

# Enhancing bachelor students' ownership in hands-on education: the case of mechanical engineering

## Applicants

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## 1. Background

The focus of this proposal is on hands-on education in so-called OGO-projects in the bachelor program of the mechanical engineering department. In line with TU/e's "Strategy 2030" (TU/e, 2018), this department wishes to further develop these OGO-projects in the direction of Challenge Based Learning (CBL). This kind of learning is seen as very relevant for engineers, now and in the future. Problems increasingly become complex and pressing; to face these problems, we need to develop a generation of engaged learners equipped to identify challenges and develop innovative and sustainable solutions (Nichols, Cator, & Torres, 2016). CBL is supposed to stimulate deep, engaging, meaningful and purposeful learning. Next to learning necessary knowledge and skills, CBL provides in building 21<sup>st</sup> century skills and a framework for lifelong learning. It is hands-on and collaborative (Nichols et al., 2016).

In order to further develop the OGO-projects into the direction of CBL by the department of mechanical engineering, it is important that students increase their ownership of learning process and learning outcomes. The need for this is based on experiences of teachers with ownership among their students in the current OGO-projects. They experience almost no increase in ownership among students over the years of the bachelor program. Despite the various attempts to make changes to this, for example, by carefully increasing the complexity of the projects (from less to more complex) and gradually decreasing support (fading), students in their second and third year hardly change towards more ownership when compared with first year students.

One might speculate about causes for this. Several of these may at least to some extent have to do with the structure and organisation of the Bachelor College of TU/e which encourage specific study patterns among students in a large number of courses. Another, though connected reason might be that students experience much uncertainty in project-based learning environments, for example, regarding the learning outcomes of their projects, their dependence on and cooperation with peers, and the ways in which they are assessed. Anyhow, OGO-projects characterized by hands-on and collaborative education are very important in engineering education, now and in the future. Successful education of this type demands strong ownership of students of their learning process and learning results. This is all the more important when we want to realize CBL in line with TU/e's education strategy 2030.

## 2. Towards a framework for enhancing students' ownership

Ownership refers to learning what you do for yourself based on interest; it implies independence, having control over your own learning process and learning objectives. Several aspects need to be taken into account for realizing ownership with students, which will be briefly explained below. These pertain to meeting students' basic needs, motives for ownership, and the regulation of learning activities.

### 2.1 Meeting students' basic needs

One's intrinsic motivation is essential for realizing ownership. To address students' intrinsic motivation, the learning environment must at least meet the following three basic needs that motivate one to initiate activities and that are essential for psychological health and well-being (Ryan & Deci, 2000):

1. *Competence*. This need refers to searching to control the outcome of learning and to experiencing mastery.
2. *Autonomy*. This need refers to the desire to be causal agent of one's own life and to act in harmony with your 'integrated self' (this is not the same as being independent of others).
3. *Relatedness*. This need refers to the will to interact with others, to being connected to others, and experiencing caring for others.

When these basic needs are fulfilled by the learning environment, students are assumed to feel a sense of ownership towards their learning. Next to meeting these basic needs by the learning environment, student also must feel the need to learn by themselves.

### 2.2 Motives/drives for ownership

Owning or controlling something (e.g., an object, a procedure, a process) leads to positive emotions, attitude and behaviour. It enables individuals to produce desired outcomes and to effectively exercise control of the ways that lead to these outcomes. Pierce et al. (2001) mention three internal motives for students' ownership:

1. *Self-efficacy*: one's belief in the capacity to efficiently and adequately organize and carry out a given task or to act adequately in given situations. In terms of (academic) education, self-efficacy can be defined as one's personal assessment of one's own capacities to meet (academic) assignments, tasks or training requirements.
2. *Self-identity*: who one is or want to be and what one finds important strongly determine the effort one puts in performing or exercising an assignment or task. It is therefore important to strive for the learner's commitment with the task by including opportunities for identification with an assignment or task and topic included as well with ways of learning involved.
3. *Sense of belonging*. Feelings of belonging support a person's social-emotional needs or well-being, for example, to an organization, workplace or group. This is important where learning strongly depends on team work and collaboration with peers.

### 2.3 Learning activities

Learning activities can vary from being completely regulated by the teacher (determining 100% what should be learned and how) to being completely regulated by the student (cf. Vermunt & Verloop, 1999). In hands-on education it is important to be clear about the level of independence expected

from students, thus what must be done by the teacher (for example: explaining an assignment, giving a general introduction, managing student expectations, evaluating in-between results, checking progress) and what by the students in terms of:

1. Students' self-responsibility for their learning (for example, formulating learning goals, searching for information, consulting experts, evaluating and controlling their own study progress).
2. Their collaboration in groups with their fellow students (for example, dividing tasks, bringing in experiences, combining results from the group participants, demonstrating responsibility for the group result, address each other on each person's responsibility).

**2.4. Integrated framework for analysis and further development of ownership in hands-on projects**

Figure 1 might be perceived as a framework that connects the basic needs that should be met by each learning environment on the one hand and the motives/drives for ownership on the other. For now this is a very preliminary figure illustrating that both angles of approaching hands-on learning in projects need to strengthen each other. Both also determine the kinds of regulation by the teacher or student as well as the ways of guiding the learning activities students undertake.

	competence	autonomy	relatedness
Self-efficacy	<ul style="list-style-type: none"> <li>- Setting own learning goals</li> <li>- Controlling the learning process</li> <li>- Anticipating results</li> <li>- Assessing own learning outcomes</li> </ul>	<ul style="list-style-type: none"> <li>- Aligning study goals with goals personally found relevant</li> <li>- Deciding about learning activities</li> </ul>	<ul style="list-style-type: none"> <li>- Possessing collaborative skills</li> </ul>
Self-identity	<ul style="list-style-type: none"> <li>- Awareness of task relevance</li> <li>- Reflection on and sense-making of process and results of learning</li> </ul>	<ul style="list-style-type: none"> <li>- Identifying with topic</li> <li>- Exploring meaning of task for yourself</li> <li>- Dealing with frictions between yourself and others</li> </ul>	<ul style="list-style-type: none"> <li>- Seeing interaction and other people as necessary for learning and development</li> </ul>
Sense of belonging	<ul style="list-style-type: none"> <li>- Experiencing the task as important for the profession</li> </ul>	<ul style="list-style-type: none"> <li>- Negotiating about ways of collaboration with others</li> </ul>	<ul style="list-style-type: none"> <li>- Experiencing the surplus value of collaboration and the own role in that</li> <li>- Effectively and adequately working together</li> <li>- Dealing with frictions</li> </ul>

Figure 1: Preliminary overview of ingredients for powerful learning in hands-on projects

As said, Figure 1 serves as a lens for looking at teaching and learning in the hands-on projects and as a basis for improvements. By using this lens, it will also be further developed and attuned to practice.

### 3. Objectives

Students' intrinsic motivation needs to be addressed in hands-on education, which is a necessary prerequisite for getting ownership. To realize this, we aim at the following objectives in this proposal:

1. *Getting a clear picture of how students' ownership in hands-on education projects can be characterized and enhanced by specific measures regarding the implementation of (combinations of) basic learning needs and motives/drives for ownership.*  
For example, by giving a clear introduction about the relevance of a task for the profession ('sense of belonging'/'competence'), coaching on reaching goals set by the students themselves ('self-efficacy'/'autonomy') with support of the teacher ('relatedness'), and to be achieved by dividing tasks based on individual preferences ('self-identity'/'autonomy').
2. *Connecting the patterns resulting from 1 with the regulation of learning activities by the teacher and students respectively.*  
For example, for the pattern mentioned above it seems useful to give students much self-responsibility for their learning (formulating learning goals, searching for information, etc.), but is it important that the teacher takes care for matching this with the learning preferences of the students (for example, with first year students in particular).
3. *Getting a clear picture of how, when and under what conditions study regulation by the teacher can be gradually taken over by students during the consecutive years of the bachelor program.*
4. *Extra objective we aim at setting up an OGO project that pretends to be challenge-based right from the start for two groups of students (case: "dynamic systems") and use Figure 1 as an important source for that. We develop a learning environment that is based on an open ended and relevant question from business. We assume that this objective helps to identify the added value of a challenge-based perspective for regular OGO-projects and how to develop these more into the direction of such a perspective.*

The objectives 1,2 and 3 will be realized by combining the development/improvement of hands-on education projects and monitoring research in several rounds (see below). The research and development activities needed for setting up a challenge-based OGO project (objective 4) run parallel to these.

An overarching objective is to make insights, experiences and good practices available to the other departments of TU/e by way of presentations, guidelines in a manual and professional publications. As such, this project may have a number of implications for further developing engineering education at TU/e into the desired direction as expressed in TU/e's education strategy 2030.

### 5. Approach

The following project phases will be distinguished:

1. Making Figure 1 fit the practice of current hands-on education projects in the different years of the bachelor program of mechanical engineering. This will be done in consultation with

teachers on the basis of observations of a number of representative hands-on projects by the researcher involved.

2. Making a manual together with teachers based on the results from phase 1. During the execution of the projects the teachers will exchange experiences with the manual.
3. A selection of students will be interviewed about their ownership and how this is realized in their projects. A sample of projects in different years of the bachelor program will be observed for this purpose as well. The more developed Figure 1 will be used for making the observation and interview schemes.
4. The findings from phase 3, together with the experiences of the teachers in phase 2, will be used to improve the basis for the manual and the manual itself. Again the teachers exchange experiences with the manual during the execution of the projects.
5. Making final adjustments to the manual together with the teachers, and making relevant insights, experiences and good practices available to other departments of TU/e. This includes thus the manual and professional publications.

The set up, execution and evaluation of the challenge-based OGO project will roughly follow the same project phases, so that information exchange and feedback can be used in between for further development.

## 6. Planning

The planning will be for 24 months:

### Phase 1-3: January 2019 – February 2020

- Contacting teachers and observing 15 projects by researcher (*January-April 2019*)
- Conversations with teachers and making Figure 1 fit current practices in close collaboration with the teachers (*May-July 2019*)
- Making the manual together with the teachers, trying it out by the teachers and exchanging experiences to be collected by the researcher (*August 2019-January 2020*)
- Observations of projects and interviews with students by the researcher (*September 2019-February 2020*)

### Phase 4-5: January – September 2020

- Improving the manual together with the teachers (*March-April 2020*)
- Collecting teacher experiences by the researcher (*May-July 2020*)
- Making final adjustments to the manual together with teachers (*August-September 2020*)
- Presenting results within and outside TU/e, writing professional publications (*October-December 2020*)

## References

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