wanted to gain a proper understanding of it. We did not accept the supposedly obvious problem and set out to find a solution for it. We refused, in this context, to presuppose an arbitrary understanding of responsibility or to recognise an understanding of responsibility merely because it comes from a potential or supposed authority. Secondly, we did all this with a view to asking how we must act to do justice to the matter. Thus, thirdly, we have understood and reflected on ourselves as the cause of our actions. What would it mean if that were already a form of responsible action? According to this view, a person acts responsibly who relates to their own actions in a certain way: They ask themselves *what* they do, *why* they do it and *how* they do it (in what way and under what conditions). Since they understand themselves as the cause of their actions, they also understand that they can relate to them in reflecting on these issues. This means that they can and must also ask themselves whether they should do what they do or what they should do for what reasons.

We wanted to enable the students to look at their own actions in this way as well. They were to be enabled to make the presuppositions of their own actions transparent to themselves. We considered that if the students could learn to do this, they would in future act less automatically in the way they have done it in the past, or do what they do less arbitrarily, or not act merely out of obedience.

But with this it was also clear: if we want to give students the opportunity to make decisions and to act accordingly in a responsible way or more responsibly than they may have done in the past, then we cannot treat them like automatons that one feeds with input. Instead, we must see them as acting subjects who ought to be able to arrive at independent judgements, and whom we must therefore also allow to contradict us. Not in an arbitrary way, of course, but we would be good teachers if we were exemplary in what we try to teach. In other words: teaching in this respect and in our context would have to be a practical exercise in reflection for *both* sides—for the teachers as well as for the learners. But since no one can be forced to reflect, there would also be no guarantee that the impartation would succeed. The possibility of

failure still lies in the nature of things. It is in our hands to provide the possibilities to be able to relate to one's own actions in a reflective way. But as with any other opportunities, there is always the option of refusing this offer. Since taking responsibility is something that can only be done by the actor, we have no choice but to rely on the voluntary understanding and acceptance of the students.

With this, we have finally reflected on one last aspect of responsibility as it arises in our context: the scope and limits of our responsibility. In conclusion, when talking to the students about responsible action, we would have to enable them to:

- understand themselves as the cause of their actions,
- therefore ask themselves what they do, how they do it and why they do it,
- therefore reflect on what the specific conditions of their actions are and what, against this background, falls reasonably within their scope of action for which they are responsible, and
- finally be able to reflect on whether they should do something—and what they should do as well as why.

At least here, responsible action thus shows itself as a kind of justice: those who act responsibly (under conditions) try to do justice to certain aspects of their actions, especially being the cause of their actions. So, what we would have to teach as a practical skill would be a particular attitude towards one's own doing. And because this attitude positions one's own actions under a principle—in our case under the principle of responsibility—it can be referred to as an "ethos". In our understanding responsibility starts here. But whether it also ends here is another question.

3 RESULTS

3.1 Implementation

As we have seen, the essential part of our teaching should be to enable students to develop an attitude towards one's own doing. The core of our teaching must therefore be to offer them opportunities in which they can relate to themselves and practice reflective competence. To enable this reflection, we have set ourselves three goals (cf. Fig. 1): 1) we would need to "open doors" to a new attitude for the students; 2) we would have to enable students to "open doors" to reflection for themselves; and 3) we would have to show the students connections between their attitude and the work they do on their project.

We call the overall concept "ethical accompanying reflection". The concept consists of four distinct but connected components: a 90-minute ethics lecture, a 120-minute ethics workshop, a series of reflection sessions and a lecture series. The first three components were delivered by trained philosophers, mentors from the Institute of Philosophy. The lecture series component was realized by inviting "practitioners" from the industry.

The **ethics lecture** represents the students' first systematic encounter with questions of ethical responsibility within the framework of the course. It is structured more traditionally as a lecture and is intended to convey the relevance of dealing with this topic in this framework. We expect the ethics lecture to contribute to goals 1 and 3 we mentioned. In the current version of the lecture, the necessity to deal with one's own responsibility is derived and justified from the self-image of engineering practice: since they experience and understand themselves as acting and shaping, the necessity of responsibility can also be addressed based on the experience of this freedom now.

The **ethics workshop** is also a plenary event and is intended to create a bridge between the ethics lecture and the reflection sessions. We regarded the workshop as

serving our goals 1 and 2. Accordingly, it differs from the ethics lecture in that the students should already be actively involved in discussions–in accordance with our approach–not with the aim of developing solutions to problems, but rather in such a way that their answers can themselves be made the subject of joint analysis and discussion. In this way, the workshop interrogates the students' "natural" judgements and addresses the basis for their justification. In the current version, we devote most of the workshop to discussing a trade-off example: confronted with the question of how the AI of an autonomously driving car should "decide" in a certain dangerous situation, we divide the students into teams. They are asked to discuss the basis on which they would make and justify their judgement under the guidance of their philosophy mentor. The results of the team discussions are shared with everyone in the final plenary again. The aim of the exercise was not to arrive at a definitive judgement on a seemingly harmless example, which presumably everyone would have an opinion about, but to ask what the students presuppose for their judgement in each case, and in turn to make this presupposition the object of consideration.

As the most appropriate way to engage with the students and thereby create the space for reflection, we decided to have multiple small group meetings with the teams, called **reflection sessions**. They form the core of our accompanying reflection: each student team is assigned a philosophy mentor who meets with the team for four 90-minute sessions over a period of two months. The themes of these sessions are not determined by the philosophy mentors, and no pre-determined learning objective is issued for any of the sessions. In these sessions, it is very important that the philosophy mentors engage with the students and react to the situation they are in. Of course, the discussion is about the status of the development projects themselves. But in this discussion, aspects of responsible action are worked out–not following a theory, but through the philosophy mentors engaging with the situation in a new way, i.e., with the object itself. Here we ask which criteria the students have used for problem identification and innovation potential, and why these criteria were used instead of others, for example. We ask about their reasons for ultimately choosing one product idea for implementation and why these are good reasons. We ask about the fundamental values that they are acting on in the project and why they think that they should do so. We further ask what they see themselves as responsible for and what they don't, as well as the reasons for that. In this way, the students are confronted with aspects of their judgements and actions that are taken for granted and otherwise rather non-objective for them. However, this does not happen artificially and with external standards; rather, it emerges from the project situation and is based on the criteria and standards expressed by the students themselves. In this way, we enable ourselves to discuss not just what should be done, how it should be done, and for what reasons, but also where the responsibilities and the limits of our own responsibility lie. The reflection sessions are therefore suited to each of our three goals.

As a final component, we organized a **lecture series** as a complementary format. In this series, we invited five guest speakers to talk about situations in their professional practice in which they were confronted with questions of responsibility according to their own assessment and the challenges their faced. The aim was not to tell success stories. Rather, these presentations were intended to demonstrate the many different levels on which such questions of responsibility can arise, which cannot be dealt with using a standard procedure. To ensure a certain uniform structure in the lectures and an orientation towards our need for knowledge, we drafted a catalogue of guiding questions. In addition, we held preliminary talks with all the speakers to agree on the direction of the presentation and discuss a first draft. The lectures themselves did not

refer to each other, but we organized them in a way that the levels of reflection changed from lecture to lecture. In our view, this was well-suited to helping achieve goals 1 and 3.
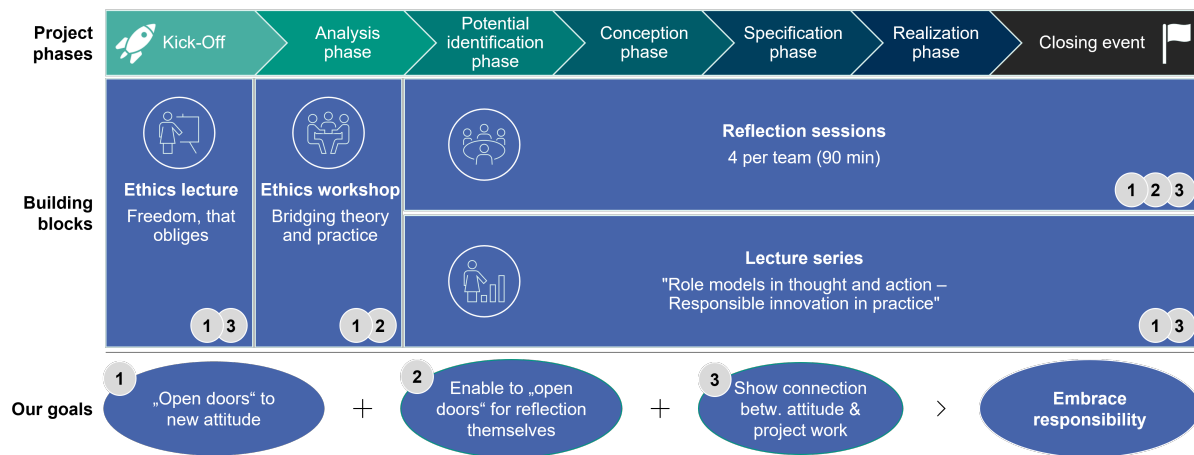

Fig. 1: Project phases of the course and implementation of the teaching approach

3.2 Evaluation and Discussion

Of course, we asked ourselves about possibilities for determining whether our accompanying reflection has an impact and, if so, what kind.

A possible impact can be analytically differentiated according to the "places" in which it finds expression. It would be desirable to look for an impact in the results of the students' work. We do not know any method to determine this, since it is impossible to determine the results that the students would have arrived at without the accompanying reflection. Since we do not primarily want to impart knowledge, but rather to enable an attitude, which only shows itself in practice, one would have to ascertain the status of the students' attitudes beforehand. And even so, it is uncertain whether they subsequently act due to an "ethos" or only display a socially desirable behaviour. A possible approach is to ask which aspects of their decisions the students themselves would attribute to the accompanying reflection. However, such an effect would only be an indirect phenomenon, which could also only be determined unreliably by discourse, even if the discursive discussion would be interesting.

This discursive element does, however, point to a second "place" where we can evaluate a possible impact, namely the reactions to and judgements about the accompanying reflection by the people involved. For this, we perceived various evaluation possibilities, some of which were quite elaborate (cf. Table 1).

Table 1. Applied evaluation methods.

	Students	Mentors	Externals
Cohort 1	Anonymous questionnaire	Interim reflection meeting with engineering mentors and philosophy mentors	Sociological accompanying study
		Follow-up meetings with engineering mentors and philosophy mentors	
Cohort 2	Anonymous questionnaire	Interim reflection meeting with philosophy mentors	/
		Follow-up meetings with engineering mentors and philosophy mentors	

		Documentation assignment for philosophy mentors	

In both cohorts, we were not able to derive any tangible improvements to the course from the questionnaire, but we were able to confirm the fundamentally positive reception by the students. However, participation in the survey was limited to 40 percent in each cohort. In addition, students' responses were very diverse in individual aspects of the course, but students did not make use of the opportunity to give their reasons. For us, it therefore remains unclear according to which criteria the students judged and whether these are appropriate. Certainly, the fact that the reasons for their responses were mostly omitted that the students did not consider the possibility for a discursive discussion with us to be necessary–whatever their reasons may have been. The interim reflection meetings and follow-up meetings with the mentors of the first cohort were rather unsystematic and most closely resembled an exchange of experience. A shared finding was the fact that the students had difficulties understanding the purpose of the accompanying reflection and had expectations that we could not possibly fulfil because they did not correspond to our mandate. We therefore brought to the second cohort the insight of needing to manage expectations better and we clearly stated what our mandate is not in as many places as possible. This insight flowed into the conceptual redesign of the ethics lecture and the ethics workshop as well, both of which aim now to better reflect what constitutes the core of the accompanying reflection in their content and procedure.

For the first cohort, we also accepted the services of sociological accompanying studies. A research team from the university was commissioned to use a qualitative study to investigate the effects and impacts of our teaching offer for the students and to develop possible suggestions for improvement. Data was collected through participant observations of our teaching practice, semi-structured interviews with students and philosophy mentors, as well as text analyses of the milestone presentations. The 29-page study, which is not publicly available, concluded overall and in principle that, on the one hand, "the integration of ethical and responsibility-related reflective content in the course [...] was valuable according to all participating students, engineering and philosophy mentors" (Hausstein 2022). It also stated that our project required a considerable amount of human and temporal resources, but with external conditions being beyond our control, was not always able to meet this requirement. On the other hand, several other results showed that this study was based on a different understanding of our role than what we discussed in section 2 above. The study thus has only limited usefulness for us. If it were to be repeated, we would have to engage with our colleagues in a much greater effort to reach a common understanding of what we aspire to.

In contrast, a real novelty was introduced with the documentation of the reflection sessions by the philosophy mentors in the second cohort. We of course asked ourselves whether we had given ourselves a meaningful work assignment with this format in the first place, whether the considered approach made sense, and what we might have to change in the objectives. Therefore, the documentation by the philosophy mentors is a kind of reflective self-evaluation, which should have the side effect of individual reflective follow-up by the respective mentors. In six questions, each with sub-questions, the documentation asks, among other things, about the topics discussed, the ethical issues discussed, the particularly noteworthy interventions on the part of the students in terms of content and performance, and the approaches used by the mentors, as well as what the mentors would do differently in

retrospect to their own approach. As a result, we have a large amount of data that both allows for a comparison between the individual teams for each session and would make a possible development over all reflection sessions visible for each team (which is currently being evaluated for the second cohort). Of course, the same applies to the philosophy mentors' assessments of their own approach.

4 SUMMARY AND ACKNOWLEDGMENTS

We have shown that our entire teaching concept is designed to provide opportunities for reflection on one's own practice of judgement and its presuppositions in order to potentially adopt a new attitude towards one's own decisions and their foundations. Our primary goal is not to impart knowledge that can be tested.

The evaluations completed thus far and those currently ongoing indicated, that we set high aspirations for ourselves and require a high degree of willingness of the students to engage with us as well as to spend enough time engaging with the topic of responsible action in addition to everything else they must do for their projects. This willingness is not always present or evident. Some students tend to dogmatically determine for themselves and everyone else what is right and what is wrong and use rhetorical persuasion to get their way. These students do not seem to be interested in conversation. But they are the same students who cause unproductive conflicts in other team contexts in the project. Consequently, the reflection sessions then help other team members to see the real problem and its logical causes. They can then limit such destructive actors with reference to the common team purpose–again encouraged by the reflection sessions. In addition, there are those students whose thinking–for whatever reason–cannot break out of the problem-solving mode during the mentoring period, and who thus block their path to reflection. Our outreach is most promising with those students who are open to learning something new. They curiously accept our offer to try something different from what they are used to and to take a distanced view of their own presuppositions and supposedly self-evident facts. All students demonstrate that they make value judgements and have an idea of what is right and wrong. But not all of them are therefore ready to talk about it. Not even when they make value judgements in a professional context and their attention is drawn to it. But since we are always dealing with teams and groups, the actual addressees of such disputes are then the other participants, even if they are only observing. In all this, we must concede that with the at least perceived high pressure to succeed in their project, some students simply do not have the necessary time to acquire such a self-critical attitude.

As mentioned above, it is difficult or impossible to reliably demonstrate a direct impact of the accompanying reflection in the final products of the students' projects. And it is equally impossible to verify a virtuous attitude. However, since we have the discursive option at our disposal, through which we can indirectly determine whether someone is performing in a responsible way, from our point of view the next step is to find an answer to the question of which approaches are suitable for obtaining feedback from students in which they can prove themselves to be the mature, responsible persons we are trying to address them as.

However, our own standards also show that we ourselves must not succumb to the pressure of problem-solving thinking. We must set aside our own reflexes and be reflective in our exchange with students and in dealing with their problems and our own. Admittedly, in what we are trying to teach, there is no guarantee that the teaching will succeed. But the least we have to do is to measure our own actions against these common standards of responsible action and assess whether we are living up to them.

In turn, this seems to us to be a central prerequisite for a possible transfer of our attempt to other contexts. And this insight is as old as the philosophical doctrine of virtue itself: whoever wants to convey a virtuous attitude must act as a role model in this matter. They must demonstrate in practice what it means to act virtuously, and they must provide the framework conditions in which it is possible to learn to act virtuously. In our case, these conditions comprise the hopefully exemplary behaviour of the philosophy mentors in the reflection sessions, the reports in the series of lectures by the practitioners, and, we hope, the overall conception of our accompanying reflection. Whether our ethics lecture, ethics workshop, and our style of reflection sessions make sense in other contexts depends on what exactly is to be taught. In our opinion it makes sense if you want to create an opportunity to show what responsible action can mean and if you understand responsibility in the way we have made explicit in section 2. However, in our opinion the internal reflective consistency of content and practice is what matters in any case.

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