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MEASURING SOCIAL IMPACT IN ENGINEERING EDUCATION TO IMPROVE SUSTAINABILITY SKILLS

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ABSTRACT

In times of social climate protection movements, such as Fridays for Future, the priorities of society, industry and higher education are currently changing. The consideration of sustainability challenges is increasing. In the context of sustainable development, social skills are crucial to achieving the United Nations Sustainable Development Goals (SDGs). In particular, the impact that educational activities have on people, communities and society is therefore coming to the fore. Research has shown that people with high levels of social competence are better able to manage stressful situations, maintain positive relationships and communicate effectively. They are also associated with better academic performance and career success. However, especially in engineering programs, the social pillar is underrepresented compared to the environmental and economic pillars.

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In response to these changes, higher education institutions should be more aware of their social impact - from individual forms of teaching to entire modules and degree programs. To specifically determine the potential for improvement and derive resulting change for further development, we present an initial framework for social impact measurement by transferring already established approaches from the business sector to the education sector. To demonstrate the applicability, we measure the key competencies taught in undergraduate engineering programs in Germany.

The aim is to prepare the students for success in the modern world of work and their future contribution to sustainable development. Additionally, the university can include the results in its sustainability report. Our method can be applied to different teaching methods and enables their comparison.

1 INTRODUCTION

In the last decade, societal and political attention has shifted towards increasing sustainability, which encompasses social, environmental and economic pillars (Linnér and Wibeck 2019). Therefore, the social role of companies is shifting as well. Customers no longer choose products only based on price and function, but increasingly on the values, beliefs and social contribution of the company. This is not specific to one industry and important to survive in the market (Abeysekera 2021). Currently, the focus of companies and the educational sector is mainly on addressing the environmental and economic pillar, but there is still a lack for the consideration of the social pillar.

Social impact refers to the impact that product and service related activities have on people, communities and society (Vanclay 2003; Rawhouser 2019). A company has various qualitative and quantitative methods to measure it for the whole organization, individual projects or activities. It allows reviewing their efforts to create public value and subsequently adjust their offerings. Since universities train the workforce of the future for companies, they cannot escape this trend. It is therefore becoming increasingly important for them to analyze and transparently communicate the sustainability impact (Roorda 2008).

In this paper, we therefore develop first steps for an approach to measure the social impact of our study programs in the department of energy technology (University of Applied Sciences Aachen). We transfer an already established business framework approaches to the education sector.

2 METHODOLOGY

Measuring social impacts is more complex than measuring economic and environmental factors. These are mainly measured quantitatively, e.g. through revenues, expenditures, global warming potential (CO₂e), soil toxicity.

In contrast, social aspects are difficult to quantify, therefore surveys are commonly used as a qualitative tool (Arena et al. 2015).

All of them have in common a precise analysis of the company, including the vision, which is the motivating, positively formulated idea of the state you want to achieve with your company. This is followed by the mission statement that emerges as a mandate to make it a reality. In addition, there is afterwards the organization's value proposition, i.e. a statement that describes the value that a company or a product offers the customer. The next step is the stakeholder analysis. This means gathering information about all the people/organizations (stakeholders) that are affected by the organization and may influence it both positively and negatively. It also helps to identify the beneficiaries of the product/service. Conducting a stakeholder analysis allows to identify their needs and expectations so that we can then address them specifically.

Many also consider the value chain with the additional extension of outcome (short-term effects) and impact (long-term effects). This is based on the theory of change. Key Performance Indicators (KPIs) are then used for measurement, which can be used to determine the current status and progress in relation to the objective within an organization (Arena et al. 2015; Perrini et al. 2021; Abeysekera 2022). These are set up according to the SMART principle: Specific, Measurable, Attainable, Realistic, Time-sensitive (Dominguez 2019).

Currently, there are different approaches to measuring the social pillar and different similar wordings e.g. social value, social performance, social accounting (Arena et al. 2015; Rawhouser 2019).

We decided to use for our approach the recommendation manual of the Erasmus+ project “Social Impact Measurement for Civil Society Organizations (SIM4CSOs)”. It suggests the following basic steps (“related questions”) (SIM4CSOs 2022):

1. Organisational Scope (“Who are we?”)
2. Problem statement (“What we do & why?”)
3. Key stakeholders (“Who we affect?”)
4. Value Chain (“How is it supposed to work?”)
5. Outcomes plan (“How will we measure it?”)
6. Reporting plan (“How will we report?”)

For the following chapter, we have only provided the most important results and selected points that are relevant for understanding the measurement of social impact. Therefore, we have not included step 6 in the publication, as the previous steps should be completed first.

3 RESULTS

For a better overview, we have used the model of the Impact Business Model Canvas (IBMC) as an additional assistance for the documentation (Fig. 1), which we have slightly modified for our needs (Soule 2019). Following steps one to five, we gradually fill it with content. Since we only consider selected aspects, the IBMC is not completely finalized.

Problem Statement The main problem is the changing profile of requirements for our teaching offers, which leads to uncertainty about whether we prepare properly for future work.				
Vision Statement Our vision is to provide teaching for national & international professionals of the future, so that they are optimally trained for the challenges of the sustainable, diverse & global working world.			Mission Statement We aim to provide family-oriented, innovative & practical education & training of engineers in the field of energy technology through inter- & transdisciplinary research & teaching.	
Key Partners Industry External research institutes Scientific communities Media	Key Activities Teaching: - Professional training - Study programs - Final & project work Research & Development Consulting	Value Proposition International experience Interdisciplinary Thinking Family learning atmosphere Invite to participate Educate on sustainable issues Improved job opportunities Research-related Practice-oriented	Stakeholder Engagement Events Homepage Personal contact Training/ Education Co-Creation Advisory	Customer & Beneficiaries Students Research Institutes Partner Companies Industry
	Key Resources Lecturers Researchers Expertise (didactic, specialized) Network (partner companies) Common social goal Material/ financial resources		Channels Homepage/Social Media Open day Cooperation contact data Network meetings/conferences Email, elearning platform Courses	
Cost Structure Fixed costs: facility & Infrastructure Operating costs: staff, research facilities, travel expenses Variable costs: reserves, one-time investments, projects			Revenue Streams Basic funding (state) Project funding (federal, state, EU, industry) Donations (industry, private individuals) Revenue from consulting & training	
Intended Outcomes & Impact <i>Will be added when the full analysis is completed</i>				

Fig. 1. Impact Business Model Canvas (Draft)

In the first step organisational scope, we first summarized our key resources, channels of communication, cost structure, revenue stream, and added it to the IBMC (Fig. 1). Then, based on the general university strategy of the (University of Applied Sciences Aachen) and in cooperation with the dean's office of the Department of Energy

Technology, we defined the vision and mission statement as well as our value proposition (Fig. 1).

As the second step problem statement, we added the key activities (Fig. 1), which describe what are we currently doing. The main purpose of the faculty activities is to provide education for the future professionals (see vision & mission Fig. 1). Therefore, the relevant teaching activities were identified in more detail on the basis of the module handbooks and program descriptions. We offer in all our programs lectures, exercises, tutoriums, practical/lab courses, guest lectures, project work, thesis writing and field excursions. The related outputs are examination results, practical course certificates, presentations, assignments/reports, feedback, personal notes and finally the engineering degree. For the start of our social measurement, we have limited ourselves here to the offerings in our undergraduate degree programs (mechanical engineering, electrical engineering and industrial engineering).

Next, was the identification of the problem and resulting challenges for our educational offer. The main problem is the changing profile of requirements for our engineering graduates (Heidling et. al. 2019; Giesenbauer and Müller-Christ 2020). It also leads to uncertainty about whether we are preparing them properly for their future work. This is due to the fact that the current teaching focus is mainly on specialist knowledge and not yet comprehensively on a key competence profile (Trilling and Fadel 2009; Heidling et. al. 2019). In addition, it is also changing as a result of globalization, digitization and sustainable development (Giesenbauer and Müller-Christ 2020). For this reason, we must reorient ourselves as a university in order to ensure the best possible education for our students in the future. We summarized these results and included them in the IBMC (Fig. 1).

In the third step key stakeholders, we analysed our stakeholders and segmented them into:

- Internal stakeholder: state government (North Rhine Westphalia, Germany), university management (rectorate), university administration, deanery (faculty management), professors, lecturers, staff, students (national, international), student representation, scientific advisory board, research institutes of the faculty, partner companies
- External stakeholder: industry, research institutes, scientific communities, society, media, public (social Actors & NGOs)

Based on the stakeholder analysis, we classified the stakeholders according to categories key stakeholders, customers & beneficiaries, stakeholder engagement in our IBMC (Fig. 1). Since we only want to give a brief overview of the applied methodology in this publication, we limited ourselves to the beneficiary “students”.

In the fourth step value chain, we started to create the social value chain for our students (Fig. 2). From the earlier mention steps, we had already the input, activities and outputs for the chain. The missing part and additional next step was to focus on our outcomes and impacts. Based on a literature review, we answered the question of what impacts (long-term) and outcomes (short-term) we achieve and how we can measure these impacts/outcomes using indicators. Then we looked at what learning techniques we can apply to influence them positively. To demonstrate the procedure, here an example:

Quality of life is intended as the long term effect through professional development and economic advantage with the degree-specific knowledge, practical relevance and awareness (Tillbury 2011; Heidling et. al. 2019). For the challenges of the sustainable, digitalized and globalized working world, we aim to prepare our graduates specifically

and effectively by addressing 21st century skills (future skills). Three categories of skills are identified (Trilling and Fadel 2009):

- Learning & Innovation – “The 4 C’s”: Critical Thinking & Problem Solving, Creativity & Innovation, Communication, Collaboration
- Digital Literacy: Information Literacy, Media Literacy, Information & Communication Technologies Literacy
- Career & Life: Flexibility & Adaptability, Initiative & Self-Direction, Social & Cross-Cultural Interaction, Productivity & Accountability, Leadership & Responsibility

This is ensured through our innovative & practice-oriented higher education with the engagement of our industry partners, research institutes and academic policy (Trilling and Fadel 2009; Subrahmanyam 2020). In addition, an expert review, commissioned by the UNESCO, identifies active learning techniques, applicable in engineering courses, which support the development of the 4 C’s: group discussions, case studies, critical reading and writing, problem-based learning, fieldwork and outdoor learning (Tillbury 2011).

Due to the preferred requirements of the industry, more employment opportunities arise from the competence profile of the students (Trilling and Fadel 2009; Tillbury 2011; Subrahmanyam 2020). This results in improved financial security.

Furthermore, we aim to improve their personal well-being (Trilling and Fadel 2009). It is influenced on the one hand by the long-term possible improved economic situation and on the other by the direct enrichment through development of self-esteem within the teaching methods (Trilling and Fadel 2009; Tillbury 2011). This leads to the development of internal motivation to acquire new knowledge (Trilling and Fadel 2009).

Based on the research results, we visualised the entire value chain for students in Fig. 2. For clarity and a better overview, we didn’t add again the literature sources.

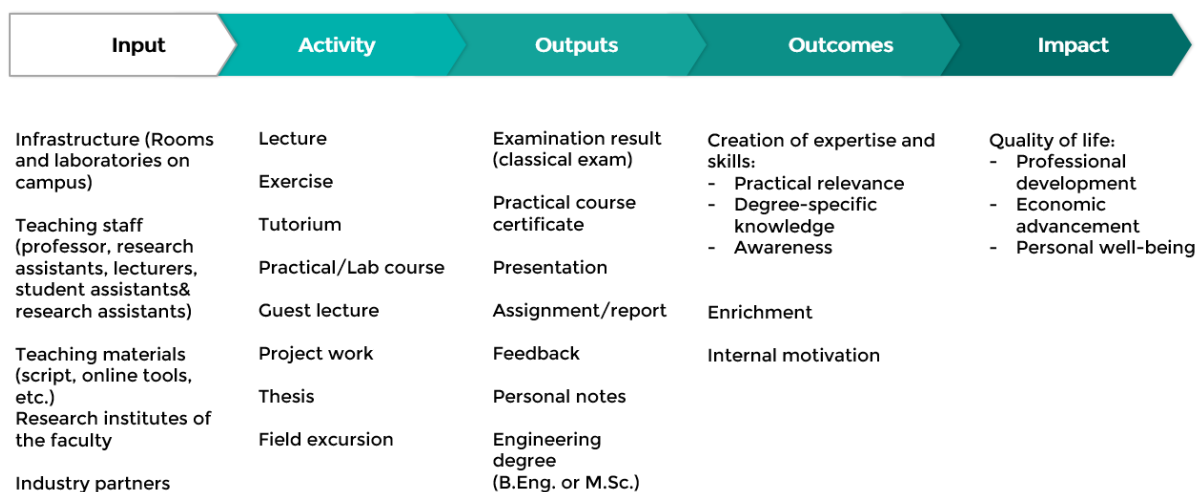


Fig. 2. Students Social Value Chain

In the fifth steps outcomes plan, we created an example of one outcome and one impact of KPI with metric, data source and the frequency of the measurement. Fig. 3 shows the result for the outcome "Creation of expertise and skills", where we restricted ourselves to the specific sub-item "Awareness".

Outcome	Indicator	Metric	Data Source	Frequency
Creation of expertise and skills: - Awareness	Mindfulness & attention for sustainability	% of answer 3 & 4 to the second question (% of students that increased their awareness about _____ after the course)	<ul style="list-style-type: none"> Question before: „How much are you aware of _____?“ (specific topic; e.g. climate change challenges) 1- I never heard of it 2- I just heard about it 3 - I know it at little bit 4- I am full aware Question after: „Do you think this lecture helped you to increase your attention and mindfulness of _____?“ (specific topic) 1- I was already aware about it. 2- I didn't had knowledge about it and think I didn't gain more attention nor mindfulness. 3 - I extended a little bit. 4- I think I am more aware of it. 	Beginning & end of each semester in every course that address sustainability topics

Fig. 3. Example for outcome measurement (Awareness)

For demonstration, we have chosen mindfulness and attention for sustainability as an indicator, because it creates awareness (Yeganeh and Kolb 2009). Typically, multiple qualitative and quantitative indicators should be used, as the more data that is included, the stronger the results. In the metric for the selected indicator, we measure how many students have actually achieved this outcome through our activities, e.g. a lecture here. For this purpose, we ask a short question at the beginning and end of each semester in every course that deals with sustainability.

Fig. 4 shows the result for the impact "Quality of life", where we restricted ourselves to the specific sub-item "Professional development".

Impact	Indicator	Metric	Data Source	Frequency
Quality of life: - Professional development	Critical Thinking	<p>% of courses in the curriculum with problem and project based learning elements</p> <p>Number of students that have successfully completed the course</p> <p>% of students that increases the competence critical thinking</p>	<p>Description module /degree programs</p> <p>Exam result (record/statistics)</p> <p>Professional assessment of the teachers based on the students' self-reflection report and the impression during participation</p>	<p>Counting in the accreditation cycle (every 4 years)</p> <p>During & after every course that used problem and project-based learning</p> <p>During & after every course that used problem and project-based learning</p>

Fig. 4. Example for impact measurement (Critical Thinking)

4 OUTLOOK

With the present results, a first foundation for measuring the social impact for students has been created. In a next step, the not yet considered outcomes and impacts in Fig. 2 will be developed and subsequently added to Fig. 3 & 4 accordingly.

This is done by setting up the desired competence profile for our graduates on the basis of an extended multi-criteria literature research and by weighting the individual facets. In this way, it is ensured that all important required competences have been taken into account. Based on these results, the outcomes, impacts and the corresponding KPIs are determined.

For the collection of the KPIs, the existing literature in the field of didactics, social sciences and psychology is used, as there are already established methodologies in this field available through several research studies. Subsequently, the evaluation queries, graduate surveys and module descriptions are consulted for data collection of the results.

In order to ensure that the state of development doesn't have to be recorded manually in the future, it is planned to establish a database for collecting the data. This way, the existing data will only have to be imported in the tool, e.g. evaluation results via Excel or module descriptions via pdf, and there will as well be a manual input field.

The next step is to align the results and impacts with the relevant SDGs to ensure that we are making a positive contribution to these goals. Both direct and indirectly influenced impacts will be recorded and benchmarked against previous results. It facilitates our communication with the public through our sustainability report and our channels (Fig. 1). The report will be produced within the framework of the accreditation cycle and is important to present the progress of continuous improvement in a measurable and transparent way.

Subsequently, the approach developed to measure our social impact will be discussed and reflected upon with internal stakeholders in order to further improve the results achieved so far.

Therefore, a teaching survey will then be conducted in the faculty to find out which teaching methods are currently used and which competences are already taught in the respective degree programmes. In this way, the applicability of the measurement can be evaluated in an initial trial run and improved if necessary.

Afterward, the first results will be used to evaluate the current status of the study programmes and from this to identify both potential for improvement and to formulate targets and goals for our indicators. Our aim is to establish a baseline teaching quality standard that will help to continuously improve our courses by setting realistic, long-term and small-step targets.

After completing this intrating process for our beneficiaries students, we want to extend our social impact measurement to our other beneficiaries (Fig. 1). For this purpose, the complete process is repeated and adapted accordingly for these groups.

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