5.1

Evaluating and Researching Transferable Competencies and Skills

Esther Ventura-Medina[a], Natascha van Hattum-Janssen[b], and Gillian Saunders-Smits[c]

[a] Eindhoven University of Technology, the Netherlands, ORCID: 0000-0002-1041-945X;
[b] Saxion University of Applied Sciences, the Netherlands, ORCID: 0000-0002-2373-191X;
[c] Delft University of Technology, the Netherlands, ORCID: 0000-0002-2905-864X.

Keywords: *research approaches, research methods, evaluation, research ethics, theoretical frameworks, research methodologies*

This introductory chapter to Part 5 focuses on scholarship and research to evaluate the development of transferable competencies and skills. Evaluation and research of educational activities provide evidence of what, how, and why some outcomes occur. This knowledge could be used by stakeholders to improve education. It also helps to inform the engineering education community about areas that require attention and are worthy of further investigation, as well as to inform future practice through evidence. We start by introducing you to the scholarship of evaluation and research, as distinct stages in an inquiry continuum, before outlining the specific topics covered in this part of the handbook. In this context, we feel it is pertinent to establish why it is important to evaluate activities targeting the development of transferable skills and competencies in addition to the purpose of carrying out research on these topics.

DOI: 10.59490/mt.266.94.

1 Introduction

When designing Part 5 of the handbook, which focuses on evaluating needs, interventions, and outcomes of teaching transferable competencies and skills in engineering education, we intended this part to be the most advanced of the handbook, as it deals with assessing and evidencing the impact of our practices on students' learning. Therefore, this part is about reflecting on your teaching practice, and as such it takes you on a journey and guides you through the process of evaluating and researching your own teaching and its outcomes in a scientific manner. This journey starts by entering the realm of the educational sciences, since its approaches to research differ to those used within engineering, with which some of you may be more familiar (National Research Council, 2012). Therefore, as authors of the introductory chapter, we will not cover all areas related to this topic of evaluation and research in depth but aim to raise your awareness of some concepts and prepare the ground for you to start your own journey.

In this part, the authors aim to provide you with guidelines for evaluation and research at different scales; from learning activities in the classroom (nano level) to the larger scale of programmes at a single university, and universities at the national or international level (macro or supra level), zooming out to the comparison of transferable competencies and skills development across curricular contexts.

Chapter 5.2 raises the first fundamental question: what competencies and skills to include in an engineering programme and how to ensure that they are relevant for current and future professionals. Deciding this demands continuous alignment with industry and a mechanism to monitor the relevance of transferable competencies and skills for future engineering graduates. In Chapter 5.3, the authors provide you with a framework to evaluate programme level outcomes of competency and skill development. The next Chapter (5.4) is focused on the effectiveness on specific skill-based interventions within the classroom, how to evaluate the impact of an intervention, how to analyse and compare interventions for skills learning, and how to identify the impact of these interventions. Chapter 5.5 zooms out to a more macro level and uses a landscape analysis to make comparisons across different institutional contexts. In the final Chapter (5.6), you will learn more about sharing the findings of your scholarship and research into evaluation, and how the different ways of publishing influence the impact that your work has on the practice of others. The next sections in this Chapter will familiarize you with some evaluation and research principles covered in the rest of Part 5 and set the stage for you to continue your own exploration.

2 From educational practice to research

As part of your educational practice, you are often asked to look back, reflect on, and evaluate whether you have achieved the desired learning outcomes and the reasons why or why not. The use of evidence-based methods for evaluation can be really useful for this process of looking both back and forward. This is why, in this Section, we will introduce you to the world of inquiry and research in engineering education and show you how this field may be of benefit to you when evaluating your own educational practice.

2.1 Why evaluate educational practices?

As an engineering educator, thinking about how to design learning experiences effectively for your students to develop competencies and skills may be the first step towards carrying out sound educational research. We see the process of improving education as one existing on a continuum of inquiry, where educators move in within it depending on their goals. Each stage of this continuum represents an increase in methodological rigour and public scrutiny moving towards growing engagement with empirical evidence.

Improving education starts with regular and effective teaching, as shown in the inquiry framework for research on engineering education by Borrego and Streveler (2014). Effective teaching focuses on using best teaching practices and content to improve teaching and in turn students' learning.

The next stage, after regular and effective teaching, is referred to as scholarly teaching, or, as described by Potter and Kustra (2011, p. 3): "*teaching grounded in critical reflection using systematically and strategically gathered evidence, related and explained by well-reasoned theory and philosophical understanding, with the goal of maximizing learning through effective teaching."* This is the first stage in approaching teaching and learning more scientifically by gathering evidence and assessing classroom practices to improve teaching.

Where scholarly teaching impacts the activity of teaching and the learning of the students, scholarship of teaching and learning (SoTL), the next stage in this continuum, contributes to scholarly knowledge in a more formal way (Richlin & Cox, 2004). SoTL is defined by Potter and Kustra (2011, p. 2) as "*the systematic study of teaching and learning, using established or validated criteria of scholarship, to understand how teaching (beliefs, behaviours, attitudes, and values) can maximize learning, and/or develop a more accurate understanding of learning, resulting in products that are publicly shared for critique and use by an appropriate community*;" or, as described by Boyer (1990, p. 23) in his founding work on SoTL, "*teaching both educates and entices future scholars*". Borrego and Streveler (2014) emphasise that SoTL is an activity that leads to findings that can be evaluated and criticised publicly and thus leads to knowledge that future teachers and scholars can build on.

The final stage in the continuum is the discipline-based field of engineering education research (EER), which goes well beyond the practice of effective engineering teaching. Borrego and Streveler (2014, p. 458) describe three additional characteristics of EER respect to SoTL: it

1. *"Begins with a research question focusing on the 'why' or 'how' of learning (Paulsen, 2001);*
2. *Ties the question to learning, pedagogical, or social theory and interprets the results of the research in light of theory. This allows for the research to build theory and increase the significance of the findings;*

3. *Pays careful attention to the design of the study, the methods used, the validity and reliability of the findings. This will enable the study to hold up to scrutiny by a broad audience, again creating a potential for greater impact of results".*

It goes beyond the specific population of a specific classroom or a higher education institution — being able to draw conclusions for a broader population of learners characterises EER (Borrego & Streveler, 2014). These characteristics differentiate SoTL from EER.

EER is comparatively young compared to the more traditional fields of educational sciences and has only really started to grow in the past 40 years (Jesiek et al., 2009; Saunders-Smits & Leandro Cruz, 2020). Contrary to much of the research that takes place in engineering, research in the fields of educational sciences and EER is characterised as low-consensus research (Power, 2021). This term describes fields or topics with significant disagreement among experts regarding theories, methodologies, and research questions, often characterized by diverse perspectives and conflicting findings. As such you should not be surprised if you find yourself in healthy academic discourse with colleagues on what is the best way to go forward. Dart et al. (2025) identify themes and subthemes that influence the development of a researcher in engineering education — environment, community, knowledge acquisition, and personal attributes — and make clear that the pathway from scholarly teaching to EER is a complex process that goes beyond the individual development of the researcher. If you are interested in diving deeper into this field, we recommend the *International handbook of engineering education research* (Johri, 2023), which is available as open access.

2.2 Levels and actors in evaluation and research of educational practices

The ultimate aim of an evaluation or research carried out in the context of engineering curricula is to improve education, as mentioned earlier. Education is an ecosystem with different actors that operate at different levels (van den Akker, 2003). Hence, it is important to consider the level at which evaluation or research is done within this ecosystem, as well as the actors involved and their respective perspectives (see Table 5.1.1).

You might be interested in how students acquire and further develop transferable competencies and skills (e.g., to collaborate, communicate, self-regulate) in relation to a specific activity within a module or in the classroom (nano level, Chapter 5.4), how transferable competencies and skills are acquired or developed over a period of time during a module (micro level), how transferable competencies and skills develop throughout an entire programme (meso level, Chapter 5.3), or how programmes across a university or a number of universities support the development of transferable competencies and skills (macro or supra-level, Chapters 5.2 and 5.5). The macro and supra level can also pertain to national or international actors, respectively, and can be linked to policy makers such as accreditation bodies (see Chapter 1.4 of this handbook). How you approach the design of the evaluation or investigation will vary depending on the level at which you operate. However, conceptually the approach for designing a rigorous evaluation or research in learning are not context-bound. Therefore, many elements can be transferred and scaled from one level to another. We elaborate these points further in Section 3.

Table 5.1.1: Levels and actors within the educational ecosystem in the context of evaluation and research of transferable competencies and skills.

Educational level	*Actors' perspective*
Classroom activity (nano level)	Students, lecturers, educational support
Module (micro level)	Students, lecturers, educational support
Programme (meso level)	Students, lecturers, programme director, educational designers
University programmes (macro level)	Students, lecturers, programme directors, educational support, deans, local and national policy makers
Programmes across universities (supra level)	Students, lecturers, programme directors, educational support, deans, and local, national, and international policy makers

The understanding that is derived from evaluating the impact of an intervention or investigating an identified challenge in the context of skills and competencies can be useful to inform lecturers and educational designers (nano level) when designing future educational activities in the classroom (e.g., Mio et al., 2019). Likewise, understanding what works and how students develop transferable skills and competencies over the duration of a module, a problem, or a project (micro and meso level) can help educators and educational designers to consider the design of a coherent and cohesive curricula that supports thorough skills and competency development (e.g., Mabley et al., 2020). Finally, understanding what is effective in different programmes and university environments can help policy makers consider what needs to be in place to support the holistic development of skills and competencies at institutional, national (macro) and international (supra) level (e.g., Chans et al., 2025).

When looking at the different levels of the education ecosystem, it might be obvious which actors to involve (e.g., educators, programme directors, educational support, deans). Involving students in cycles of educational improvement is valuable to ensure that their educational outcomes and experience are enriched (Cook-Sather et al., 2014). Their involvement can be as participants in studies but also as co-designers of educational activities and subsequent participants in evaluation and research. This choice can have an impact on how the investigation is carried out, which necessitates ethical considerations, as we will discuss in Section 4.2.

Now that we have covered the reasons for conducting evaluations and research, as well as the actors involved and levels in which such activity can take place, we will consider in more detail the ways in which the evaluation and research are designed and conducted.

3 Lines of inquiry and theoretical grounding

When considering EER as a field of research, it is important to start by clarifying the position of the theme in the EER field and that of the researchers. Fensham (2004) proposed criteria to position EER as a field of research. His criteria are grouped into structural, intra-research, and outcome categories, and are helpful in shaping the field of EER. When developing lines of inquiry, the intra-research criteria especially need to be considered (see Table 5.1.2).

Table 5.1.2: Fensham's criteria (structural, research and outcome) for defining the field of engineering education research (adapted from Borrego and Bernhard, 2011). Notice that only the research and outcome criteria are included here for relevance.

Research criterion	*Description*
Scientific knowledge	Knowledge of engineering and education required to conduct the research
Asking questions	Asking distinctive research questions not addressed by other fields
Conceptual and theoretical development	Theoretical models with predictive or explanatory power
Research methodologies	Invention, development or at least adaptation of methodologies, techniques, or instruments
Progression	Researchers are informed by previous studies and build upon or deepen understanding
Model publications	Publications that other researchers hold up as models of conduct and presentation of research in the field
Seminal publications	Publications recognised as important or definitive because they marked new directions or provided new insights
Outcome criterion	*Description*
Implications for practice	Outcomes of research that are used in the practice of engineering education

When setting up your research, these criteria support your approach and make you aware of how EER distinguishes itself from other fields. For example, when setting up research questions pertaining to the evaluation of transferable competencies and skills, you need to be aware of how similar questions have already been studied in related fields (e.g., science education, disciplinary education) and how your questions are relevant for developing transferable competencies and skills specifically in engineering education. You can become aware of these through a literature review. Through the process of studying the literature, you also familiarise yourself with the theoretical grounding and the state of the art in related fields of educational research and can adapt them to your own EER. Svinicki (2010) provides a guide of theoretical frameworks in education and links these with common issues found in engineering classrooms and programmes in higher education. She subsequently formulates researchable questions. A theoretical framework, which interconnects ideas, concepts, and relationships of interest in the study, helps to inform the design of the inquiry (Magama, 2021). The theoretical framework not only comprises theories and models on learning but also consists of concepts and ideas derived from earlier research. Hence, a theoretical framework provides a good way to learn what has been done on the specific topic within and outside your field and allows you to ask questions that have yet to be answered and are worthy of investigation within your field.

The most prevalent theories used in research focused on the development of transferable competencies and skills recognise that learning occurs in connection with the social environment: social cognitive theory (Bandura, 1986), situated learning theory (Lave & Wenger, 1991), and social cultural theory (Vygotsky, 1978). Theories related to motivation and agency, such as achievement goal theory (Dweck & Leggett, 1988; Elliot & Church, 1997), self-determination theory (Deci & Ryan, 1985) and expectancy-value theory (Eccles et al., 1983), can also serve to inform research in relation to transferable competency and skill development. The choice of theory used depends very much on the topic or question at hand and the level at which the problem is situated (e.g., nano, micro, meso level).

4 Approaches to evaluation and research

When starting to formulate your evaluation and research process, it is important that you become familiar with what is already known about the topic and problem of interest through a literature study. Next, you can make a link between the problem and a relevant theory about how people learn. This process helps you to formulate the questions that guide your inquiry or research. By going through iterative cycles between problem analysis, theory, and questions, you refine your focus. We provide examples of general research questions, perspective and level, and theory in Table 5.1.3. For examples of evaluation questions and associated methodologies for educational outcomes and interventions, we invite you to read Chapter 5.3, section 5 and Chapter 5.4, section 4 respectively.

There are several ways in which the process of inquiry can be approached. Here, we will elaborate on different approaches to applied research that can be considered in educational contexts (McKenney & Reeves, 2018), as well as broader approaches that are generally used in research (Cohen et al., 2018; Creswell & Creswell, 2018).

Action Research (AR), Design Research (DR), and Educational Design Research (EDR) are considered applied research approaches. However, where the principal goal of AR is the systematic improvement of local classroom practice based on critical reflection through teacher inquiry (Metler, 2021), DR and EDR have the dual focus of improving classroom practices and advancing theoretical understanding through the design and testing of interventions (McKenney & Reeves, 2018). Although in some of the literature a distinction is made between what characterises DR and EDR in regard to applied research in education, McKenney and Reeves (2018) use the term EDR as an umbrella term for all approaches to applied research that share this dual purpose. EDR offers three main inquiry orientations — research for, on, and through interventions — based on the implementation of a specific educational design, i.e., an intervention. In this sense, EDR is also considered an interventionist approach.

EDR follows specific steps or phases each involving the interaction between research and practice — problem analysis and exploration, design and construction, and evaluation and reflection — that are mostly considered in iterative cycles. Possible points of departure in the inquiry process could be (McKenney & Reeves, 2018):

1. When there is a change in the instruction design by means of an intervention, typically in response to an already identified problem in the classroom, that calls for evidence to ascertain if the intervention has met the goals based on the characteristics of the intervention design (i.e., research on interventions). Formulating question 4 in Table 5.1.3 in terms of the effectiveness of the intervention (i.e., 'how well does…') is an example of inquiry on an intervention.
2. When further understanding of the problem is necessary before a solution or an intervention can be designed (i.e., research for interventions), that will provide both theoretical understanding and input for intervention design. Questions 1 and 3 in Table 5.1.3 are examples of questions that seek to investigate and understand a situation before any intervention is designed.
3. When there is interest in understanding certain learning and teaching phenomena and an intervention can provide a means by which this can be studied (i.e., research through interventions). Question 4 in Table 5.1.3 focusing on the students' responses to the intervention is an example of inquiry through an intervention.

When you are interested in understanding a problem, the effect of an intervention or a phenomenon more broadly, you use a "*systematic, controlled, empirical and critical investigation*" of propositions and relations associated to the object of study (Cohen et al., 2017, section 1.2). In doing this, and particularly in the context of transitioning to EER, you are often challenged about your beliefs and position in relation to the nature of knowledge and how it is constructed (i.e., epistemology), your world view (i.e., philosophical perspectives), and your professional identity, for instance, engineer, educator, or educational researcher (Dart et al., 2025).

4.1 Research design

When designing research in general, it is important that your research approach considers the interactions between your views and belief about the nature of the research (i.e., world views), the type of designs, and the research methodologies (Creswell & Creswell, 2018). It is through research design that you attend to the formulated research questions guiding the inquiry. In doing so you follow a process that systematically, structurally, and iteratively gives coherence to the research approach. Research design provides a blueprint that satisfies the research purpose (Cohen et al., 2017, section 7.1) and considers the alignment between a theoretical framework and methods of data collection, analysis, interpretation, and validation (Maxwell, 2013), ultimately rendering the approach coherent.

In practical terms, research design should align well with the questions formulated (what would you like to learn or know? What are the questions you have?), the methodologies used (how could these answer your questions? What type of data is useful in answering the questions? How and when do you collect the data? How do you analyse the data? What perspective do you use to interpret the data?), and the relevant theories and knowledge of the current state of the art (what is already known in this area or about these questions?) on the specific competencies and skills under investigation.

As the research question is a critical part of the inquiry process, we would like to elaborate further on this point. It is important to formulate questions that are relevant and useful, connected to the purpose, theories and knowledge of the field and topic, and that are clear, focused, and feasible. Examples of topics and general questions of interest, the perspective and level at which they are considered, and the possible theoretical approaches that could be used to inform the research design, are presented in Table 5.1.3.

In general, a good approach is to formulate one to two general broad questions for a project or study, such as those in Table 5.1.3, and a sequence of subsidiary questions (typically 1-7), each considering a single concept, phenomenon, or relationship addressing 'what', 'how', 'why', or relevant hypotheses (Creswell & Creswell, 2018; Ritchie et al., 2013). Research questions are generally classified as explorative, descriptive, comparative, hypothesis testing, and interpretivist or meaning-making questions. Depending on the type of question and the purpose of the inquiry, three types of research designs can be selected: quantitative, qualitative, and mixed methods (Creswell & Creswell, 2018). For instance, from the suggested questions in table 5.1.3, questions 2 and 3 involve the exploration of opportunities provided to students at programme level. Question 4 involves making sense of the actions of students working in teams to understand how a specific intervention helps them (and possibly why), making this a good example of an interpretivist question. Question 2 could also be intending to seek a description of the mechanisms supporting skill development at programme level. Questions 1 and 5 could be seen as intending to test a hypothesis or to establish causal relationships respectively, with the possibility of focusing also on explanations and descriptions. In all cases, setting sub-questions can help with further refinement as mentioned earlier.

Table 5.1.3: Examples of potential topics and questions of interest, the actor perspective and level in the educational ecosystems aligned with potentially relevant theories.

	Question	*Actor perspective*	*Education level*	*Theoretical grounding*
1.	To what extent do students in my module develop their leadership and interpersonal communication while working in teams?	Student learning	Module/ activity	Social cognitive theory (Bandura, 1986), experiential learning theory (Kolb, 1984)
2.	How do current opportunities for students to work in teams in my programme contribute to their development of project management skills over time?	Student learning over time	Programme/ series of activities and interventions	Social cognitive theory (Bandura, 1986), socio-cultural theory (Vygotsky, 1978), expertise development - deliberate practice model (Ericson et al., 1993)
3.	What competencies are essential for students in my programme to succeed in their internship?	Student/ workplace	Module/ programme	Situated learning (Lave & Wenger, 1991), social cognitive theory (Bandura, 1986)
4.	How (well) does the 'workshop on teamwork management' at the beginning of my module help students to set up team processes?	Student	Module/ intervention	Social cognitive theory (Bandura, 1986), self-regulated learning (Zimmerman, 1986), socially shared regulation (Hadwin et al., 2018)
5.	What is the effect of using online quizzes in the self-regulatory behaviour of first-year students?	Student	Module/ programme/ intervention	Social cognitive theory (Bandura, 1986), self-regulated learning (Zimmerman, 1986)

After the formulation of the research question and sub-questions, you should select the appropriate research design and methods. Features such as the nature of the research question and the number of participants can help in deciding what approach to take.

Quantitative designs and methods are preferred when a theory is being tested or the deductions about relationships and characteristics of the sample population are of interest. They are also a good fit when the population of participants is sizeable, as they allow for use of statistical analysis, which can be split in descriptive statistics, correlational analysis, and factor analysis (Borrego et al., 2009). Quantitative designs include experimental designs such as true- and quasi-experiments as well as non-experimental designs such as causal-comparative designs, correlational designs, and surveys (Creswell & Creswell, 2018).

Qualitative designs and methods are favoured when the research question is of a descriptive, explanatory, or meaning-making nature and tries to address 'what', 'how' and 'why' questions, which requires rich contextual data (Borrego et al., 2009). Qualitative designs comprise procedures from different perspectives, such as grounded theory, phenomenology, ethnography, narrative research, and case studies (Creswell & Creswell, 2018). Much of the data collected is conversational, textual, or visual, and is analysed through different approaches bound by the design procedure and theoretical framework. In comparison to quantitative designs, that are mostly dominated by deductive approaches, qualitative data analysis often follows an inductive approach, providing space for interpretivist perspectives which can be completed for the smaller sample of participants typical of qualitative studies (Borrego et al., 2009).

Mixed methods designs involve the combination or integration of both quantitative and qualitative designs. Some forms of mixed methods design are (Creswell & Creswell, 2018):

- *convergent parallel.* Looking to merge data to yield a comprehensive analysis;
- *explanatory sequential.* In which quantitative research is followed by explanatory qualitative research;
- *exploratory sequential.* In which qualitative exploration takes place in order to build a quantitative phase;
- *embedded.* That is, either convergent or sequential data are combined with complementary data;
- *multiphase mixed methods.* Employment of both concurrent and sequential strategies.

We want to emphasise that there is no such thing as correct or incorrect research method or design; instead, the right research design should be selected that will best answer the research question (Borrego et al., 2009). Methods and design should also satisfy the criteria for coherence in research (Maxwell, 2013), which state that there should be clear alignment and connection between the goals, the theory and state of the art, the research questions, the methods, and the validity of the results.

In any line of inquiry, be it for evaluating the effectiveness and impact of an intervention at different levels or for understanding an issue or phenomenon in the classroom, the process involved in planning is very similar. Later in section 4.3 (Table 5.1.4) we touch on examples of approaches that could serve to guide evaluation and research designs making explicit distinctions between broad questions, level, target groups, and research design and methods. You will also find examples in the subsequent chapters of this part that elaborate on these points.

4.2 Ethical considerations

In preparing an evaluation or research design it is important to consider the ethical aspects of the inquiry. Ethical dilemmas might appear because of the nature of the research (e.g., involving minority groups), the contexts, procedures, methods, and type of data collected, the characteristics of participants (e.g., students with specific learning needs), and manner in which data might be used in the dissemination of results (Cohen et al., 2017, section 7.1; Sochacka et al., 2018). All these need to be considered in research design and planning. While designing and planning your research, it is essential that you consider how to communicate with stakeholders to clarify the reasons for conducting the investigation, the activities that this entails, and how the outcomes will help in further improving the educational setting. These actions help participants to make informed decisions about their participation in your research. In many cases the participants in a study are your own students, and in such cases, it is important to clarify to them how any potential conflicts of interest and power relationships are being addressed. For instance, if the target population are students in your module, how would you reassure students that their grades will not be affected by their participation (or lack thereof) in a study? In such cases, asking students to consent to participate (informed consent) does not sufficiently address ethical aspects. We will not cover how to address ethical dilemmas in EER in detail here. However, following institutional codes of ethics and procedures for ethical approval is essential for carrying out research in a responsible manner. We encourage you to apply for ethical approval early, as the process can help you to clarify many of the details related to the execution of the research (e.g., dealing with privacy, power imbalance, data management and storage) and ensure that you pay attention to any potential impact on different student groups. Higher education institutions have policies and procedures that help to fulfil ethical expectations and ensure legal compliance for investigations dealing with human participants. Note that ethical approval takes time and is a process better started earlier to ensure that this is in place before you start with any data collection. In addition, if you wish to publish the findings of your work, having obtained ethical approval is a requirement by many publishers.

4.3 Examples of evaluation and research design and methods in the context of transferable competencies and skills

Examples of broad research questions used to guide the selection of research design and methods, as well as the data collection and analytical approaches to data, are presented in Table 5.1.4.

Table 5.1.4: Examples of potential research designs and methods relevant to broad research questions on transferable competencies and skills at different levels and with different perspectives. Note: the methods proposed here are by no means exhaustive and are intended as examples only.

	Broad question	*Design*	*Methods: data collection and*	*Methods: analytical approaches*
1.	To what extent do students in my module develop their leadership and interpersonal communication while working in teams?	Quantitative Mixed: explanatory	Survey instrument, interviews, focus groups, observations, documentation	Statistical analysis (descriptive, inferential) explanatory analysis (grounded theory, qualitative content analysis, thematic analysis)
2.	How do current opportunities for students to work in teams in my programme contribute to their development of project management skills over time?	Qualitative	Longitudinal interviews, documentation	Narrative analysis, interpretative phenomenological analysis
3.	What competencies are essential for students in my programme to succeed in their internship?	Mixed: exploratory	Interviews, focus groups, surveys, Q-methodology	Case study analysis, thematic analysis, Q-methodology, descriptive and inferential statistics, exploratory factor analysis
4.	How (well) does the 'workshop on team-work management' at the beginning of my module help students to set-up team processes?	Qualitative	Interviews, exit cards, focus groups, observations, documentation	Qualitative content analysis, thematic analysis
5.	What is the effect of using online quizzes in the self-regulatory behaviour of first year students?	Quantitative Mixed: convergent embedded	Survey, online analytics, interviews	Sequential analysis of online trace data, descriptive, inferential and comparative statistics, thematic analysis

As mentioned earlier, the questions should be aligned with the theoretical foundations that guide the inquiry. Ultimately, preparing a research design is an iterative process. For more about research methods in engineering education, we recommend the upcoming *International handbook of engineering education research methods* (Johri et al., n.d.) and Dewar et al. (2018) and for general education research works by Bakker (2018), Creswell (& Creswell (2018), Cohen et al. (2017), Mertler (2024), and Svinicki (2004).

4.4 Quality criteria for EER

In designing evaluation and research approaches to study education in competencies and skills, it is important to recognise some of the aspects that influence their development. You know that much of the learning takes place outside the classroom and as such it is influenced by external factors that are not possible for you to control or to capture. This is of particular importance when trying to use control groups in an experimental or quasi-experimental design, where you aim to establish cause-effect relationships. Similarly, when using qualitative approaches where students self-report or must recall past experiences, the data might be biased as it is contingent on students' own beliefs and values. Learning is a social activity and as such many factors affect the sense making, knowledge construction, and competency development of individuals. Likewise, when using surveys, the participants might be representative of only a part of the student population, potentially skewing the results. To strengthen the quality of research, a good strategy is to use different sources of data (i.e., data triangulation). Therefore, when making claims and attempting to generalise findings from your research, you must be open about the potential limitations which could arise from assumptions made, methods of data, and/or analytical approaches.

There are quality criteria that help establish the validity, reliability, objectivity, and generalizability of quantitative designs and the equivalent credibility, dependability, reflexivity, and transferability in qualitative designs (Borrego et al., 2009). It is important therefore to consider these at all stages of the evaluation and research process. To learn more about this, we have provided you with our recommendations of some of the more general literature on research design, research in education, and engineering education research, which you can find in Section 4.3.

5 Informing practice

We invite you to continue reading this part of the handbook to learn more about specific examples and cases where evaluation and research of competencies and skills have been carried out. Firstly, with respect to evaluating the relevance of skills, Chapter 5.2 presents cases in three different contexts (engineering skills in Finland, in the timber construction sector at different levels, and in the nuclear industry in Australia) where relevant skills were identified via various evaluation frameworks and approaches. Secondly, relevant to the evaluation of programme outcomes, Chapter 5.3 shows an approach to evaluate the attainment of competencies and skills developed from quality assurance frameworks, using student assessment data. Following on to consider the evaluation of activities and interventions, Chapter 5.4, on evaluating interventions that develop transferable competencies and skills, offers a clear and practical guide to carry out the evaluations of interventions implemented at classroom level (case 1) and programme level (case 2). When it comes to institutional and cross-institutional perspectives, Chapter 5.5 presents approaches to carry out reviews: comparisons within and across institutions are exemplified by a case focused on the instruction of communication across institutions in Canada. Relevant to sharing the findings of your work is Chapter 5.6, which showcases how to report and disseminate findings from evaluation and research that help in building knowledge and contributing to the redesign of education activities to improve the quality of educational practices.

We invite you to experiment in evaluating and researching your own teaching and to reflect on your own approaches. Most universities have a Centre for Teaching and Learning where you can find more information and context specific support. The SoTL international community (International Society for the Scholarship of Teaching and Learning, n.d.) is also a source of inspiration, information, and support. You might also want to check local SoTL institutional or national networks that connect education researchers or consider attending one of the various Engineering Education conferences, such as our own SEFI annual conference. As mentioned in Chapter 5.6, conferences offer a supportive environment in which to first disseminate your own scholarly activity by presenting and publishing your evaluation findings. It is our hope that this and subsequent chapters will help you in taking the first steps to becoming a reflective educator.

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AI statement

During the preparation of this work the authors did not make use of any AI tools.

Contributor statement

Conceptualisation	Esther Ventura-Medina, Natascha van Hattum-Janssen, Gillian Saunders-Smits
Project administration	Esther Ventura-Medina, Natascha van Hattum-Janssen, Gillian Saunders-Smits
Visualisation	Esther Ventura-Medina, Natascha van Hattum-Janssen, Gillian Saunders-Smits
Writing - original draft	Esther Ventura-Medina, Natascha van Hattum-Janssen, Gillian Saunders-Smits
Writing - reviewing and editing	Esther Ventura-Medina, Natascha van Hattum-Janssen, Gillian Saunders-Smits