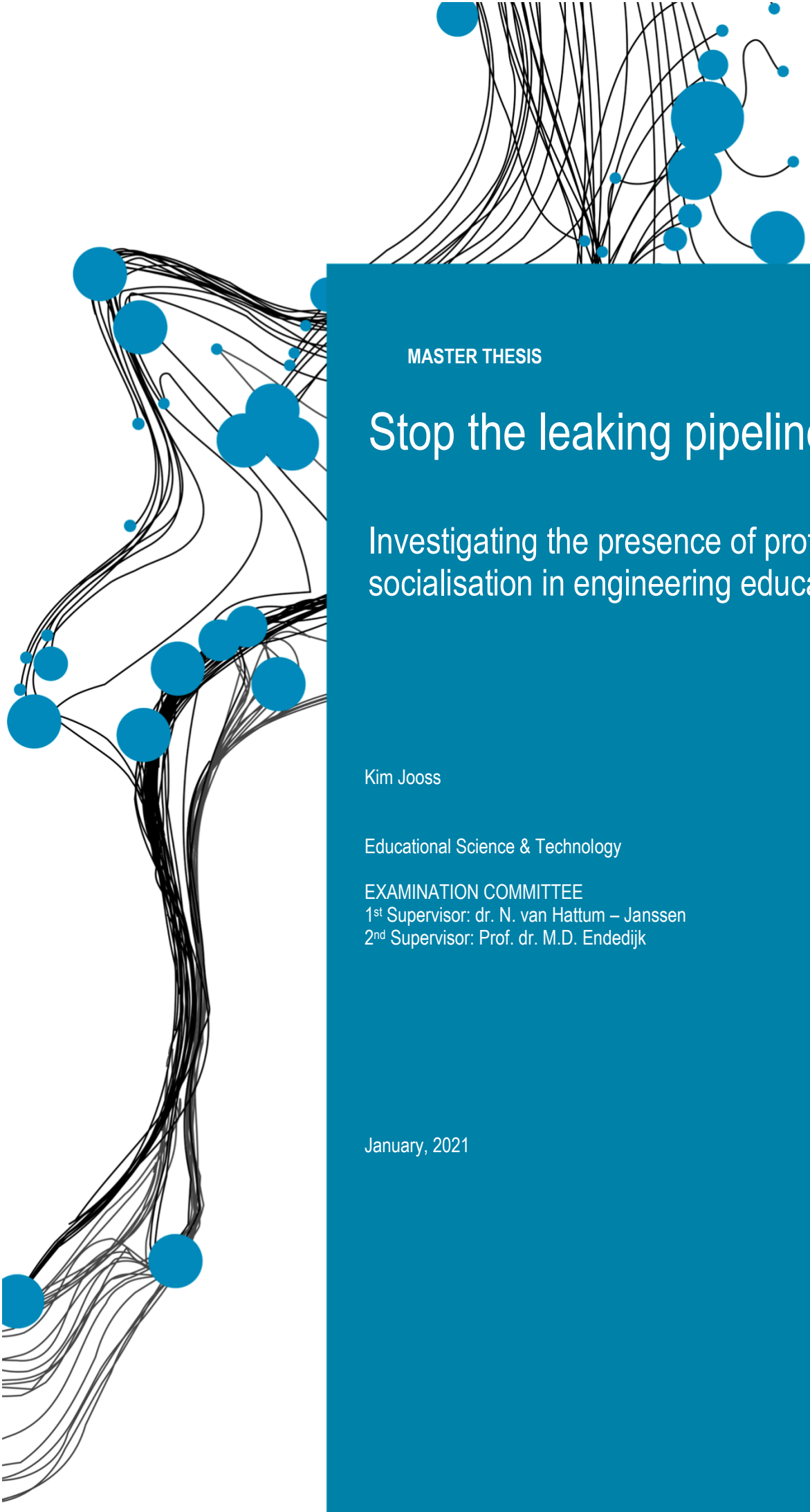

MASTER THESIS

Stop the leaking pipeline!

Investigating the presence of professional socialisation in engineering education

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Educational Science & Technology

EXAMINATION COMMITTEE
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Abstract

Nowadays, there is an increasingly growing lack of engineers. One of the possible explanations for this is that around 40% of the graduated engineers leave the engineering sector. A factor contributing to this is an underdeveloped professional identity (PI) as an engineer. One way the PI is shaped, is by engaging in professional socialising experiences. The current study aimed to investigate how professional socialisation is present in engineering curricula. To do so, the formal and perceived curricula of four degree programmes are investigated. The formal curriculum is investigated by document analysis and the perceived curriculum is investigated by using both semi-structured interviews and a survey. The results revealed that professional socialisation in the formal curriculum of the programs under study is primarily focused on the lower levels of engagement, namely at exposing students to the profession and to some extent on gaining knowledge about the profession. After the first two years of the degree programme, there are some experiences focused on interacting with the profession, but there are little experiences focusing on reflection. The analysis of the perceived curriculum indicated that there are other professional socialising experiences embedded than covered in the formal curriculum, indicating that there is a misalignment between the formal and perceived curriculum. Besides insight in the formal and perceived curriculum, a rubric was developed which aims to map the presence of professional socialisation in the formal curriculum. The rubric seems a good first step to investigate the presence of professional socialisation in the curriculum, but further research is needed to validate the rubric. This study adds value to the existing literature, since this study is the first which developed an instrument to map the presence of professional socialisation in engineering curricula.

Keywords: Professional identity, STEM, Engineering, Curriculum, Professional socialisation

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Problem statement

Nowadays, society is becoming increasingly dependent on technology. Considering this, there is a need for qualified employees who are developing these technologies to remain economically competitive (Thibaut et al., 2018). In the current situation, there is a shortage of engineers in the technical sector in the Netherlands (van der Aalst & van den Beuke, 2017; Thibaut et al., 2018). Several attempts have been made to solve this problem, most of them focus on educating more students by increasing the number of students in the field of Science, Technology, Engineering and Mathematics (STEM). One example of these initiatives is making pupils enthusiastic, so it becomes more likely for them to choose a study in the STEM field (Techniekpact, 2020). Despite those initiatives, there is still a lack of engineers. A possible explanation why these initiatives did not completely solve the problem is the fact that around 40% of the graduates from the university of applied sciences (UAS) and 12% of the graduates from the university leave the technical sector (van Langen, Jenniskens & Hurk, 2019). Thus, several attempts were made to increase the intake in engineering studies, but when students graduate, several find jobs outside the engineering sector.

The professional identity (PI) of students is a crucial concept in explaining why graduates leave the technical sector. PI is defined as the collective of experiences, attributes, values, motives and beliefs which makes an individual defines themselves with a professional role (Ibarra,1999). Graduates who have a stronger and more developed PI as an engineer are more likely to choose a career in the STEM sector than graduates who have a less developed and weaker PI as an engineer (van Hattum-Janssen & Endedijk, 2017). PI has both an individual and a social aspect. From the individual aspect, PI is based on the self-concept of a person in relation to a specific profession (Stevens, O'connor, Garrison, Jocuns & Amos, 2008). The social aspect highlights that the identity of a person is also shaped by the perceptions of others, for example role incumbents. (Stevens et al., 2008). Based on this social aspect, the development of PI can be seen as the result of the socialisation process (Smith & Hatmaker, 2014).

The educational context is important in the process of professional socialisation. As Schein (1967) wrote, the educational institutes are the major agents of professional socialisation. Some roles require a specific preparation. During the education, students learn the specific knowledge, values and skills which are required for the professional role. However, earlier literature did not show exactly how this process of professional socialisation takes place during education (Morelock, 2017). Therefore, this study aims to gain more insight into this process. To do so, several degree programmes are investigated to see how professional socialisation is present in their curriculum.

Previous research studied professional socialisation in other disciplines than engineering. For example, in medical education (Kay, Berry & Coles, 2019; Monrouxe, 2010) and in teacher training (Beauchamp & Thomas, 2009) research is conducted about professional socialisation. However, there has been less research done in the field of engineering. But precisely in this sector, it is important to do research because there is a shortage of engineers. Further, previous research acknowledged the process of professional socialisation (Thornton & Nardi, 1975). Cornelissen and van Wyk (2007) reviewed several models of professional socialisation and concluded that knowledge about the process of professional socialisation of students is valuable for academics. It would also be valuable for the planning of curricula, so that the process could be taken into account. However, they do not make any concrete recommendations on how this is reflected in the curriculum and how the curriculum could be contributing to the professional socialisation process.

To gain more insight into the process of professional socialisation in engineering education, this study aims to investigate the presence of professional socialisation in the curriculum. By using document analysis in combination with interviews with teachers and surveys for teachers, conclusions can be drawn about the presence of professional socialisation in the curriculum. Furthermore, a rubric is developed which allows degree programmes to analyse their curriculum in terms of professional socialisation and provide advice on how they can improve their curriculum in terms of professional socialisation.

Theoretical framework

Professional identity development

In the literature, various definitions of PI are described. Cech (2014) operationalizes the PI as personal motives, interests, competences and experiences that are associated with a specific professional role. In contrast, according to Dutton, Dukerich and Harquail (1994) the PI refers to the alignment of an individuals' self-concept with his/her perceptions of the characteristics of the profession as a social group. This definition highlights more the social aspect of PI. Others, for example Stevens et al. (2008), state that the PI can be understood in twofold; being positioned by others and being positioning oneself. So, in the current study, PI is seen as a concept with two sides, an individual and a social.

When looking at PI development as a social process, Ibarra (2004) suggests that PI is shaped by three basic processes which occur continuously. First, individuals develop a self-concept by doing new things. Those new things could refer to participating in real professional activities. Second, by interacting with people in different networks, individuals get a view of where they are now and what they are trying to become. Third, those first two processes provide input for storytelling and sense-making. Namely, individuals reflect upon these experiences and can pinpoint turning points which are the start point for creating new stories about themselves.

So, the social aspect of PI development is a continuous process in which individuals do new things, interact with different people and make sense upon these experiences in order to (re)design their self-concept.

Professional socialisation

When arguing from a social perspective, the development of PI is the result of the socialisation process (Smith & Hatmaker, 2014). Bloom (1963) defines socialisation as the process through which individuals acquire professional attitudes and values aiming to prepare them for their professional role. Professional socialisation can be seen as both a process and an outcome (Lai & Lim, 2012). When it is seen as an outcome, it can lead to the development of a PI. Professional socialisation can also be seen as a process. As Thornton and Nardi (1975) describe, role identification is a process which develops through four stages namely anticipatory socialisation, formal socialisation, informal socialisation and personal socialisation.

According to Thornton and Nardi (1975) a role is not fully acquired until the individual passes through all stages and finally accepts the final outcome. Socialisation starts with the

anticipatory stage. Individuals get exposed to the behavioural, cognitive and attitudinal features of a role. These expectations are often based on generalized resources such as stereotypes, which could result in incomplete views of role types. Second, in the formal socialisation stage, the social context starts to play a role. Now, the expectations are based on the exposure to role incumbents. Further, the expectations here are directed to everyone within a specific profession. Therefore, they are related to the system of a specific profession and therefore can be seen as formal expectations. Third, in the informal socialisation stage, an individual becomes familiar with the informal expectations which are not covered by the system. Therefore, these expectations arise from interactions with role incumbents. Last, in the personal socialisation stage, a fusion from the individual and social professional roles takes place. In the previous phases, individuals perceive several expectations and conceptualisations of a role, these expectations and conceptualisations are adapted to their own personality. Concluding, an individual first perceives several expectations and conceptualisation of a role through generalized sources, formal sources and informal sources. Thereafter, these expectations and conceptualisations are integrated with the personality of an individual (Thornton & Nardi, 1975).

Weidman, Twale and Stein (2001) reviewed the stages of Thornton and Nardi (1975) and made several comments to the different phases. For the formal socialisation stage, they mention that this phase is not enough to be successful, and that the informal domain is necessary. For the informal socialisation stage, they mention that formal classroom instruction is not enough to develop an individual into a professional. As soon as an individual reaches a professional level, the academic part must be ended. These comments indicate that these stages are necessarily for an individual to become a professional.

Eliot and Turns (2011) reviewed the model from Thornton and Nardi (1975) and from Weidman et al. (2001) and found that ‘sense making’ is the core of these models. They refer to sense making as giving meaning to the internal and external urges which are important in shaping the identity.

Thus, professional socialisation is a process in which an individual makes sense to the different internal and external urges through four stages. These stages are also present in engineering education, when an individual chooses a degree programme, this relates to the anticipatory stage. When an individual is enrolled in domain specific courses, this relates to the formal stage. When an individual does an internship and interacts with role incumbents, this relates to the informal stage. It could be that the personal stage is not present in education since various expectations are needed for this stage.

Core elements of socialisation

In the process of professional socialisation, there are three core elements which lead to professional socialisation (Weidman et al., 2001). These are knowledge acquisition, investment and involvement. These core elements are present in each stage of professional socialisation (Thornton & Nardi, 1975).

Knowledge acquisition is on one hand about the cognitive knowledge which is related to the profession. On the other hand, knowledge acquisition is also more about affective knowledge. For example, the role expectations. By gaining this knowledge, an individual starts to feel like a role incumbent resulting in identification with the specific role. In investment, socialisation is fostered through commitment. This commitment is something which has value for an individual. An example of investment could be enrolling in a specific degree program (anticipatory stage) or enrolling in content-related courses (formal stage). In involvement, an individual actually participates in an activity related to the professional role. This could be the professional role itself or the preparation for this role.

Weidman et al. (2001) wrote that although these core elements are individually discussed, they are interrelated with each other. For example, students gain specific knowledge when they are enrolled in a specific degree program, which refers to knowledge acquisition and investment. On the other hand, when students do an internship, they learn more about the normative role expectations, which refer to involvement and knowledge acquisition.

So, the professional socialisation of students takes place through four stages and in each stage, the core elements are present. Translated to engineering education, knowledge acquisition could happen for example, through lectures where students gain knowledge about a specific profession. Investment could happen when an individual decides to invest time by enrolling in a degree program. Involvement could happen when a student does his internship and thus is involved with the profession itself.

Professional socialisation in higher education

Professional socialisation takes place in higher education. Professional socialisation is studied in other disciplines than engineering, for example in medical education (Kay et al., 2019; Monrouxe, 2010) and in teacher training (Beauchamp & Thomas, 2009; Flores & Day, 2006). In medical education, the white coat ceremonies are an example of professional socialising experiences (Kay et al., 2019; Monrouxe, 2010). In teacher training, an individual's past experiences as a student and classroom practice are examples of professional socialising experiences (Flores & Day, 2006).

Though, there are some studies which investigated professional socialisation in engineering education. For example Pierrakos, Beam, Constantz, Johri and Anderson (2009) state that the first year in engineering education is critical, so students should be educated about the breadth of the engineering profession and they should have an idea about what it is to be an engineer. They also recommend that students should have the opportunity to be involved in engineering related activities so that they are able to identify themselves with the profession. Last, they mention that role models are important in the first year. In this year, there should be courses which expose students to these role models. Other studies investigated more concrete professional socialising experiences, for example Carbone, Rayner, Ye and Durandet (2020) found that site visits in engineering foster a PI. Further, internships are also fostering professional identity (Dehing, Jochems & Baartman, 2013). Besides these activities, where students are able to get directly involved with the professional practices, participating in communities of practice (CoP) also fosters the formation of a PI. A concrete example of CoP's are semester long projects (Du, 2006). At the start of a project, a new community is formed because a group of individuals has the shared responsibility to solve a problem. During the project, individuals get to know each other and establish a common repertoire of experiences, language and working routings.

Eliot and Turns (2011) investigated which activities are embedded in engineering education. They state that engineering education offers opportunities to engage in real professional activities and that there are opportunities to interact with professionals, for example through project-based learning or internships. However, activities related to sense-making tend to be more exclusive.

Concluding, there are several experiences mentioned in education which foster PI development. In the present study, these are seen as professional socialising experiences since these experiences highlight the social aspect of PI development and can be seen as the more concrete forms of the core elements of socialisation (Weidman et al., 2001).

Curriculum concepts

There are two concepts of the concepts which can be distinguished which are important when it comes to professional socialisation, namely the discipline-oriented and the professional-oriented curriculum (Dehing et al., 2013). Traditionally seen, most curricula can be categorized as discipline oriented: the first two year of the curriculum are used to acquire sufficient disciplinary knowledge. From the third year on, professional socializing experiences are embedded such as internships and projects. This resulted in a delay of the formation of professional identity (Bilodeau, 2004). In contrast, in the professional-oriented curriculum, acquiring knowledge and applying this in a realistic context are more intertwined. Students

have to think and act like engineers from the beginning of the curriculum, resulting in identity development from the start of the curriculum (Dehing et al., 2013)

Curriculum perspectives

There are multiple definitions of the concept curriculum in literature. Originally, the word curriculum has Latin roots, it stems from the word *curerre* which means to run. This Latin verb refers to both a vehicle and a course (Glatthorn, Whitehead & Boschee, 2018). In education, the most obvious interpretation is to view the curriculum as a course for learning (Thijs & van den Akker, 2009). One short and to the point definition is from Taba (1962), who defines the curriculum as a plan for learning.

Glatthorn et al., (2018) state that a curriculum can be characterized as either prescriptive, descriptive or both. When it is prescriptive, it is about what ought to happen and can be seen as the intention of the programme. In contrast, the descriptive part of the curriculum is what actually happens in the classroom.

This distinction proposes that there is a discrepancy between the planned and the taught curriculum. This distinction is also made in the different curricular perspectives of Goodlad (1979). He describes different perspectives of curriculum, namely the ideological curriculum, formal curriculum, perceived curriculum, operational curriculum and experienced curriculum. The ideological and formal curriculum are more prescriptive whereas the perceived, operational and experienced curriculum are more descriptive (Goodlad, 1979). According to Klein, Tye and Wright (1979) the ideological curriculum can be seen as the curriculum which is recommended by professional associates and commissions. The formal curriculum describes what *should* be done. It is often more specific than the ideological curriculum with a rationale, general goals, objectives and learning activities. The perceived curriculum is about what teachers bring in the curriculum, often their own values, beliefs and competencies. The operational curriculum can be seen as the taught curriculum, what can be observed in the classroom. Noteworthy is that the operational curriculum does not always fit with the formal curriculum. The experienced curriculum is on one hand about the student thoughts of the curriculum and on the other hand about what they have learned.

The current study will take into account the formal and the perceived curriculum. This makes it possible to check whether conscious attention is paid to professional socialisation in the formal curriculum. The perceived curriculum indicates to what extent the formal curriculum is put into practice.

Components of curriculum

All different perspectives of the curriculum consist of different components. Thijs and van den Akker (2009) distinguish the following: rationale, aims and objectives, learning activities, content, assessment, teacher role, facilities and resources, grouping, location and time. Van Hattum-Janssen and Endedijk (2019) added the role of the professional. Thijs and van den Akker (2009) presented these components in a spider web, because every component is related to each other.

The rationale focuses on the question why they are learning and is central in the spider web. The rationale is often focused on subject, society and student (Tyler, 1957). Therefore, the rationale should contain information about acquiring knowledge and transferring culture, equipping society and personal development (Thijs & van den Akker, 2009).

The aims and objectives focus on the goals towards the students are learning. This definition is in line with Zohrabi (2008) who state that objectives provide guidelines to students and teachers since the objectives include the goal of a course.

The learning activities focus on the activities through which students are learning to explain how they are learning. Zohrabi (2008) argues that these learning activities should be provided to the students in a meaningful context, rather than providing these in an abstract and mechanical way. Additionally, two studies found that the PI development is a result of curricular learning activities and extracurricular activities (Beam & Pierrakos, 2009; Bilodeau, 2004; Eliot & Turns, 2011).

The content focuses on what students are learning. Sheppard, Macatangay, Colby and Sullivan (2008) distinguish three categories of preparation in engineering education, namely: disciplinary content, knowledge of the profession and knowledge of the practice. Dehing et al. (2013) found that courses mainly focus on academic knowledge and engineering skills.

Assessment is about how learning is assessed. From the perspective of professional socialisation, authentic assessment is a related concept. Authentic assessment requires students to use the same knowledge, skills and attitudes as they need in use in their professional lives (Gulikers, Bastiaens & Kirschner, 2004). By engaging in authentic tasks, students will develop their identities as student engineers (Male & King, 2004)

The teacher role focuses on how the teacher is facilitating learning. When teachers have working experience in the field, they are perceived as role models (Hunter, Laursen & Seymour, 2006), which are important for professional socialisation (Bragg, 1976; Ibarra, 1999) For the UAS, it seems that on average, 66% of the teachers has experience in the field (Stichting mobiliteitsfonds HBO, 2006). At the university, these numbers are slightly different. A distinction is made between three function types at the university: assistant professor, associate professor and full professor. For the assistant professors, 42% is from the field, for

associate professors, this is 18% and for full professors, this is approximately 33% (de Goede, Belder & de Jonge, 2013).

The role of the professional focuses on how the professional is facilitating learning (van Hattum-Janssen & Endedijk, 2019). Multiple studies acknowledged the importance of role incumbents for professional socialisation. Hirschy et al. (2014) wrote that role incumbents determine the degree of fitness with the profession. Additionally, Cornelissen and van Wyk (2007) wrote that when a student interacts with a role incumbent, the student gets the opportunity to become aware of the appropriate professional attitudes and expectations. He also learns how these expectations are carried out.

Facilities and resources focus on the facilities and materials which are available at the institute through which students are learning. These could refer to learning methods and digital resources (Thijs & van den Akker, 2009). For example, specific software or manufacturing facilities.

Grouping focuses with whom the students are learning. According to Du (2006), when students participate in a CoP, this fosters the development of a PI. Hunter et al. (2006) also found that meaning making in a CoP fosters the development of PI. However, Allie et al. (2009) state that the classroom community always differs from the workplace community. Therefore, the classroom community should present a range of identities in order to be representative for the workplace community.

Location focuses on the educational context in which the students are learning. This could refer to fieldwork, where students learn through field trips, internships and placements. Here, students get exposed to the real world engineering context (Carbone et al., 2020).

Finally, time is about the time spent in a professional and educational context. Sufficient time should be reserved for professional socialising experiences. When there is too less time reserved for exposure to the engineering context, this could lead to misperceptions of the engineering practice (Male & King, 2014).

These curricular components are used to systematically analyse the formal and perceived curriculum. This makes it possible to investigate the presence of professional socialisation per curricular component.

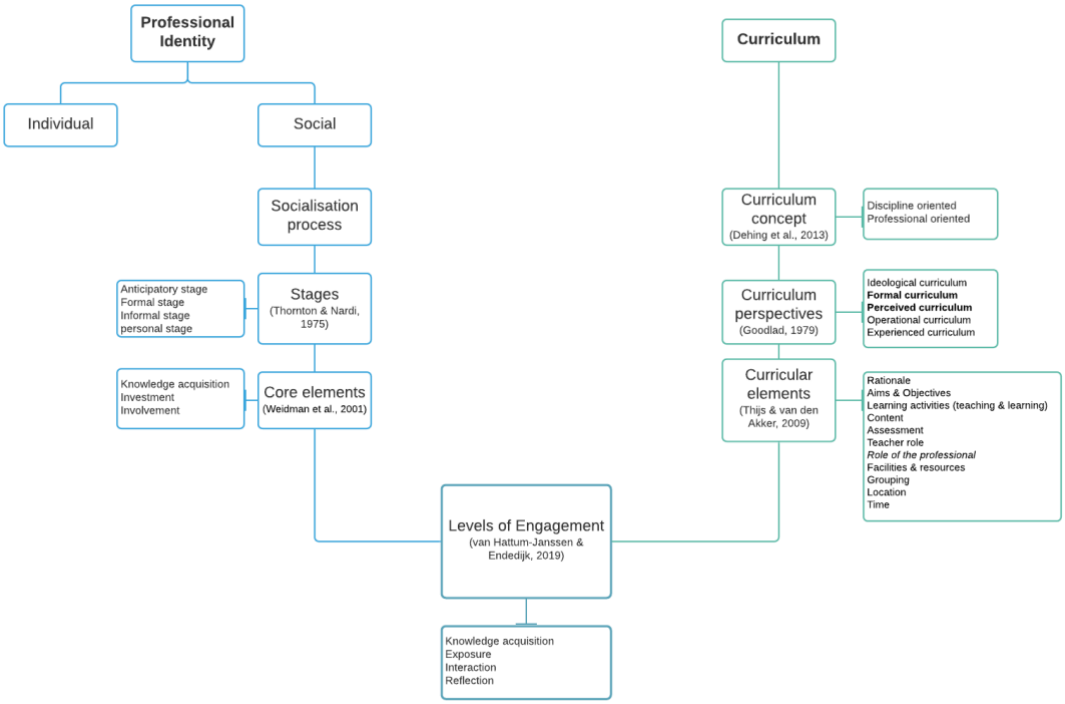

Figure 1. Overview of all theoretical constructs.

Levels of engagement

The core elements of socialisation from Weidman et al. (2001) are on an individual level. To study the presence of professional socialisation in the curriculum, another conceptualisation is needed. Therefore, this study uses the levels of engagement (van Hattum-Janssen & Endedijk, 2019). The levels of engagement make it able to identify which experiences are necessary within a curriculum to provide opportunities for professional socialisation. The levels of engagement range from knowledge acquisition on the professional field, to exposure to the professional field, to interacting with the professional field to reflecting on these experiences and their (possible) working field.

In knowledge acquisition, students learn about their future profession (van Hattum-Janssen & Endedijk, 2019). At this level, students are not yet exposed to realistic professional contexts, indicating that this level takes place in an educational setting. An example of an experience categorized as knowledge acquisition is looking for vacancies within the engineering sector.

At the exposure level, students are exposed to professional practice. Though, students do not play an active role in this level yet and are in the role of student. Practically, these refer to exposure to guest lectures, excursions and site visits. Exposure to role models is also an example of an experience categorized as exposure. Here, students become familiar with the normative role expectations.

The interaction level is about actively participating in some aspect of the professional role, or the preparation of it (van Hattum-Janssen & Endedijk, 2019). In contrast to exposure, students are now in the role of professional. When interaction takes place between a student and a role incumbent, the student is able to compare his vision and expectations of the professional role with the ones of the role incumbent. Further, the student becomes familiar with the written and unwritten norms and values of the professional practice. This could result in incongruencies between the self-image of a student as professional and the role incumbent with whom he is interacting. An example of interaction experiences are internships.

In reflection, the future professional reflects on earlier professional socialising experiences and therefore becomes aware of the current state of his professional identity. De Weerdt, Bouwen, Corthouts and Martens (2006) refer to reflection as a negotiator between identity and experience. Reflection allows the student to make sense of earlier experiences and integrate norms and values. Though, Moorhead, Bell, Jones-Mutton, Boetto and Bailey (2019) wrote that students need to be exposed to a range of situations, learning activities and relationships with professionals together with deep and guided reflection in order to socialize them in the profession.

So, these levels of engagement are used to investigate the presence of the curriculum in professional socialisation by providing categories in which professional socialising experiences can be placed.

Research questions

The present study will investigate how professional socialisation is embedded in engineering curricula using two different curriculum perspectives (Goodlad, 1979), namely the formal and the perceived curriculum. The broad research question in this study is the following: *How is professional socialisation present in the engineering curriculum?*

By answering this question, it will be made clear in what way and to what extent curricula contribute to professional socialisation. Previous research indicated that curricula played a role in professional socialisation (Hunter et al., 2006; Siraj-Blatchford, 1993; Trede, Macklin & Bridges, 2012). However, this is not investigated systematically yet. By answering this research question, the role of engineering curricula in developing PI will be more concrete. This study examines the extent to which this is done consciously in the formal curriculum. This answers the first sub question: *How is professional socialisation present in the formal engineering curriculum?*

Further, this study examines the extent to which this is experienced. This answers the second sub question*: How is professional socialisation present in the perceived engineering curriculum based on teacher's perception?*

To investigate the formal and perceived curriculum, an instrument to measure the extent of professional socialisation is developed.

Research design and methods

To answer the research question, a case study is conducted in which four cases are investigated with a predominantly qualitative research design with the use of content analysis, semi-structured interviews, and a survey. In the following sections, the methods for those three different parts are described.

Part 1: Investigating the formal curriculum

Research design

To investigate the formal curriculum, content analysis was used. The content analysis included document analysis. Content analysis can be defined as the process of structuring and reporting written data (Cohen, Manion & Morrison, 2007). To do so, the formal curriculum documents of four STEM degree programmes are analysed to identify the presence of professional socialising in the formal curriculum. More specifically, in which component of the curriculum as acknowledged by Thijs and van den Akker (2009) these experiences are and to what level of engagement (van Hattum-Janssen & Endedijk, 2019) these experiences belong.

Participants

In total, four degree programmes participated in this study. These are a technical study and a less technical study, which is more on the intersection of technology and management both offered at a university and a UAS.

Instrumentation

For conducting the document analysis, no instrument was used since all documents were already available. These documents include programme documents, curriculum and assessment plans, course descriptions, study guides and manuals, and PowerPoint presentations of the course personal and professional development. Thus, these documents are about the curriculum plan about a specific course or module. However, for the intersection programme at the university, documents were not directly available. Here, the formal curriculum documents were requested from the programme coordinator.

Procedure

Permission for this study has been granted by the BMS Ethics Committee of the University of Twente. After this permission was acquired, the document analysis was conducted. To code the documents, Atlas.ti software was used. The formal curriculum documents of the four participating degree programmes were analysed. A total 108 documents

were analysed. From which 41 are from the technical degree programme at the UAS, 40 are from the intersection degree programme at the UAS, 11 from the technical degree programme at the university and 16 from the intersection degree programme at the university.

The documents were divided into two groups. One group contained the technical degree programmes and the other group contained the intersection degree programmes. The intersection group was coded by another student researcher. The first set of codes were based on the curricular component of Thijs and van den Akker (2009) and the second set was based on the levels of engagement (van Hattum-Janssen & Endedijk, 2019). The coding scheme is visualised in table 1. Every fragment was categorized with two codes, one about the curricular element and one about the level of engagement. To code the documents, all documents were read first. Thereafter, the professional socialising experiences in that document are marked. Last, it was decided to which curricular component these professional socialising experiences belong and to what level of engagement. For example, the fragment “the company will also be involved during the project” was coded with ‘Role of the professional’ and ‘exposure’. After all documents were coded, the researchers reviewed the coding of the other group to make sure it was done in the same way. When there were inconsistencies, these were discussed.

Data analysis

When the documents were coded based on the coding scheme (see table 1), a quality check for the inter-coder reliability was done and a Krippendorff’s α of .68 was reached. This score is considered fair to good (Krippendorff, 1980). At this point, there was no method on how to interpret these findings to investigate the relationship between professional socialisation and the curriculum as a whole. Therefore, a rubric was developed together with another student researcher, in order to measure the presence of professional socialisation for each year of the degree programme. To develop the rubric, the insights of the data is used, indicating a deductive approach. The rubric is visible in Table 2. The rubric is based on the different curricular components and the levels of engagement. Vertically, the curricular components and horizontally, the values are visible. In each cell, a description is given of how this element should look like when it belongs to a certain level of engagement. This description is based on the insights gained from the data analysis. For several descriptions, the levels of engagement are used. However, for certain components (rationale, teacher role, assessment, facilities and resources, grouping, location and time) this was not feasible since these components are not logically connected to the levels of engagement. The precise construction of the descriptors is described in the result chapter.

The rubric is an analytical scoring rubric which allows the assessor to score each criterion on a different scale (Brookhart, 1999). According to Jonsson and Svingby (2007) an

analytical rubric is useful in the classroom since the results can help teachers identify the strengths and needs of a student. This phenomenon could also occur with the use of this rubric. However, the focus then is on the strengths of the rubric in terms of professional socialising experiences. The rubric can be used to measure professional socialisation in the formal curriculum. For each curricular component, a distinction is made whether this is for the whole curriculum, per year or per course or module.

When filling in the rubric for the technical study, it became clear that the first iteration of coding was not sufficient to correctly complete the rubric. Therefore, all documents were reviewed for a second iteration to make sure that the correct information was used to fill in the rubric.

Table 1

Coding scheme for document analysis

Code	**Description**
CUR- aims/objectives	All learning goals or competencies which are described.
CUR- assessment	Everything which is related to assessment.
CUR- content	Knowledge, skills and attitudes related to the profession.
CUR- facilities/resources	Facilities and materials supporting education.
CUR- grouping	Descriptions of group compositions. Also, different roles in a group.
CUR- location	The location where students learn. This could be names of companies.
CUR- role of the professional	A professional from the field contributing to the curriculum.
CUR- rationale	Answers the question 'why are they learning?'. The rationale is often the higher goal of the study.
CUR- teacher role	Ways how the teacher facilitates the learning. This could also refer to specific roles the teacher takes on in a learning activity.
CUR- teaching & learning	Activities through which students learn.
CUR- time	All phrases indicating a timeframe.
LoE- knowledge acquisition	Acquiring knowledge related to the future role or the profession.

LoE- exposure	Activities where students are exposed to the workplace, this interaction is mostly one-way. The student is in the role of student.
LoE- interaction	Activities where there is a significant chance of interaction. The student is in the role of professional.
LoE- reflection	Activities where students reflect on their acting in professional practice or on their vision of the future role.

Part 2: Investigating the perceived curriculum

Research design

To investigate the perceived curriculum, semi-structured interviews were used. The aim of the interviews was to gain detailed information about how teachers perceive the curriculum, focusing on the professional socialising experiences. The interviews enable the interviewees to discuss the situation from their point of view (Cohen et al., 2007). By using semi-structured interviews, it is possible to use probes (Hutchinson & Wilson, 1992). Probing allows the interviewer to ask for clarification when a respondent raised interesting and relevant issues (Barriball & While, 1994).

Participants

Interviews were conducted with eight teachers of the participating degree programmes. From every degree programme, two teachers participated in this study of which six males and two females. All participating teachers have also taken part in a curriculum committee of their own degree programme. This was a prerequisite since teachers who take part in a curriculum committee are more likely to be involved in the development of the curriculum and may have a better view on the curriculum than other teachers do, resulting in more valid data. Here, two different purposeful sampling techniques are used, namely criterion-i sampling and snowball sampling. For the interviews, criterion-i sampling (Palinkas et al., 2013) was used. In criterion-i sampling, participants are selected based on the assumption that they possess experience and knowledge of the phenomenon of interest. This will allow them to provide both detailed and generalizable information. Second, snowball sampling was used. Snowball sampling is useful when access to the participants is difficult (Cohen et al., 2007). Snowball sampling was used by asking participants whether they know another teacher in the curriculum committee who is able to participate in this study.

Instrumentation

To collect data about the perceived curriculum (Goodlad, 1979), semi-structured interviews with teachers were conducted. The topics and issues which are discussed in the interview were determined and specified in advance. The interviewer determined the sequence and working of the questions during the interview. To be able to answer the research question, an interview guide was developed. This interview guide was based on the guidelines of Emans (2002). The complete interview guide is attached to appendix I.

During these interviews, the focus was on the different professional socialising experiences which are embedded in the curriculum of the degree programme which they taught. The first set of questions focused on the levels of engagement. The second set of questions focused on the curricular components (Thijs & van den Akker, 2009).

The structure and questions of the interviews were tested during a pilot interview. This pilot interview was used to find flaws in the structure of the questions and the interview scheme. The pilot interview was also used to test the duration of the interview and to train the interview skills of the interviewer. According to the findings of the pilot interview, adjustments have been made to the interview scheme.

Procedure

After the document analysis, the four departments of the participating studies were contacted. Attached with this e-mail was the invitation to participate in this study. With the teachers who want to participate, an appointment was made to conduct the interview. Due to the current circumstances of the COVID-19 virus, the interviews were conducted through video calls. Prior to the interview, the participants had to fill in a consent form. Because of practical reasons, the consent form was sent online via Qualtrics software. The duration of the interviews was between 45 and 75 minutes. The transcripts of the interviews were made with Amberscript software. Access to Amberscript was provided by the BMS lab of the University of Twente. A copy of the transcript was sent to the respondents to get their approval.

Data analysis

For the interviews, the first step was to transcribe the material. Thereafter, the material was also coded based on the same coding scheme (Table 1) as used for the document analysis. By using this coding scheme, the professional socialising experiences became clear as well as to which curricular element and level of engagement these experiences belong. Last, the data is clustered to get specific stories for the specific degree programmes. Then, the perceived curriculum was compared with the formal curriculum to see whether there are

differences. For example, when teachers mentioned more site visits then covered in the formal curricula. If there were differences, it was determined whether these changed the view which was created based on the formal curriculum.

Part 3: Investigating the professional experience of teachers

This part aimed to investigate the teacher component in the curriculum (Thijs & van den Akker, 2009). However, due to low responses on the survey, it was decided to not take these into account. The method and data can be found in Appendix V.

Results

This research aimed to investigate the presence of professional socialisation in engineering curricula. First, the rubric which is developed will be presented, then the results of each case will be presented. For each case, the results of the formal and perceived curriculum will be presented sequentially.

Rubric to measure professional socialisation

In Table 2, the rubric is presented which is used to investigate the extent of professional socialisation per curricular element. The rubric can be used to measure professional socialisation in the formal curriculum. For each curricular component, a distinction is made whether this is for the whole curriculum, per year or per course or module. The descriptors for certain components are based on the level of engagement (van Hattum-Janssen & Endedijk, 2019). Though, this was not feasible for every component. For example for the rationale, teacher role, assessment, facilities and resources, grouping, location and time.

For the rationale, the descriptors are based on the extent to which a rationale describes the possible future working field and the extent to which the relation is described between the graduated student and the possible working field. This gives an insight to what extent the rationale pays attention to the professional field. It should be noted that for the university, the professional field is defined as the professional field for which they are educating, instead of the research profession. For the teacher role, the descriptors are based on the percentage of the teachers which a) has working experience in the field in which they are teaching and b) is combining their teaching job with a job in the field in which they are teaching. For the role of the professional, only two levels of engagement are used: exposure and interaction, a further distinction is made in the number of professionals, when different professionals are involved, students could have a wider view of possible selves. For assessment, a distinction is made based on the extent of authenticity. If an assessment is more authentic, this could provide students with a more representative view of the profession. For facilities and resources, a distinction is made between the degree of novelty of a tool and the type of arrangement (testing arrangement or an arrangement which is representative for the field). By making this distinction, the extent of authenticity is visible. For grouping, a distinction is made between the different backgrounds in a group and whether the group is mono or multidisciplinary. In a multidisciplinary group, students are able to investigate the boundaries of their future profession. For location, a distinction is made between the number of companies they visit and whether these companies are in the same specialised field or in different fields. For time a distinction is made for short- or long-term experiences and the combination. It is assumed that a long term experience will provide students with a better view of the profession (internships)

than a short term experience (excursion). For the remaining components aims and objectives, content and teaching and learning, the descriptors are directly based on the levels of engagement.

The rubric gives an insight in the presence of professional socialisation in a curriculum. Though, it is important to mention that the value is in the increasing levels of engagement over time. Namely, if the first year already focusses on reflection, this does not have value because reflection really has value if there are certain experiences to reflect on (Moorhead et al., 2019). Therefore, it is better to reflect when students first gain knowledge about the profession, get exposed to the profession and are able to interact with professionals in the first years.

Table 2

Rubric[1] to measure the extent of professional socialisation in the formal curricula

	1	2	3	4	5
Rationale: The higher goal of the study. Answers the question 'why are they learning?'. This is often described in the mission and/or vision of the programme. **Per curriculum**	The mission/vision pays little or no attention to the relationship with the possible field of work.	The possible field of work is mentioned but not or hardly described.	The possible field of work is clearly described.	The relationship between the possible field of work and the graduate student is described. For example, by concretely describing (using examples) what a graduate student does in the work field.	The possible field of work for which education is provided is described. In addition, the relationship between the possible work field and the graduated student is described.
Aims & Objectives: Answers the question 'Towards which goals are they learning?'. These are often specified as learning goals or competencies which are described or summed up. **Per course / module**	In little or no learning objectives / competences a link is made between having certain knowledge or skills and being a professional.	In the learning objectives / competences it is included that students gain knowledge about the future profession / work field.	In the learning objectives / competences it is included that students get a realistic impression of the professional practice.	The learning objectives / competencies states that students should be able to interact with professionals.	In the learning objectives / competences it is included that students should be able to reflect on their experiences in professional practice.

[1] The rubric is developed in collaboration with another student researcher, see Notes on Contributors.

Content: Answers the question 'what are they learning?'. These are often specified as the knowledge, skills and attitudes related to the profession. **Per course / module**	Adjustments to the subject are hardly or not at all coordinated with the work field.	The course contains knowledge about the work field. For example, something is said about different professions, norms and values and/or about the company culture. This also includes cases.	Data from the work field is used as an example. For example, annual reports that are used for calculations.	The work field provides a practical assignment.	The work field co-creates content for the profession. For example, a company has developed a course in cooperation with the study that is included in the curriculum.
Teaching & learning: Answers the question 'How are they learning?'. These are often specified as the activities through which students learn. **Per course / module**	There are activities in the profession where students learn about the future profession, but students do not yet come into contact with the work field.	There are activities in the course in which students are exposed to a simulated environment.	There are activities in the profession in which students are exposed to the work field. Here the student is in the role of student.	There are activities in the course in which students interact with the work field. Here the student is in the role of a professional.	Activities are included in which students reflect on an experience related to the work field.
Teacher role: The percentage of teachers that have recent (<= 5 years ago) working experience in the profession and **Per Year**	Less than 20% of the teachers have recent work experience in the field they are teaching in.	At least 20% but less than 40% of the teachers have recent work experience in the field they are training in.	At least 40% but less than 60% of the teachers have recent work experience in the field they are training in.	At least 60% but less than 80% of the teachers have recent work experience in the field they are teaching in.	More than 80% of the teachers have recent work experience in the field they are training in.
Teacher role: the percentage of teachers that is currently combining their teaching job with a job in the profession. **Per year**	Less than 20% of the teachers are working in the field they are teaching in , in addition to their job as a teacher.	At least 20% but less than 40% of the teachers are working in the field they are teaching in, in addition to their job as a teacher.	At least 40% but less than 60% of the teachers are working in the field they are teaching in, in addition to their job as a teacher.	At least 60% but less than 80% of the teachers are working in the field they are teaching in, in addition to their job as a teacher.	More than 80% of the teachers are working in the field they are teaching in , in addition to their job as a teacher.

Role of the professional: How and to what extent is a professional (who is not an alumnus) from the field contributing to the curriculum? **Per Year**	Professionals make little or no contribution to the curriculum.	A professional contributes to the curriculum but interacts hardly at all with students.	Multiple professionals contribute to the curriculum, but interacts hardly at all with students.	A professional contributes to the curriculum and interacts with students.	Several professionals contribute to the curriculum and interact with students.
Role of professional: How and to what extent is an alumnus from the field contributing to the curriculum? **Per Year**	Alumni make little or no contribution to the curriculum.	An alumnus contributes to the curriculum but interacts hardly at all with students.	Alumni contribute to the curriculum but interacts hardly at all with students.	An alumnus contributes to the curriculum and interacts with students.	alumni contribute to the curriculum and interact with students.
Assessment: Answers the question: 'How is their learning assessed?'. This refers to the specific types of assessment. **Per course / module**	Only knowledge tests are used in the course.	Assessment of knowledge or competencies in a standardized but realistic situation such as a case, simulation or practical test.	Assessment of a reflection in which students reflect on an experience and link this to their possible future career, such as a reflection on an internship.	Assessment on a product which could also be made in the work field like a professional product as a result of a project.	Assessment on an authentic professional activity such as an internship-practice assignment or graduation project.
Facilities and resources: Answers the question: 'With what are they learning?'. This often refers to the specific materials, devices and software which are used. A distinction is made between the setup and the novelty. **Per year**	Little or no use is made of supporting resources that are (partly) representative of the work field.	Students use outdated but representative resources in a test setup.	Students use outdated yet representative tools in an arrangement that is representative of the work field.	Students make use of new, representative resources in a test setup.	Students make use of new, representative resources in a setup that is representative of the work field.

Grouping: Answers the question 'With whom are they learning?'. This often refers to the type of group compositions. A distinction is made between the mono- and interdisciplinarity of a group and the extent to which students in a group have the same background. **Per course / module**	Students do not or hardly work in (monodisciplinary) groups.	Students with the same background work in a monodisciplinary group.	Students with a different background work in a monodisciplinary group.	Students from the same profession with the same background work together with other students in an interdisciplinary group.	Students from the same profession with a different background work together with other students in an interdisciplinary group.
Location: Answers the question 'Where are they learning?'. A distinction is made between the variety of different locations and the time spent on location. **Per year**	Students are not or hardly active in the work field during the year.	Students visit one company.	Students visit several companies from the same specialist field.	Students visit several companies from two different specialist directions.	Students visit several companies from three or more different specialist directions.
Time: Refers to the amount of time which is reserved for activities in connection with the profession. A distinction is made between stand-alone and long-term experiences. Stand-alone experience: The experience has a total reserved duration of one day or less. Long-term experience: The experience consists of a continuous period of at least six working days. **Per year**	There is little or no time set aside for activities that have a connection with the field of work.	Time is reserved for several separate experiences.	Time is reserved for one long-term experience.	Time is reserved for one or more separate experiences and one long-term experience.	Time is reserved for several long term experiences (possibly in combination with several separate experiences).

Technical degree programme at university

Formal curriculum

In the formal curriculum of the technical degree programme at the university, every curricular component has professional socialising experiences. In table 3 an overview of fragments per curricular component is presented. A summary of this table can be found in Appendix IV.

Table 3

Sample of fragments from the formal curriculum of the technical degree programme at the University

Component	Fragments year 1	Fragments year 2	Fragments year 3
Rationale	"This programme educates bachelors to a junior-academic level of working and thinking and instils an attitude and skills directed towards solving problems and designing new products, processes and systems. The development of the communication and social skills that are necessary to perform satisfactorily as a bachelor in a multidisciplinary team is an integral part of the programme. [..]		
Aims	"Analysing design problems using engineering design principles"	"Student is able to reflect based on their strong and weak points in the role of ME as well as future professional"	"Analyse a problem with some complexity in the field of Mechanical engineering"
Content	"Familiarize student with language of mechanical engineering" "The subject of the project is different every year and relates to the latest issues in that field"	"a new problem is formulated in cooperation with a company (or organisation)" "During the bachelor programme they have been introduced to three different profiles, the researcher, the designer and the organiser."	"Project is placed in a realistic situation" "addressing an existing research problem offered by one of the research chairs."
Teaching and learning	" Present to a technically educated client" "a presentation session related to an excursion to a manufacturing facility" " the project group will take the role of a project team in a company with the mission to redesign and improve such a system." "Write a (design-) report for the client"	"Where desired and possible, the company will also be involved during the project."	"In this project a complex production system will be designed in a realistic setting"
Role of the professional	"at the end, a technical report has to written in which the results are presented for employer with technical knowledge"	"The client (company) introduces the problem and reflects on the results at the end of the project."	
Assessment	"Digital problems" "practical" "Written exam, Digital exam, presentation, oral exam, project report" "Written exam, poster, summary & oral exam, report"	"writing a short essay about professional strengths and improvement points related to these profiles.'" "Written exam, report, oral group exam" "Practical, demonstration, essay"	"FEM assignments" "written exam, paper, assignment" "Presentation & defence" "Content of the assignment" "management of the assignment"
Facilities and resources	"write simple programs in MATLAB" "the 3D CAD system SolidWorks"	"MATLAB scripts of the examples in the lecture notes" "construct surface and solid geometries in a 3D CAD system"	"Write a simple program in MATLAB;"
Grouping	"groups of 8 students work in a team" "the project group will take the role of a project team in a company with the mission to redesign and improve such a system."	"Each project group ideally consists of nine students, with an equal distribution over the IDE, IEM and ME backgrounds." "in groups of 2 students (the project groups)"	"a research group"
Location	"an excursion to a manufacturing facility"		

The rubric is used to create a heatmap, which is visualised in Figure 2. In this heatmap, the extent of professional socialisation per module is visualised. The numbers are referring to the score in the rubric. The exact descriptor can be found in Table 2.

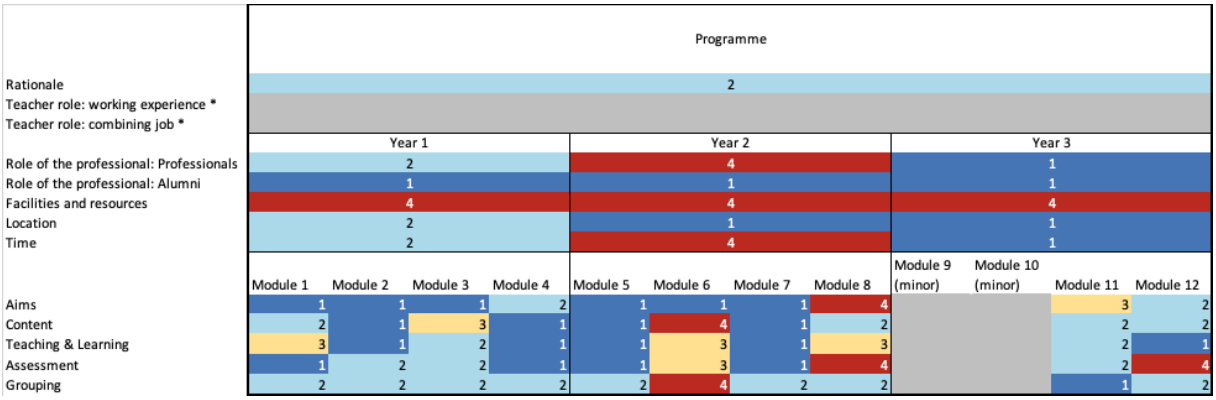

Figure 2. Heatmap from the formal curriculum of the technical degree program at the university. * data was not representative enough.

Summarizing, the rationale pays little attention to the possible future working field. Related to the role of the professional, a technical employer serves as target audience and professionals are involved during one project. Related to facilities and resources, MATLAB and Solidworks are used for multiple assignments. Related to location, there is one company visit. Related to time, time is reserved for the company visit and for the project in collaboration with professionals. Further, there are some aims described which have a relation to the professional practice. Related to content, some projects are based on real-life examples and students gain knowledge about the different profiles as a mechanical engineer. Related to teaching and learning, students visit one company, are sometimes involved in a project with a real client and have to write a reflection once. Related to assessment, various forms are used such as written tests, oral tests, practicums and reports. Related to grouping, students work in groups in every project, only one of them is multidisciplinary.

Perceived curriculum

During the interviews, teachers were asked how the rationale is represented in the curriculum. They explained that during work in project groups, there is sort of interdisciplinary group work. Several students within the group are focussing on the thermodynamic part, a few on a material science part, which more directs to different specializations. The rationale also states that students obtain a junior think- and work level with associated attitudes and skills. A teacher said that "*The skills are very explicit in the projects and very implicit in the courses*".

Related to the aims and objectives, teachers said that when students have to attend a certain experience with the field, this is often also written as a learning goal. For example, a teacher describes:

“If, for example, there is a project [...]. They have to make a final report of that. Then one of the learning objectives is to be able to present the results in a clear or unambiguous way to the client, the technical client".

Further, teachers explained that the aims and objectives include soft skills. This is especially represented in module six and eight. A teacher explained: *“we have learning objectives of modules and in that sense, it is mainly in the learning objectives of module eight with professional orientation and six with working for a real company”.*

Related to content, teachers mentioned the field committee where adaptations in the curriculum are being discussed with. Further, teachers explained that projects always have a relationship with professional practice. Sometimes the assignments are directly taken out of professional practice. Further, a teacher said that adaptations to the bachelor curriculum are made through the master’s programme.

“In particular, this is reflected in the master's programme when students do master's assignments and internships. And then, if necessary, what should be included in master's subjects. Well, and if it turns out that students really should have basic knowledge for this, it eventually comes back to bachelor's education, but it is via the top, because few graduates directly enter the professional practice.”

Related to teaching and learning, teachers explained that there are companies involved in projects sometimes. Teachers gave the example of module six, where students participate in an interdisciplinary project team and develop a product for a real company who serves as a client. There are also several guest lectures and company visits embedded in the curriculum. Some of these guest lectures are offered by alumni.

“Yes, in the case of the projects now and then, we sometimes have someone working in a company who then tells us something about [...] how that happens. [...] I think that this is almost always embedded in the projects and then indeed in the last six months in academic skills.”

In module eight, various professionals are invited to tell something about their job.

> *"I have linked guest speakers from seven different professions to a specialisation. We have seven specialisations in the master, for example for the health towards someone who had a company with breathing machines for the thermodynamics with climate control, so I tried to find a typical example of that specialisation."*

In the end, students have to write an essay to reflect on these guest lectures and describe which master programme suits them best.
Further, there are no internships included, except when students do not want to participate in the master: *"We do not have an internship except, if a student really indicates that I am not going to do a master's, […] they can do a quartile during their minor, so 10 weeks, they can do an internship".*

There are also various excursions included: *"Module one is always a company visit, at the very beginning. Then they also have to ask several questions".*

> *"So excursions in module one, three, four, eight and six are actually also known as excursions. A bit of what is possible. But that's what I just said, not so much for professional orientation, but more to show, for example, they had to have such a hoisting system for our ship in module four. shipyard, to hoist something to shore."*

Students also have to look for vacancies in their first year: *"In the first year we let them do an assignment - they have to write a kind of motivation letter there, which you also do with applications based on vacancies they are looking for online".*

In the graduation, teachers mentioned that students have the opportunity to collect data in terms of conducting measurements in a company, these measurements will take no longer than several days.

Related to the role of the professional, teachers explained that professionals and alumni are contributing to the curriculum by giving guest lectures and providing feedback when they serve as a client for a project. Sometimes, professionals also play a role in assessment: "*in the case of that project from module six, there is cooperation between the various parties and, if there really is a company involved, they sometimes choose, for example, the best project group or something similar".*

Related to the teacher role, teachers said that there are teachers who have working experience in the professional field. Sometimes, teachers have a job in the professional field besides their teaching job. However, there are more teachers without experience than teachers with experience. Teachers are sometimes seen as a role model: *“I sometimes notice that they look up to lecturers and admire them”.*

Related to assessment, one teacher told that in module six, the company chooses the best group, but this is an informal event.

> *“Yes, that is informal. In the end, the teachers determine whether the learning objectives have been achieved. They give feedback, play a role in the assessment, sometimes they have a kind of audience jury or extra prize, but we never let them assess them completely themselves. We keep that under our own control.”*

Related to facilities and resources, both teachers explained that students use tools which are also used in the field, for example Solid Works.

Related to grouping, students work in an interdisciplinary group during module six. However, in most other mono-disciplinary teams, students fulfil a different role in terms of specialisation:

> *"Yes, then you often have the project group of well say eight, but if you have eight people, then there are two. They are very busy with a thermodynamic part. Two others, therefore, with the materialistic part and two others are mainly occupied with that life cycle and the other two are then often in one of the other groups.”*

In terms of roles, teachers told that in the first-year students obtain another role every week.

Related to location, students have an excursion in module one, three, four, six and eight. Students also learn on location when they do an internship and sometimes in their graduation. But these last two are not usual.

Related to time, no questions were asked.

Besides the planned curriculum, teachers also mentioned several extra-curricular activities where students get exposed to the field. The study association plays a role: *“They also go on excursions. So, of course, that was not official on our part, but we do support the study association in this”.* They also provide lunch lectures every week. Here, a professional gives a guest lecture. Further, there are also the career days. There also was an alumni community who facilitated a design competition with real clients every year. Students could participate in this, but this is not happening anymore.

In sum, the rationale is represented in that students work in interdisciplinary teams and the skills as covered in the rationale are explicitly embedded in the project and implicit in the courses. Related to aims, experiences in the field are often also described as learning goals. The aims also include soft skills which are represented in module six and eight. Related to content, there is a field committee, projects always have a relation with practice and sometimes are directly taken out of professional practice. Related to teaching and learning, companies are sometimes involved in projects, there are guest lectures and company visits. Some guest lectures are offered by alumni. Related to the role of the professional, professionals have a role during projects, guest lectures and sometimes in assessment. Related to the teacher role, some teachers have working experience and are sometimes seen as role models. Related to assessment, professionals are involved in module six. Related to facilities and resources, various software is used which is representative for the field. Related to grouping, students work in groups multiple times, and one time this group is multidisciplinary. Related to location, students visit various companies during the excursions.

When comparing the formal curriculum with the perceived curriculum, there are several differences visible. In the formal curriculum, it is not stated that all projects are based on real life examples. Although in the perceived curriculum, teachers explained that this is the case. Related to teaching and learning, in the formal curriculum, internship is written as a teaching method. However, teachers stated that there were no internships except for students who do not want to participate in the masters' programme. Teachers added that there are guest lectures, excursions in module three, four, six and eight, sometimes offered by alumni, interviews and the assignment where students had to write a motivational letter. All these experiences were not covered in the formal curriculum. Related to the role of the professional, teachers mentioned the role of alumni. This is not described in the formal curriculum. Related to grouping, teachers describe the different specialising roles in mono disciplinary groups, this is not described in the formal curriculum. Last, teachers mentioned the role of the study association. For location, there are more locations covered in the perceived curriculum than in the formal curriculum. Concluding, for this degree programme, teachers provided a much richer view for the elements teaching and learning, grouping and location.

Technical degree programme at university of applied sciences

Formal curriculum

In the formal curriculum of the technical degree programme at the UAS, there are professional socialising experiences described for each curricular component. In Table 4, an overview of fragments per curricular component is presented. A summary of this table can be found in Appendix IV.

Table 4

Examples of fragments from the formal curriculum of the technical degree programme at the university of applied sciences

Component	Fragment year 1	Fragment year 2	Fragment year 3	Fragment year 4
Rationale	"[…] Een bij ons afgestudeerde […] vertaalt klantwensen naar technisch uitvoerbare oplossingen en vertaalt bevindingen uit (wetenschappelijk) onderzoek naar praktische toepassingen"			
Aims	"Aan de hand van bewijzen kunnen laten zien dat hij zich bewust is van de specifieke werktuigbouwkundige competenties"	"Ervaring op doen in engineering werk. "Kennismaken met een aantal belangrijke aspecten van een productiebedrijf."		"Toont de student aan dat competenties voldoende ontwikkeld zijn om als Bachelor (of beginnend Engineering) in de beroepspraktijk te kunnen functioneren."
Content	"Oriëntatie op studie, oriëntatie op beroep, professionaliteit" "Je bezoek aan de WOTS"	"Ontwerpen van een motorhefinrichting. " "De theorie en de toepassing dient men te verifiëren in een praktijksituatie."	"Nadat je een stageplaats met opdracht(en) hebt verworven" "The opdrachten komen o.a. van bedrijven en lectoraten van Saxion."	"De student dient in overleg met de opdrachtgever (bedrijf of instelling) zelf een omschrijving van de opdracht op te stellen."
Teaching and learning	"3-tal bedrijfsbezoeken. 5-tal bedrijfspresentatie." "Bezoek aan WOTS-beurs"	"Een excursie naar Voortman" "Het bedrijfsbezoek" "Tijdens je bezoek aan de beurs" "Tijdens je bezoek aan de Bedrijvendag"	"Start van je stage, met je bedrijfs- en schoolbegeleider" "Smart solutions semester"	"Leerverslag" "Het is noodzakelijk dat de student inzicht kan verwerven in de structuur, cultuur en het functioneren van het bedrijf"
Role of the professional	"3-tal bedrijfsbezoeken. 5-tal bedrijfspresentatie."	"een excursie naar Voortman" "Bedrijfsbezoek" "Excursie stork thermeq" "Tijdens je bezoek aan de beurs"	"je bedrijfs- en schoolbegeleider."	"Een vaste begeleider of bedrijfscoach beschikbaar is)." "Het bedrijf dient tenminste 10-15 vaste werknemers in dienst te hebben."
Role of the professional: Alumni				
Assessment	"Technische tekeningen" "Cijfer op grond van persoonlijke en groepsbewijzen van kunnen." "2 prakticumopdrachten in Matlab" "Schriftelijk tentamen en meetpracticum"	"Verslag en eindpresentatie." "De groepsopdrachten" "Het praktijkdeel wordt beoordeeld met een groepscijfer gebaseerd op de eindpresentatie en de voorbereiding (verslag) en uitvoering van het bedrijfsbezoek"		"Vakbekwaam functioneren. "Professioneel functioneren. "Het bereikte eindresultaat en mate van voltooiing van de opdracht" "Het leerverslag."
Facilities and resources	CAD tekenen, CNC-programma, CNC-meten, profielprojector, Matlab	"Vastgelegd in tekeningen en 3D CAD" "Het maken van een CAD-applicatie m.b.v. MS-Visual Basic en SolidWorks" "MATLAB/SIMULINK"		
Grouping	"Groepen van 5 studenten." "Samenwerken in team met andere studenten, buitenlandse studenten en havoscholieren"	"Een groep van maximaal vier personen" "5-6 personen uit dezelfde klas"	"Deze projectteams bestaan uit 4-8 studenten van verschillende opleidingen van Saxion."	
Location	"3-tal bedrijfsbezoeken."	"Een excursie naar Voortman" "Bedrijfsbezoek" "Excursie stork thermeq"	"Start van je stage, met je bedrijfs- en schoolbegeleider"	"Het bedrijf waar een opdracht wordt uitgevoerd dient tenminste 10-15 vaste werknemers in dienst te hebben.

Based on the fragments in Table 4, a heatmap is created by filling in the rubric. This heatmap is visible in Figure 3. The exact description of the scores can be found in the rubric in Table 2.

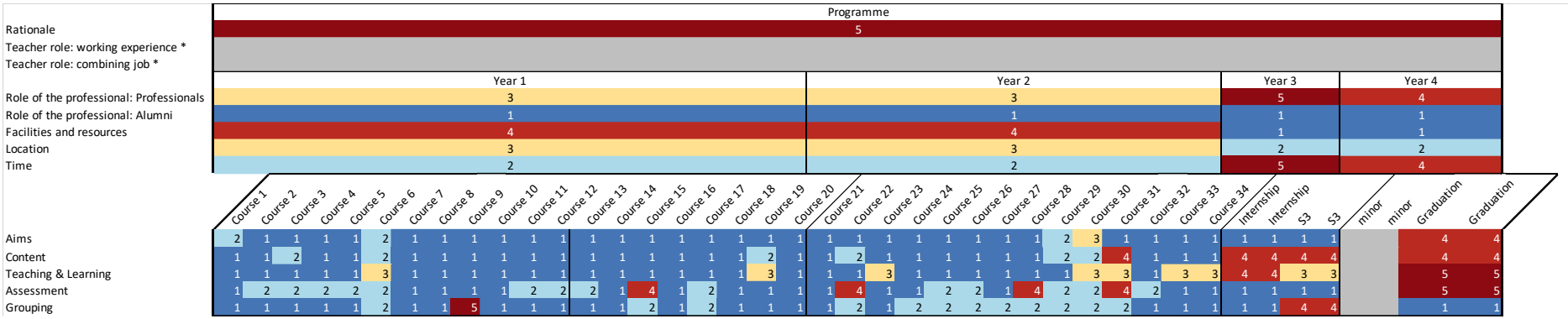

Figure 3. Heatmap from the formal curriculum of the technical degree programme at the university of applied sciences.

* data was not representative enough.

Summarizing, the rationale covers the possible future working field of graduates. Related to the role of the professional, professionals have a role during the excursions, guest lectures and during internships. Related to facilities and resources, CNC programmes, MATLAB, Solidworks and MS-Visual are used. Related to location, there are various company visits and two internships in a company. Further, related to time, time is reserved for the company visits and guest lectures, the projects in collaboration with a company and for the internships. Related to the aims and objectives, some aims are described relating to the profession, for example acting as engineers or properly function in practice. Related to content, some projects are based on cases or taken directly out of professional practice. There are also courses offered relating to orientation in the profession. Related to teaching and learning, there are multiple excursions, guest lectures, visit to career fairs and internships embedded. Related to assessment, various forms are used such as written tests, results of projects, practical assignments, assignments, presentations and reflections. Related to grouping, students work in groups various times, one of them is multidisciplinary

Perceived curriculum

During the interviews, teachers were asked how the rationale is represented in the curriculum. In the rationale it is stated that graduates should be able to convert ideas to practical applications. A teacher explained:

> *"These practical applications are there, particularly in the fact that we mainly educate as designers with a certain design strategy and a design methodology that they have to use - and that is, yes, that is then and then very practical."*

Additionally, they ask companies for assignments which students can solve. The rationale highlights the research aspect. This is embedded in the whole curriculum, mainly during the internships, smart solution semester and during the graduation internship.

In relation to the aims and objectives, a focus is placed on the competencies required as a professional: *"But if we are really talking about the competencies at the moment that you are really in a company, that is mainly in the internship, and especially during graduation".*

Related to content, teachers said that adaptations to the curriculum are always presented to the field committee. In addition, they explained that companies provide input for some projects, smart solutions semester (S3), international project week, the internship and graduation. Teachers have a role here: *"Colleagues sometimes go looking for a company for*

an assignment, [...] we have the international project week every year and an unbelievable number of companies come to us".

There is also a course orientation on study and profession. It also happened that two employees of a firm taught some lessons:

> "*We had a company with two employees teaching with us. So that was a lot of fun. One of them is still on our field committee [...], which, unfortunately, is not structural. It can hardly be made structural, but it is extremely valuable."*

Related to teaching and learning, teachers mentioned that there are various activities within the curriculum where students get in touch with the working field. This already starts in the first year, where students visit three companies:

> *"They have three different company visits, all with different themes. One theme is: what do you do as an intern or graduate? One theme is: what does a mechanical engineer do at a company? And the third theme is: what products can you work on? [..] and present to the whole class."*

One teacher mentioned that students also visit various career fairs during the first two years. After visiting, they have to reflect on this. Additionally, both teachers explained the international project week: *"an international project week, that is once a year, where students involve in a week-long project for a company".*

Related to guest lectures, both teachers mentioned that there are four to five guest lectures included in the curriculum and several excursions: *"project courses are often carried out for companies. A real assignment from the company and a company visit are part of this […] the company is also present at the final presentations".*

Teachers explained that in the third and fourth year, students have a smart solution semester where they do an assignment for a company. They also do an internship at a company and they graduate at a company. During their graduation, students have to write a reflection and fill out a 360 degrees feedback form. A teacher explained more about reflection:

"In the new curriculum, we want something more, but technology and reflection is a no go [...] that if you want something, you have to do it very carefully. Actually, this is mainly in the graduation [...] then I send in the 360 degrees feedback form. What's in it, so I always say, ask a few people in your work environment what are your good points and your fewer good points?"

Related to the role of the professional, teachers explained that professionals have a role in a field committee. Additionally, they have a role during guest lectures, when they serve as a client for a project or in the smart solutions semester, during internships and graduations. A teacher explained: *"Client, that is to say, they ultimately examine whether the solution provided by the students is indeed what they want".*

Professionals also interact with students during the interview in the first year. Finally, professionals had a role when they taught a lesson series.

Related to the teacher role, teachers estimate that approximately 50% of the teachers has working experience in the field. They also mentioned that students see this as a benefit. Teachers try to serve as a role model: *"I try to be, actually, role model is a bit ambitious, I think […], but I do try to make a student look around and be curious and explore the world".*

Related to assessment, teachers said that companies sometimes have an advising role in the assessment of projects. This also happens during internships and graduation. One teacher thought this also was the case during the smart solutions semester. During the internship and graduation, students also get assessed on their performance in the field.

Related to facilities and resources, teachers said that all software which they use is representative for the field. A teacher said: *"I would almost say 100%: yes, representative".* They mentioned the use of MATLAB Simulink, Solidworks and Ansys. Additionally, there is a workshop with all kinds of machines and a manufacturing line, which students use during a project.

Related to grouping, teachers explained that students work in multidisciplinary teams once.

"Yes, that happens during that 3S project. There is a group of different degree programmes and indeed we have the international project week. Again, that is a week, but also in that week a student from different courses of different years works together."

Related to location, students attend various career fairs, companies for excursions, internships and graduation companies.

No questions were asked regarding the time.

Besides the planned curriculum, one teacher mentioned that the study association arranges excursions. Sometimes these are in collaboration with the study.

In sum, the rationale is represented through the programme that educates designers which is practical. The research aspect of the rationale is embedded especially during internships and smart solution semester. Related to aims and objectives, competencies are embedded during internship and graduation. Related to content, there is a field committee and companies provide input in for projects. There is also a course related to orientation on the profession. Related to teaching and learning, students visit various companies, career fairs, participate in the international project week and smart solutions semester with an assignment from a company. There are also guest lectures. Last there are internships and graduation where reflection also plays a role. Related to the role of the professional, professionals have a role in the field committee, guest lectures and when they serve as client. Related to the teacher role, some teachers have working experience in the profession, they try to serve as role models. Related to assessment, professionals sometimes have an advising role. Related to facilities and resources, all used software is representative for the field. There is also a manufacturing line. Related to grouping, students work in interdisciplinary groups multiple times. Related to location, students visit various companies during excursions, internships and graduation.

When comparing the formal with the perceived curriculum, various differences are visible, for example in the aims and objectives. Teachers only mention the competencies during internships and graduations and the role aspect in the smart solution semester. Related to content, one teacher told that two employees of a company taught a lesson series. This is not written in the formal curriculum. Related to teaching and learning, in the formal curriculum, it is stated that students do a personal profile test, reflect on their action and visit the business days. These are all not covered in the perceived curriculum. Teachers mentioned that students conduct interviews with professionals related on three themes in the first year and that they conduct a 360 degrees feedback during their graduation. These two are not covered in the formal curriculum. Noteworthy is the international project week, which is covered in both the formal and perceived curriculum. However, it is not stated in the formal curriculum how often this happens, while in the perceived curriculum, teachers said that this happens each year, so students participate four times. Related to the role of the professional, the perceived curriculum covered the role of professionals during interviews and two employees who taught a lesson series. Related to facilities and resources, the formal curriculum covered more specific software tools which are not all covered in the perceived curriculum. The perceived curriculum covered the manufacturing line and the workshop. Concluding, for this degree program, teachers provided a much richer view for teaching and learning and the role of the professional.

Intersection degree programme at university

Formal curriculum

In the formal curricula of IEM at the university, various professional socialising experiences are found. The fragments are summarized in table 5. A summary of this table can be found in Appendix IV.

Table 5

Examples of fragments from the formal curriculum of intersection degree programme at the university

	Year 1	Year 2	Year 3
Rationale	"[..] particularly focuses on organizational problems in contexts with high societal relevance. […] students can analyse the root causes, can design solutions, can prospectively assess solutions in a (optimization/simulation/analytical) model, and can implement the outcomes in situations where typically they need to work together with people from various other disciplines.		
Aims	"The student knows some basic principles of and complications with valuation problems in business context." "Is able to critically interview an IEM alumnus to obtain a clear view on the work field of an IEM engineer and the professional skills you need as a manager"	" Be familiar with successful examples of online businesses that bring customizable products to the market using online channels" "The student can act as a project manager of the project team for a period of approximately 1 weeks,"	"Write a critical reflection on your own professional conduct" "Students need a
Content	"Project assignment 1: Operations at New Balance;" "Inventory management and problem solving at Diversey Enschede" "Design and implementation of a Dashboard based on The Balanced scorecard for a given company" "The modelling and automation of a business process for a given company"	" the annual reports of several companies" "To touch upon the 'real' complexities in product development, students participate in a development project with a factual problem formulation. The client (company) introduces the problem and reflects on the results at the end of the project."	"bachelor assignment "
Teaching & Learning	" the last one is based on Diversey Enschede, a company" "the opportunity to visit this company." " a factory tour at Diversey Enschede" " Interview with an alumnus" "Reflection assignment"	" a formal meeting with the client (company)" "Both the client and the examiners provide the group with feedback" "Several guest lectures"	"Student needs to involve different stakeholders in their project plan" " Visit the internship company/organisation"
Role of the professional	"Managers of Diversey Enschede will introduce themselves" "Students also have the opportunity to participate in a factory tour at Diversey Enschede" "Interview with an alumnus"	"Workshops are often provided by guest lecturers."	"with support of company and university supervisors" "This supervisor must have sufficient knowledge and experience to supervise the project."
Role of the professional: Alumni	"Interview with an alumnus"	"a number of MSc-students will have a tutor role."	
Assessment	"The written report "the product." "Assignment 5 Reflection" "Project reports "OR-tests" "Interview with an alumnus"	"the final group presentation" " the evaluation of your performance." "Design brief" "Project exam" "Project fair" "Individual walkthrough demo + reflection report" "assignments"	"Project plan Research Cycle (essay assignment) Academic poster" "• Your performance; • Oral presentation of the project results"
Facilities and resources	"visual basic Excel "data management and web related technologies (e.g., MySQL)" "a BI tool (e.g.: Tableau)" "Application Development Platform (ADP) (e.g.: Mendi)"	"Annual Reports (freely available) CAD/CAM systems ERP system"	
Grouping	" project group of up to six students" "A project group consists of 6 or 7 persons" "you will share with students from the Business and Information Technology (BIT) programme" "A project group consists of maximum 4 persons"	"The nominal group size is 6 students." "To emphasise the realistic setting, students collaborate in multi-disciplinary project groups " "The project is carried out in a multi-disciplinary team of BIT/IEM students. "Each team will consist of maximum 7 students with at least 1 BIT students per team" "Project groups have size of approximately 10 and are multidisciplinary"	" The Bachelor's thesis is an individual assignment "
Location	"a factory tour at Diversey Enschede" "Question hour at Diversey"		While executing your bachelor's project off campus, you will be employed by an organisation for approximately 8-10 weeks."

By filling in the rubric based on these fragments, a heatmap is created. This heatmap is visualised in Figure 4. The definition of the scores in each cell can be found in the rubric in Table 2.

	Programme											
Rationale	1											
Teacher role: working experience *												
Teacher role: combining job *												
	Year 1				Year 2				Year 3			
Role of the professional: Professionals	3				4				4			
Role of the professional: Alumni	4				2				1			
Facilities and resources	5				4				1			
Location	2				1				2			
Time	2				4				4			
	Module 1	Module 2	Module 3	Module 4	Module 5	Module 6	Module 7	Module 8	Module 9 (minor)	Module 10 (minor)	Module 11	Module 12
Aims	2	3	1	1	1	3	2	3			4	5
Content	4	3	3	1	3	4	2	2			4	4
Teaching & Learning	2	3	1	2	2	3	3	1			4	5
Assessment	4	4	4	2	2	4	4	4			2	2
Grouping	2	2	2	2	2	4	4	4			2	1

Figure 4: Heatmap from the formal curriculum of intersection degree programme at the University.

* data is not representative enough

Summarizing, the rationale does not pay much attention to professional socialisation. Related to the role of the professional, professionals have a role during the guest lectures, interviews and the internship. Alumni have a role as interviewee and tutor. Related to facilities and resources, various software packages are used such as visual basic, excel, monte carlo simulations, Application development platforms, BI tools, ERP systems and CAD/CAM system. Related to location, students visit one company and conduct their internship externally. Related to time, time is reserved for projects based on cases or in collaboration with professionals, guest lectures, excursions and the internship. Further, various aims pay attention to the professional practice, for example, students have to re-formulate a problem provided by a client and use appropriate modelling tools. Related to content, companies provide input for various projects, courses and for the internship. Related to teaching and learning, there are various guest lectures and company visits. Students also have to conduct several interviews and participate in a management game. Last, students do an internship externally. Related to assessment, various forms are used, such as written tests, written reports, reflections and demonstrations. Related to grouping, various modules are shared with other degree programmes. Students work in groups multiple times, two times in a multidisciplinary group.

Perceived curriculum

The rationale of the study states that students should be able to work in a multidisciplinary environment. Teachers explained that this is also represented in the curriculum: *"We have a lot of multidisciplinary, also in modules. We collaborate a lot with other programmes".*

Furthermore, the rationale also states that students should be able to both analyse a problem as well as implement a solution. A teacher explained that this is represented in the project: "*We have cases in every project and in every course"*.

Related to the aims and objectives, one teacher mentioned that some goals related to graduation include several professional skills. Students get assessed on these goals during their graduation: *"And some items that relate to professional skills, like whether the students are working independently and whether the communication skills, are good, was it smooth".*

In terms of content, teachers explained that adjustments in the curriculum are always presented to the working field first. Furthermore, the field provides content for the curriculum. A teacher explained that there is a strong connection with alumni in this regard: *"We have used alumni in all kinds of ways in education. They are providing projects from their own companies or organizations where they work".*
They gave the example of module six where students create a consumer product: *"[…] and then every year we have a different company presenting a design question".*
Teachers said they use cases which are representative for the field in every module. One teacher gave the example of an entrepreneurial module where students set up their own company. In this module, various professionals are involved. During their graduation, the content is also provided by a company: *"In the third year of the bachelor's we also have an internship/graduate thesis assignment. This is a quartile with a preparatory quartile in which students are actually presented with a problem in an organisation".*

Related to teaching and learning, teachers explained that in every module there is a reflection part: "*We have also skill part in our curriculum and there are all kinds of reflections, I guess. And during these reflections, they reflect about their experience at the company".*
Sometimes a company involved during projects:

> "*Well, that's where the IKEA people, or whatever company that is, come to university. They tell in an hour. Well, we want to grow up in the bathroom market and how? [...] In between, they will come to university. The students have to pitch for 10 minutes. They immediately get feedback [...] and at the end there is a closing market - and there the designers are again and there are the prototypes [...] And they have to be presented to the company."*

There are also several guest lectures as well as excursions embedded in the curriculum. For example, in the first year, students go to JohnsonDiversey: "*So, most of the time it is*

inspiration. What kind of issues do we encounter there? [...] It's mainly a tour of the factory or the place where the service is provided, or a product is made".

A teacher mentioned that guest lectures are a big part of the entrepreneurial module. Here, professionals from the field provide guest lectures about starting a company. One of the teachers said that alumni also play a role in these guest lectures and excursions.
There is also an interview with an alumnus: *"Even in the first year our students already interview an alumnus for orientation on future work, they are going to talk to an alumnus by going there for a visit".* Additionally, there are also serious games involved in the project: *"we have more of them in the programme, all of which actually recreate business situations in the very real way".* In the last part of the programme, students have to prepare their graduation in collaboration with the company. Teachers explained that students visit the company and talk about the design of their graduation. Students also attend a market where they have to pitch their assignment in order to find a supervisor.

Related to the role of the professional, teachers said that professionals provide feedback on the content in the curriculum. Alumni are also involved by offering projects, excursions, guest lectures and serve as interviewee. Professionals are involved in module six as well as the entrepreneurial module and during the graduation.

In relation to the teacher role, one teacher estimates that 10% of the teachers has working experience in the field. When teachers do not have working experience, the graduations offer them an opportunity to create a view of the professional field. Teachers are a source of inspiration rather than a role model. Teachers also share anecdotes about their working experience in the field; *"I tell an extraordinary number of anecdotes, as do my fellow lecturers, from our business experience".*

Related to assessment, professionals have a role in assessment. Sometimes, these professionals are alumni. At the end of module six, the company chooses the best design and during graduation, the external assessor has a role in the assessment. During graduation, students get assessed on their professional skills. During the other projects, companies also assess students: *"in the projects in the bachelor modules, companies reflect on the quality of the solution, did they stick to the assignment, do they have taken a professional attitude".*
One teacher mentioned a moment where students have to write a reflection which is also assessed.

In terms of facilities and resources, the software which is used in the curriculum is a representative of the field. One teacher explained: *"Students already learn Excel and visual basic, an applications programming language in Excel in module one. They get all kinds of data-science software, they learn to work with tableau and with R and they learn to program*

with Python". Furthermore, students learn something related to ERP systems which are also used in the field.

Related to grouping, there are many modules which are multidisciplinary. A teacher indicated: "*But another module, that is the first module of the second year which, together with industrial design and mechanical engineering, 9 students in group three from each programme, from […], 3 from […] and 3 from […]".*

A teacher explained that students work in groups in every module. In the serious game in module four, the roles which are divided are representative for the field. For example, CEO and SFO.

Related to location, there are several excursions, for example to JohnsonDiversey or to warehouses of big companies. Students also go to companies for interviews and internships.

Related to time, there are no questions asked.

Further, there is an extracurricular activity which is not covered in the planned curriculum. That is, the study association organises most excursions.

In sum, the rationale is represented in the various multidisciplinary activities and the cases used in courses and projects. Related to aims, the aims of the graduation include various professional skills. Related to content, there is a field committee, alumni are asked to provide content. Cases are used in every module and during the graduation content is also provided by a company. Related to teaching and learning, reflection is a part in every module, companies are sometimes involved during projects. There are also excursions, guest lectures, serious games and an internship. Related to the role of the professional, professionals provide feedback on the content. Alumni offer content for projects or serve as guest lecturer. Related to the teacher role, some teachers have working experience in the profession and provide inspiration. Related to assessment, professionals are involved sometimes. Related to facilities and resources, the software is representative for the field. Related to grouping, various modules are multidisciplinary. Related to location, students visit various companies.

When comparing the formal with the perceived curriculum, several differences are found. There is a difference in the aims and objectives. In the perceived curriculum, only the aims for the graduation were covered, whereas in the formal curriculum, more aims are covered. Related to content, the formal curriculum mentions the use of annual reports, these are not mentioned by the teachers. The teachers mentioned the existence of the field committee, which is not covered in the formal curriculum. Related to teaching and learning, in the perceived curriculum it is covered that teachers tell anecdotes about their experiences in the field, that reflection is a part of every module, that there are cases in every module, that alumni are involved in excursion and that some students attend a forum. These are all not covered in the formal curriculum. Further, the formal curricula stated that there is an opportunity to attend

a symposium and that students visit their internship company when writing their plan. Students also have to write a reflection on their professional construct. Related to the role of the professional, alumni have a significant role in the perceived curriculum, which is not covered in the formal curriculum. Related to location, in the perceived curriculum, more opportunities to visit a company are covered than written in the formal curriculum. Last, the perceived curriculum covered the role of the study association. Concluding, for this degree programme, teachers provided a much richer view for teaching and learning, the role of the professional and location.

Intersection degree programme at university of applied sciences

Formal curriculum

In the formal curricula of IEM at the university, various professional socialising experiences are found. The fragments are summarized in table 6. A summary of this table can be found in Appendix IV.

Table 6

Examples of fragments from the formal curriculum of intersection degree programme at the university of applied sciences

	Year 1	Year 2	Year 3
Rationale	"De afgestudeerde […] is een specialist in het ontwerpen en verbeteren van productontwikkelings-, productie- en logistieke processen waarmee kwaliteits- en productiviteitsvraagstukken worden opgelost. Het werkveld van de Saxion opleiding Technische Bedrijfskunde focust zich op de maakindustrie in Oost-Nederland welke wordt gekenmerkt als technologisch vernieuwend (hightech) en stuksgewijs.		
Aims	"Het kunnen leren van eigen ervaringen en het kunnen reflecteren op eigen handelen"	"Rekening houden met belangen, werkwijzen en resultaten van collega's"	"Het kunnen leren van eigen ervaringen en het kunnen reflecteren op eigen handelen"
Content	"Om als bedrijfskundige binnen een organisatie bekwaam te kunnen functioneren is kennis van en inzicht in deze verschillende facetten van organisaties noodzakelijk." "In dit project ga je uitgebreid kennismaken met een bestaand bedrijf" "Casusopdrachten"	"De projectgroepen werken aan een van onderstaande zes actuele thema's die zijn afgeleid van actuele ontwikkelingen binnen de TBK-beroepspraktijk" "2 cases"	"Diverse artikelen of cases" "De kennis en vaardigheden ontwikkeld om met dit type vraagstukken te kunnen omgaan als voorbereiding op het functioneren in de beroepspraktijk" " "Bedrijven leveren voor het project casus-opdrachten"
Teaching and learning	"Bezoek bij een tweedejaars stagiair op zijn of haar huidige stageadres." "Er zal een bezoek worden gebracht aan het bedrijf." "Zal <EIGEN BEDRIJF> een presentatie verzorgen."	"1 interview afnemen met een expert" "Rollenspelen plaats op basis van casussen" "Gastcollege"	"Gastcollege (RVO): "Octrooionderzoek" "Interview manager" "Managementgame: "Bedrijfsbezoeken" "reflectierapport"
Role of the professional	"Presentatie Cogas, bedrijfsbezoek en presentatie"	"Iedere student moet 1 interview afnemen met een expert"	RvB kan gevormd worden door meerdere (vak)docenten, maar ook door mensen uit de praktijk, gastcolleges en interview"
Role of the professional: Alumni			
Assessment	"Schriftelijke toets" "Digitale toets" "Rapport" "Verdediging" "Groepsopdracht" "Luistertoets" "Groepsrapportages"	"Groepsopdracht" "Schriftelijke toets" "Werkstuk" "Tentamen" "opdrachten" "uitwerking casus"	"Innovatiecasus" "Mini-colloquium "Verslag" "Workshop" "Project rapport" "Poster" "Reflectierapport" "Pitch" "Groepsopdracht"
Facilities and resources	"Gebruik van Excel, Access, MS Project en Power BI."		
Grouping	"Groepsopdracht" "Projectgroepen van 6 personen" "Groepen van 4" "Presentatie door twee studenten" "Groep van 4-5 personen" "maximale groepsgrootte is 4"	"Groepsopdracht" "Groepen van 2-3 studenten" "Groep van 4 of 5 studenten" "Mogelijkheid internationale groep" "Groepen van 4"	"In een team van 4 studenten" "Groepen van 4-5 studenten" "Groepen van 5-6 studenten"
Locatie	"Bezoek bij een tweedejaars stagiair op zijn of haar huidige stageadres." "Er zal een bezoek worden gebracht aan het bedrijf."	*Internship*	"bedrijfsbezoeken"

By filling in the rubric based on these fragments, a heatmap is created. This heatmap is visualised in Figure 5. The definition of the scores in each cell can be found in the rubric in Table 2.

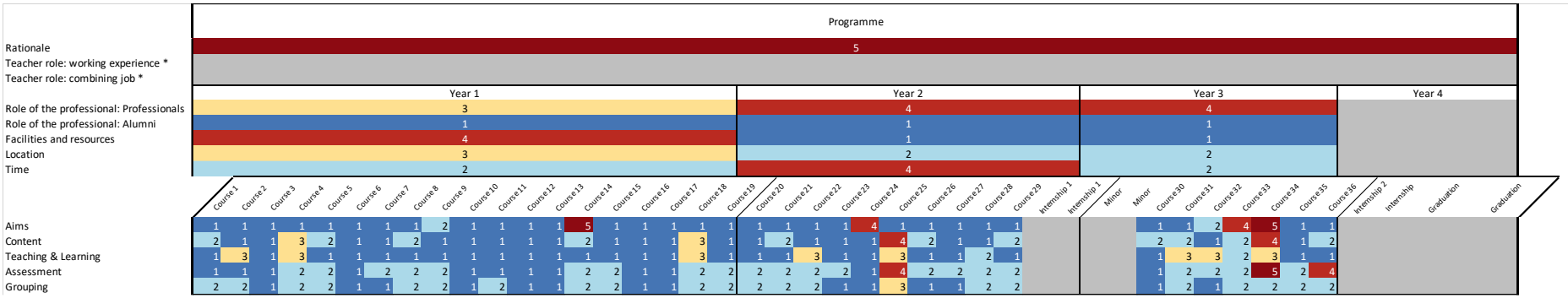

Figure 5. Heatmap from the formal curriculum of intersection degree programme at the university of applied sciences.

* data is not representative enough.

Summarizing, the rationale covers the possible future work field. Related to the role of the professional, professionals have a role during guest lectures, interviews and the serious game where professionals participate in the executive board. Related to facilities and resources, Excel, Access, MS project and Power PI are used. Related to location, students visit several companies and do two internships externally. Related to time, time is reserved for guest lectures, interviews, excursions and internships. Further, there are some aims related to the professional practice. For example, students need to learn from and reflect on their experiences. Related to content, various courses use cases or real assignments. Sometimes data from companies is used. There is also one serious game included. Related to teaching and learning, there are various experiences such as interviews with professionals, excursions, guest lectures and an internship. Related to assessment, written tests are used, as well as written reports, assignments and cases. Related to grouping, students work in groups multiple times and have the opportunity to participate in an international project group.

Perceived curriculum

In the rationale of the study, it is stated that students are practical oriented. This is represented in the curriculum by collaborating with the professional practice: "*That is because we do so much together with the business community, and that is actually from the first day, that they do an assignment for a real company and also go on excursions and company visits right away.*"

In the rationale it is also stated that graduates should be able to improve processes, this happens during their graduation. Then, they have to be able to improve processes.

Related to the aims and objectives, all aims of the study are described in relation to solving a practical issue: "*Solving an issue, that is what it is all about. So, as I see it, that is the practice*".

> *"What has been written out at educational level. That is very much part of what an engineer does when you are in the company. And we say that an is someone who optimizes a process or improves a process or develops a process for a company."*

Further, one teacher explained that reflection is a competence which is applicable for all studies at UAS.

Related to the content, there is a field committee. Here, adaptations to the curriculum are presented. Sometimes, they even develop education together. Further, the first year of the

study pays attention to the different professions and therefore serves as an orientation. Teachers explain that companies provide content for the curriculum, for example during projects, internships or graduation. Their data also serves for input during lectures. A teacher explained: "*We try to work as much as possible with real clients, not all projects have succeeded, but that is actually our aim".* And *"It is a way of thinking, and then they actually get real data from the companies and then they get to work on the project".*

Related to teaching and learning, there are several guest lectures, trips to career fairs and excursions embedded in the curriculum. During the excursions, students can often see the production process: "*But there are also often companies where you can actually see something because something is produced. So most of the time we can actually see the production*".
Several other initiatives are embedded: *"In year three we go with students to Volkswagen in Wolfsburg".* And *"[…] but that was about women in the manufacturing industry, so the female students from us as a group got together and went on company visits together".*
At the end of an excursion, students have to reflect on this: "*but also what lesson they can learn from, what are they taking with them? It is really a reflection on a person or on their professional development*".

There are also several projects in the curriculum, where they aim to have an assignment from a company. A teacher mentioned that they aim to have a company for every project, but this has not been fully achieved yet. Teachers said that later on, the interaction between students and the company becomes more intensive.

> *"You can see that it is very much in the early stages of education that companies 'stop by and take a look'. As the programme progresses [...]. Then you notice that companies find it more interesting to invest time in this, because they also get more out of it."*

There is also a project in which a serious game is included; a management game about a soda factory where students have to act like the management team. Further, during courses, students reflect on the company culture, based on their earlier experiences. Reflection is a bit spare:

> *"And if you don't include students in that mindset from day one in the programme, it becomes difficult. Well, there we are in a technical business environment. [...] Say with students from the countryside […] Then it is like, 'relax, I notice'. So reflecting is far away, while I think we could embed this more in the programme."*

During the whole study, students interact with their academic advisor. Teachers explained that by doing so, students reflect on their experiences. During the last two years, students can participate in the smart solution semesters, but this is optional. During this semester, students do a project for a company. Further, there are two internships and a graduation project during these last two years. One internship is a follow-on internship and one is a research internship.

Related to the teacher role, teachers often have connections with companies, partly because they have working experience in the professional field.

Further, teachers are aware that they serve as a role model. They are also responsible to arrange guest lectures. Last, a group of teachers serve as study career counsellors.

> *"With us, that is very much in that study career counselling. There is a lot of reflection and also on the competences of the study programme, but also in the supervision and in the conversations that you think about okay, this is coming in the programme, you are going to do an internship, where are you going to do an internship? What did you do last time?"*

Related to the role of the professional, professionals participate in the field committee. They also have a role during guest lectures, projects, internships and graduation. During projects, professionals are interacting with students, but this is mainly the case during the later phase of the study. During internships and graduation, supervisors within the company help students develop their professional skills: "*they have a role in working with the student and developing the student's professional skills and functioning in the company".*

Related to assessment, both teachers said that professionals may have a role in the assessment of projects: "*If you look at work placements and graduation, the work field really does have an important role to play in assessment."*

During graduation, there is always an external advisor which is a supervisor from another company.

Related to facilities and resources, both teachers said that students learn something about ERP systems.

> *"ERP systems, and so we show them examples rather than they can actually play with them, because then you also need data. [...] so they usually do that during the internships and so that they are able to use that data in their internships."*

Related to grouping, teachers said that the roles which students have during the first project are representative for the field. For example, one person is chairman and one person

is notary. During the first project, roles switch every week. Further, there is the smart solutions semester: "*And we also have what we call the 'smart solutions semester', but this is optional at the moment. Here, students are working interdisciplinary on an assignment with other programmes"*. Finally, there was also the excursion with all female students.

Related to location, students go to companies for several activities such as excursions or internships. For example, the excursion to Volkswagen in Wolfsburg.

Related to time, there are several guest lectures and excursions, there are two internships and a graduation. All three of them take a semester and take place in the second and fourth year.

In sum, the rationale is represented by collaborating with professional practice. Related to aims, all aims are described related to solving a practical issue. Reflection is also embedded. Related to content there is a field committee, the first year serves as an orientation and companies provide input for projects and internships. Related to teaching and learning, there are guest lectures, visits to career fairs and excursions. Reflection is embedded after such experiences. Further, projects are done in collaboration with companies sometimes. There is also a management game, two internships and a graduation project. Related to the teacher role, some teachers have working experience in the profession and they serve as role models. Related to the role of the professional, professionals have a role in guest lectures, projects, internships and graduation. Related to assessment, professionals have a role in assessment sometimes. Related to facilities and resources, ERP systems are embedded. Related to grouping, students work in groups multiple times. Sometimes these groups are multidisciplinary. Related to location, students visit various companies.

When comparing the formal curriculum with the perceived curriculum, various differences are visible there is a difference in the aims and objectives. In the formal curriculum, several learning goals are described in relation to the profession. These are not covered in the perceived curriculum. However, in the perceived curriculum, teachers mention that all aims are described from a professional perspective. Related to the content, the perceived curriculum covered that almost all projects are directly taken out of professional practice, this is not described in the formal curriculum. Related to teaching and learning, the formal curriculum mentions that students receive feedback from professionals about their behaviour, the international project week, the visit to a second year student during his internship and various interviews and innovation cases which are solved. These are all not covered in the perceived curriculum. Whereas in the perceived curriculum, they mention that some students visit a career fair, that excursions are focused on the production process and that there is a reflection component connected to this. Further, teachers mentioned the internships. Related to the role of the professional, the formal curriculum covered their role during interviews and the

management game, these were not covered in the perceived curriculum. However, the perceived curriculum covered the role of supervisors during internship and graduation, that supervisors help develop professional skills. Related to facilities and resources, the formal curriculum covered the use of a management game, books, cases and several software tools. The perceived curriculum covered only the use of ERP system. Related to grouping, the formal curriculum covered that almost all projects are group projects and that groups are more often multidisciplinary. The perceived curriculum covered that the roles in a group are representative for the field, the interdisciplinary group during the smart solutions semester and the excursion with all female students. Related to location and time, the perceived curriculum covered the internships and graduation, these are not covered in the formal curriculum. Concluding, for this degree program, teachers provided a much richer view for content, teaching and learning, location and time.

Conclusion and discussion

The aim of this study was to investigate the presence of professional socialisation in engineering curricula. To do so, both formal and perceived curricula of two degree programmes offered at a university and an UAS are investigated. First, the results of the formal curriculum will be discussed, then the results of the perceived curriculum will be discussed. Then, practical and theoretical implications as well as limitations and suggestions for further research will be discussed. Finally, a conclusion is drawn.

Professional socialisation in the formal curricula.

The current study investigated the role of the curriculum in professional socialisation. Schein (1967) indicated that a role of educational institutes is to guide the professional socialisation of students. Previous research investigated the role of educational institutes in professional socialisation. Though, these studies primarily use questionnaires to investigate the result of the education (Keltikangas & Martinsuo, 2009; Tan, van der Molen & Schmidt, 2015). These studies acknowledged the role of the curriculum in professional socialisation but did not investigate this further. The current study is one of the first which investigated the role professional socialisation in the curriculum and therefore addresses several recommendations made in earlier research. For example, Dehing (2012) mentioned that PI development should be a curriculum aim and engineering identity could serve as a common aim for curriculum development.

In general, the results indicated that the professional socialising experiences from the university and UAS are during the first two years primarily focused on exposure and to some extent on knowledge acquisition about the profession. After the first two years, there is more of a focus on interaction, except for the technical programme at the university. There are a few activities focused on reflection, but most of them are not directly focused on reflection on the professional socialising experiences. Previous research acknowledged the importance of reflection. Moorhead et al. (2019) stated that students should be exposed to a range of activities followed by deep reflection in order to be socialized to the profession. In line with this, Marcia (1966) acknowledged that one aspect of identity development is the rejection or commitment to an identity based on the reflection of exploration activities. So, when there is insufficient attention paid to reflection on experiences, this could lead to a less developed PI.

Furthermore, there are various experiences embedded in the formal curricula, such as guest lectures, excursions and internships. This is in line with the processes of Ibarra (2004) who stated that PI is shaped through engagement with professional activities. Ibarra (2004) also mentioned the development of a social network, this is partially in line with the results as

this is more represented in the formal curricula of the UAS than in the formal curricula of the university, since there are more experiences embedded where students get in contact with professionals. Finally, Ibarra (2004) mentioned the process of sense making. The results did not indicate that this is a primary process in the curriculum. However, sense making in terms of reflection sometimes happens, but this can be seen as an assignment rather than an ongoing process. Noteworthy is that there are not so many experiences focused on knowledge acquisition on the professional field. Though, there are some experiences such as a course about orientation on the profession (technical programme UAS) or serious games (intersection programme university). Knowledge acquisition is an important process in professional socialisation because by acquiring knowledge, the students are able to assess their own capacity and skills in relation to the ones needed for the profession. Further, the student starts to identify himself in the profession. (Weidman et al., 2003). Thus, by not embedding knowledge acquisition in the programme properly, an important step in professional socialisation is missing.

For the programmes at the university, it is not directly visible that there are more professional socialising experiences later in the programme. This is slightly more the case for the intersection programme, since there is an internship at the end of the programme. However, for the UAS, the results indicate that there are more professional socialising experiences during the last two years, which refers to a discipline-oriented curriculum (Dehing et al., 2013). In a discipline-oriented curriculum, the first two year of the curriculum are used to acquire sufficient disciplinary knowledge, resulting in a professional orientation starting from the third year on. In contrast, Pierrakos et al. (2009) stated that the first year of an engineering study is crucial. Students should obtain a view of the breadth of the engineering profession. The results of the university indicated that there are only few professional socialising experiences in the first year. For the technical programme, these experiences are of a lower level of engagement (van Hattum-Janssen & Endedijk, 2019), but this is not explicitly the case for the intersection programme. This could lead to less sense of belonging to the community of practice and a later start of the PI development.

Previous literature (Thornton & Nardi, 1975) described that PI forms through four stages namely anticipatory socialisation, formal socialisation, informal socialisation and personal socialisation. The formal and informal stage takes place during education. The results indicated that in the formal curriculum of both the university and UAS, there are various activities where students can observe other students and role incumbents. However, this is to a lesser extent the case for the technical programme at the university. Observing role incumbents relates to the formal socialisation stage (Thornton & Nardi, 1975).

Following this line, the formal curriculum of the UAS has several experiences embedded where students are able to interact with professionals. This is to a lesser extent the case in the formal curriculum of the university. Interacting with professionals relates to the informal socialisation stage (Thornton & Nardi, 1975). The programmes at the university do not offer many opportunities to participate in this stage, Weidman et al. (2001) state that the formal stage is insufficient to prepare students for the professional life.

Curriculum components in formal curricula

The results indicate that in the rationale of the UAS, more attention is paid to the student as a future professional. A possible explanation for this is that graduates from an UAS should be able to immediately enter the professional field (Dehing et al., 2013). Previous research acknowledged the influence of the rationale on the educational processes (Stark , Lowther, Hagerty & Orczyk, 1986). This is also acknowledged by Yeung (2011) who found that the rationale of an educational institute can guide the design of learning activities. So, the rationale could be an indicator for the extent of professional socialising experiences embedded in the formal curriculum.

The results of the formal curriculum indicate that in the aims, there is not so much attention paid to professional socialisation. Only in a few courses and modules, attention is paid in the learning goals. Since there are professional socialising experiences included in the teaching and learning component, it seems that the aims and activities are not fully aligned. A possible explanation for this is that learning objectives are not affecting student learning (Mitchell & Manzo, 2018). Though, Biggs and Tang (2007) argue that the coherence between teaching, learning and assessment is crucial for the quality of teaching, in order for the learning objectives to become actual learning outcomes. Thus, it is important to make every activity help for realizing the learning objectives.

The results of all formal curricula indicated that the content of most courses does not contain knowledge acquisition on the professional field. They rather contain assignments which are representative for the profession. This is in line with the findings of Dehing et al. (2013) who found that courses primarily focus on academic knowledge and engineering skills. However, knowledge acquisition is an important step in professional socialisation, because this is the start for an individual to feel like a role incumbent resulting in identification with the specific role (Thornton & Nardi, 1975).

The results of the formal curriculum of all programmes indicated that professionals have a role in each year. Hirschy et al. (2014) stated that role incumbents determine the fitness to the profession. Cornelissen and van Wyk (2008) mentioned that the possibilities for interaction

are important. Last, Ibarra (1999) suggests that when students get exposed to a larger variety of role models, they gain a broader repertoire of possible selves. This increases the likelihood of a successful professional adaptation, including the development of a PI. Thus, this could be indicating by acknowledging the role of the professional in the curriculum, the development of a PI can be fostered.

In line with professionals serving as role models, in most programmes, there are also some teachers who have industry experience.

The results indicated that assessment scores high in the intersection programme at the university. In all other programmes, there are some courses where assessment scores high. A high score here indicates that the type of assessment is considered authentic. When students engage in authentic tasks, students will develop accurate expectations of the engineering profession and develop their PI as an engineering student (Male & King, 2004).

Previous literature also acknowledged the importance of communities of practice for PI development (Allie et al., 2009; Du, 2006; Hunter et al., 2006; Ibarra, 2004). The results did not indicate that attention is paid to communities of practice. However, the results did indicate that in all degree programmes, students work in monodisciplinary teams very often and sometimes in multidisciplinary teams. Interacting with other disciplines fosters the development of an engineering PI (Forin, 2012). Though, grouping is not well defined in the formal curriculum. For example, little is written about group formation, which is an important aspect since this community could never be identical to a workplace community (Allie et al., 2009). Thus, when groups are not properly formed, it could be that these do not represent the range of identities which are in the workplace, resulting in a less developed PI.

Last, facilities and resources score quite high in every degree programme. That is, because specific software packages and their application is described. Using authentic facilities and resources can foster the authenticity of the learning environment. Dehing (2012) concluded that an authentic learning environment fosters the development of a PI.

The rubric is used to map the extent of professional socialising experiences over the different curricular components. Therefore, this rubric is aimed for programme assessment. Previous literature indicated that the use of rubrics is rarely used for programme evaluation (Martens, 2018). Though this is the case, there are examples of studies which used a rubric for programme evaluation, for example, Petkov and Petkova (2006) designed a rubric to analyse courses in a programme. Though rubrics are not widely used for this purpose, Popham (1997) refers to these kinds of rubrics as ‘instructional illuminators’. He wrote that these rubrics could make a huge contribution to the instructional qualities. Rubrics can support instruction by making expectations and criteria explicit which facilitates feedback and self-assessment (Jonsson & Svingby, 2007). So, rubrics have potential, however there are also some issues

with the use of rubrics to this respect. Panadero and Jonsson (2020) mention that when criteria are shared, minimal effort will be taken to meet these criteria. Further, they also mention that the users of rubrics need training too. Untrained users may implement the rubric in non-appropriate ways. Concluding, the developed rubric seems to be a good first step in measuring professional identity in the formal curricula, but several issues need to be taken into account when implementing the rubric.

Professional socialisation in the perceived curricula.

In general, the results indicate that there are more professional socialising experiences embedded in the perceived curriculum than in the formal curriculum, indicating that there are differences between the formal and perceived curriculum. This is in line with previous research (Kotoka & Kriek, 2019; Shkedi, 2009) who found evidence for misalignment between the formal and perceived curriculum. Though, by combining the formal and the perceived curricula provides a richer view of the curriculum, especially for teaching and learning, the role of the professional and location. For a more complete view of the perceived curriculum, the student perspective can also be taken into account.

When looking at the rationale and aims and objectives in the perceived curriculum, it seems that teachers have difficulties with answering these questions. This could be indicating that these components are not at the top of mind of teachers. This could also be a possible explanation for misalignment in those two components between the formal and perceived curriculum.

The results further indicate that in the perceived curriculum, teachers have a predominant role in terms of role models or being a source of inspiration. Previous literature states that role models are important for PI development (Bragg, 1976; Cornelissen & van Wyk, 2008; Ibarra, 1999; Wong & Trollope-Kumar, 2014). In the perceived curriculum of both degree programmes at the university, alumni have a role. Alumni could also serve as effective role models and role incumbents for students (Jackson, 2016; Stark, et al., 1986), which could foster their PI development.

The results indicated that the company visits in both degree programmes at the university and the intersection programme at the UAS are more focused on the content rather than gaining a view of the profession. Previous literature stated that this is especially useful for first- and second year students (Carbone et al., 2020).

The results indicated that both degree programmes at the university have a study association which plays a role in offering professional socialising experiences. The study association can also be seen as a community of practice. Previous research highlighted the importance of CoP (Du, 2006; Hunter et al., 2006). A study association could present a range

of identities, since students from all years could participate. Previous research described that this kind of communities could foster the PI development, since they have a range of identities and therefore provide a realistic representation of the workplace (Allie et al., 2009). However, it should be noted that participation in the study association is not mandatory and therefore a co-curricular activity.

In the perceived curriculum of the technical degree programme at the university, one teacher indicated that it is culture in the Netherlands that students enrol in a master programme after their bachelor. This is also represented in research; approximately 80% of the students enrol in a master programme after their bachelor (Inspectorate of Education, 2018). This could be a possible explanation why there are to a lesser extent professional socialising experiences embedded in the perceived curriculum of universities than in the perceived curriculum of universities of applied sciences.

The perceived curriculum of the technical degree programme at the UAS was more aligned with the formal curriculum. The results indicate that teachers have a responsibility to find content from companies for the curriculum. This could be a possible explanation why these kinds of experiences are not covered in the formal curriculum.

The findings of the perceived curriculum of intersection at the university indicated that there are cases in every module. According to Tomlinson and Jackson (2019), industry-based projects foster the development of PI. When there are cases embedded from the beginning of the curriculum, the curriculum tends to be more professional-oriented (Dehing et al., 2013). The results further indicate that reflection is an aspect of every module. Reflection is an important process in PI development and is the highest level of engagement (van Hattum-Janssen & Endedijk, 2019). However, reflection is especially useful when it is about the knowledge of the profession (Peel, 2005). The results did not directly indicate that all reflection aspects are about knowledge about the profession. There are more issues related with reflection. For example, Taylor (2006) wrote that when students have to do a written reflection, they can consciously or unconsciously tailor their responses. The results did not indicate that this issue is tackled.

The findings of the perceived curriculum of the intersection programme at the UAS indicate that the aims are written in relation to practice. This could be indicating that this curriculum is more professional-oriented rather than discipline-oriented (Dehing et al., 2013). Dehing et al. (2013) states that in a professional-oriented curriculum, PI development already starts from the beginning of the study because students have to behave like real engineers from the start of the programme. The results here also indicated that reflection is a subject but it should be more embedded in the curriculum. Previous literature acknowledged the role of reflection in PI development. Van Hattum-Janssen and Endedijk, (2019) wrote that reflection is necessary in order to adapt the current norms and values for the construction of a PI.

Practical implications

During this research, a rubric is developed in order to map professional socialising of a curriculum. This tool is useful for program directors to assess their own curriculum. Program directors can fill in this rubric based on the formal curriculum documents. Here, they can see for each year how well they score on all different curricular components and easily see what they can do to improve that component so that more impactful professional socialising experiences are embedded in the curriculum. This tool can also be used when designing a new curriculum, to investigate how to embed professional socialising experiences in the curriculum. For a more complete view, the perceived curriculum should also be taken into account. The perceived curriculum is especially useful for the components teaching and learning, role of the professional and location, since in general, teachers have a richer view of these components than what is described in the formal curriculum. For example, teachers explained that there are more professional socialising experiences embedded in the curriculum than covered in the formal curriculum. Though, the teachers perspective is only one of the many views which are included in the perceived curriculum. For a complete view, students should also be taken into account. Then, the differences between the teachers' perspective and student perspective become visible. Furthermore, students are able to elaborate on the value of different professional socialising experiences.

On a higher abstraction level, this research also adds to the problem of a lack of engineers. According to van Hattum-Janssen and Endedijk (2017) when the PI of a student as an engineer is more developed, it is more likely that they will stay in the technical sector which can on the long term be beneficial for the state since they will remain economically competitive (Thibaut et al., 2018). On a national level, various prerequisites could be described for technical studies based on the results of this study so that there is a higher chance that the PI of a student as an engineer is better developed.

Theoretical implications

This study contributes to literature because of several reasons. First, there is not much research conducted yet about PI development in the STEM field. There is already much research conducted about professional development in the medical and educational field. For example, the professional development among doctors (Kuo, Woo & Washington, 2018; Kay et al., 2019) and teachers (Siraj-Blatchford, 1993; Chu, 2019).

Second, there is limited knowledge on how students develop their PI and what faculty can do to foster the PI development (Nadelson et al., 2015). In line with this, Morelock (2017) stated that it is not clear how professional socialisation takes place in education. By using the

levels of engagement (van Hattum-Janssen & Endedijk, 2019) it became clear how professional socialisation is present in engineering curricula. Additionally, it was possible to categorize the experiences which are embedded in the curriculum, based on the engagement with professional socialisation. Further, by analysing the curriculum based on the curricula components (Thijs & van den Akker, 2009), a more complete view of the curriculum can be created than previous research which investigated professional socialising experiences individually, for example site visits (Carbone et al., 2020).

Last, because the current research investigated both the formal and perceived curriculum, a richer view of the curriculum is created than only analysing the formal curriculum. The perceived curriculum added value for several curricular components, for example for teaching and learning.

Limitations

Some limitations of the study need to be considered. First of all, there are three limitations about the population. First, during the interviews, only teachers within the curriculum committee are being invited. During the interviews, some teachers explained that participating in the curriculum committee was mandatory because of their position. This could have an influence on the results since other teachers, who do not participate in the curriculum committee, may also have a good view on the curriculum. Especially when they are teaching there for a long time. This could also cause a bias since teachers participating in the curriculum committee may know what is inside the formal curriculum and therefore give wished answers. A second limitation here is that there are only eight teachers who participated, so two from each study. This could cause a narrow view of the perceived curriculum of a participating study. Third, in the survey there was a low response rate, resulting in data which is not generalizable for the complete study. Two possible explanations for the low response rate are possible. First, the survey was distributed during the end of the school year. Teachers could be busy with other things related to the finishing of the school year. Another possible reason was the impact of the COVID-19 virus in the Netherlands, which caused teachers to switch to distance education. This costs them a lot of time resulting in them not having time for additional activities.

Further there are two limitations related to the document analysis. The number of documents among the participating studies was unequal. For the studies at the university, much less documents were analysed then for the studies offered at the university of applied science. Additionally, for the intersection programme at the UAS, data was missing. This could have an unintentional influence on the results as well because less documents may provide a narrower view on the curriculum. A possible reason for this could be biased selectivity, resulting in an incomplete collection of documents. Following this line, there were little or no documents

available for several impactful professional socialising experiences. For example, for internships and graduations in IEM at the UAS, no documents were available about the details of the internship.

Lastly, there are two limitations related to the generalizability of this study. First, only two institutions participated in this study. Therefore, this affects the generalizability of the results of this study. Last, this study is limited to the curriculum of the academic year of 2019-2020.

Further research

Based on this research, some suggestions for further research can be done. First, this research provides a first step into a rubric for mapping professional socialising experiences in curricula. Further research is needed in order to improve the rubric. A suggestion is to validate the rubric with students to investigate whether experiences are more impactful than others. Another suggestion is to investigate other technical studies. By doing so, the generalizability of the rubric will be improved. This could result in different rubrics for university and UAS. Last, the rubric could be more operationalized. For example, a distinction can be made in the aims and objectives, to investigate both the program aims and the aims per course. Another suggestion is to operationalize the teaching and learning activities on industry engagement and authentic learning (Carbone et al., 2020).

Another suggestion for further research is to investigate the perceived curriculum based on a student's perspective. By adding the student's perspective to the current analysis, a more rich and complete view of the presence of professional socialisation in the engineering curricula can be created.

Finally, further research could investigate the perceived curriculum by using another interview scheme. Currently, the questions in the interview scheme were focused on the curriculum as a whole, whereas in the formal curriculum analysis, a distinction was made per year. Further, the interview questions were not fully aligned with the descriptions in the rubric. In order to properly compare specific years of a curriculum, interview questions could be asked about the specific years. Based on this, a rubric could be designed for investigating the perceived curriculum.

Conclusion

Society is becoming increasingly dependent on technology. Though, many STEM graduates decide to leave the technical sector after their graduation. A factor contributing to this is an underdeveloped PI as an engineer. One way in which PI is shaped is by professional socialisation. The current study aimed to investigate the presence of professional socialisation

in the engineering curriculum. Therefore, both the formal and perceived curriculum of four degree programmes were investigated. The results of the formal curriculum revealed that all degree programmes have teaching and learning activities embedded which foster professional socialisation, such as guest lectures and site visits. Further, all studies have one or more internship(s) embedded, except for the technical study at the university. For content, all studies provide projects which are based on real-life examples. Furthermore, all studies use facilities and resources which are representative for the professional practice, but this is less the case for the intersection study at UAS. The rationale of both degree programmes at the UAS payed attention to the possible future work field. This study also investigated the perceived curriculum. It can be concluded that the perceived curriculum enriched this view by adding more activities related to teaching and learning for all degree programmes. For the degree programmes at the university, the perceived curriculum covers the role of the study association more properly. Concluding, professional socialisation in the engineering curriculum is during the first two years primarily focused on exposure and to some extent on knowledge acquisition about the profession. After the first two years, there is more of a focus on interaction, except for the technical programme at the university. However, there is little focus on reflection. Further, the rubric is a useful instrument for mapping the formal curriculum, the perceived curriculum adds value for teaching and learning to create a richer view. The rubric seems to be a first step in order to get insight in the presence of professional socialisation in the curriculum.

The current study is the first which designed an instrument to investigate the presence of professional socialisation. More research is needed in order to further develop and validate this tool. Although more research is needed, the current research takes a step in order to close the gap between the labour market and higher education by offering an opportunity to evaluate and redesign the curriculum so that more professional socialising experiences could be embedded.

Notes on contributors

The current study is part of a larger study called Bridge the Gap! The current research is being conducted in collaboration with another student researcher, E. A. Oprins, as part of our graduation projects. Together, we examined the formal curriculum of the participating studies; she did the first iteration of coding for the intersection degree programmes. We have also developed the rubric (see Table 2) together.

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Appendices

Appendix I: Interview scheme

Abstract concept	Dimensies	Indicatoren	Vragen
Aandacht besteden aan professionele socialiserende ervaringen	In het curriculum doen studenten kennis op over het werkveld, zowel formeel als informeel	Studenten leren welke mogelijke beroepen zij later kunnen uitoefenen De kennis die studenten opdoen is afgestemd op de kennis die nodig is in het werkveld Studenten krijgen inzicht in een bedrijfscultuur Studenten krijgen inzicht in de normen en waarden van de professie Studenten kunnen werkzaamheden, problemen en vraagstukken beschrijven welke in echte bedrijven uitgevoerd worden	**In hoeverre leren studenten welke beroepen zij later kunnen uitoefenen?** In hoeverre wordt de kennis in het curriculum afgestemd op de kennis die later nodig is in het werkveld? In hoeverre krijgen studenten inzicht in een bedrijfscultuur? In hoeverre raken studenten bekend met de normen en waarden die gelden in het werkveld? In hoeverre leren studenten wat voor soort opdrachten zij later in het werkveld gaan uitoefenen? Op welke momenten in het curriculum zijn deze ervaringen? Zitten er nog andere, vergelijkbare ervaringen in het curriculum welke we nog niet besproken hebben?
	In het curriculum worden studenten blootgesteld aan het werkveld	Studenten krijgen gastcolleges Studenten gaan op bedrijfsbezoek Studenten voeren een project uit waarbij een casus wordt gegeven door een bedrijf Studenten gaan naar symposia of conferenties waar zij in contact komen met bedrijven	**In hoeverre zitten er gastcolleges verwerkt in het curriculum?** Wat is de inhoud van zo'n gastcollege? **In hoeverre zitten er bedrijfsbezoeken verwerkt in het curriculum?** Bij wat voor soort bedrijven zijn dit? Wat is de inhoud van zo'n bedrijfsbezoek? **In hoeverre zijn de projecten die studenten doen gebaseerd op realistische situaties of casussen van bedrijven?**

			In hoeverre zitten er bezoeken aan symposia en conferenties opgenomen in het curriculum? Wat is het doel voor de studenten wanneer zij naar een symposia of conferentie gaan? Op welke momenten in het curriculum zijn deze ervaringen? Zitten er nog andere, vergelijkbare ervaringen in het curriculum welke we nog niet besproken hebben?
	In het curriculum interacteren studenten met het werkveld	Studenten voeren werkzaamheden uit bij een bedrijf Studenten voeren werkzaamheden uit op de werkplek Studenten doen een project voor een bedrijf waarbij het bedrijf tijdens het project betrokken blijft	**In hoeverre voeren studenten werkzaamheden uit in het werkveld?** **In hoeverre zijn er bedrijven betrokken bij de projecten die studenten doen?** Wat voor rollen hebben de bedrijven? Wat voor rollen hebben de studenten op deze momenten? En in hoeverre zijn deze vergeijkbaar met hun toekomstige rollen.
	In het curriculum reflecteren studenten op zichzelf als professional en de toekomstige rol die zij kunnen uitoefenen	Studenten reflecteren op het werkveld Studenten reflecteren op zichzelf als toekomstig professional	In hoeverre zitten er activiteiten in het curriculum waar studenten reflecteren op hun rol als toekomstig professional op het werkveld? In hoeverre zitten er activiteiten in het curriculum waar studenten reflecteren op hun ervaringen zoals zojuist besproken [stage, afstuderen] ? **In hoeverre zitten er activiteiten in het curriculum waarin studenten reflecteren op zichzelf als toekomstig professional**?
De onderdelen binnen het curriculum waarin aandacht kan worden	In het rationale wordt aandacht besteed aan de student als professional	In de missie/ visie van de studie staat dat er aandacht besteed wordt aan ervaringen waardoor studenten een beeld vormen van het werkveld	**In de missie/ visie staat [nader invullen], hoe komt dit terug in het curriculum?**

besteed aan professionele socialiserende ervaringen			
	In de (leer)doelen wordt aandacht besteed aan professionele socialiserende ervaringen	In de leerdoelen van de modules en vakken wordt beschreven dat de student enige kennis op doet van het werkveld	**In hoeverre wordt er in de leerdoelen aandacht besteed aan ervaringen zoals we die net besproken hebben?** In hoeverre wordt er in de leerdoelen aandacht besteed aan competenties en vaardigheden die studenten later nodig hebben in het werkveld? In hoeverre wordt er in de leerdoelen aandacht besteed aan het reflectievermogen van studenten? Wordt er nog op een andere manier aandacht besteed aan het werkveld in de leerdoelen?
	Er zijn in het curriculum leeractiviteiten opgenomen welke gezien kunnen worden als professionele socialiserende ervaringen	In het curriculum gaan studenten op bedrijfsbezoek In het curriculum staan gastcolleges gefaciliteerd In het curriculum staan projecten welke uitgevoerd worden in samenwerking met bedrijven In het curriculum wordt het werkveld betrokken bij leeractiviteiten	[al gevraag bij exposure]
	De docenten dragen bij aan professionele socialiserende ervaringen	Docenten komen uit het werkveld Docenten dienen als rolmodel voor de student	**In hoeverre komen docenten uit het werkveld?** Wat is uw relatie met het werkveld? **In hoeverre dienen docenten als rolmodel voor studenten?** Hoe ziet dit er in de praktijk uit?
	Professionals uit het werkveld hebben een bijdrage in het curriculum	Stagebegeleiders	**In hoeverre hebben professionals uit het werkveld een bijdrage aan de projecten van studenten?** **In hoeverre hebben stagebegeleiders een rol in het curriculum?**

			Zijn er nog andere manieren waarop professionals uit het werkveld een bijdrage leveren aan het curriculum?
	De inhoud van het curriculum is houdt rekening met kennis die later nodig is in het werkveld	Het curriculum wordt continu aangepast op basis van aanbevelingen uit het werkveld De inhoud van het curriculum is afgestemd op het werkveld	**In hoeverre is het curriculum afgestemd op de behoeften van het werkveld?** In hoeverre is dit een continu proces?
	Het werkveld heeft een rol bij toetsing	Professionals uit het werkveld worden gehoord bij beoordelingen van studenten De activiteiten in het werkveld worden getoetst	**In hoeverre hebben professionals uit het werkveld een rol bij de beoordeling van studenten?** Op welke momenten? In hoeverre worden studenten getoetst op hun handelen in het werkveld? Heeft het werkveld nog een andere inspraak bij toetsing dan zojuist besproken?
	Er worden faciliteiten en bronnen gebruikt, die ook in het werkveld gebruikt worden	De software / materialen/macines die in het curriculum gebruikt wordt, wordt ook in het werkveld gebruikt De boeken die in het curriculum gebruikt worden, wordt ook in het werkveld gebruikt De instrumenten die in het curriculum gebruikt worden, worden, worden ook in het werkveld gebruikt	**In hoeverre is de software die in het curriculum gebruikt wordt representatief voor het werkveld?** In hoeverre zijn de boeken die gebruikt worden representatief voor het werkveld? **In hoeverre zijn bepaalde instrumenten die gebruikt worden in het curriculum representatief voor het werkveld?** Zijn er nog andere manieren waarbij ondersteunende middelen afgestemd zijn op het werkveld?
	De groepering die gedurende de studie gebruikt wordt is representatief voor het werkveld	Er wordt in (multidisciplinaire) teams gewerkt De ouderejaars werken met de jongerejaars samen zodat de jongere studenten wat bijdraagt aan socialisatie. (Saxion) er worden groepen gemaakt waarin de instroom gemixt is (MBO en HAVO alumni) werken met elkaar samen	**In hoeverre wordt er in het curriculum in teams gewerkt?** **In hoeverrre wordt er in het curriculum in teams verdeeld met deelnemers uit verschillende jaarlagen?** **In hoeverre wordt er in het curriculum in multidisciplinaire teams gewerkt?**

		(UT) er worden groepen gemaakt waarin de instroom gemixt is (HBO en VWO) werken met elkaar samen De rollen die verdeeld worden in een groep zijn representatief aan die van het werkveld.	Hoe worden deze teams samengesteld? **In hoeverre zijn de rollen die verdeeld worden in een groep representatief voor het werkveld?** **SAX: In hoeverre wordt de interactie tussen mbo en havo alumni gestimuleerd?** **UT: In hoeverre wordt de interactie tussen hbo en vwo gestimuleerd?** Zijn er nog andere manieren waarop de groepering in het curriculum representatief is voor het werkveld?
	Locatie	De locatie waar studenten leren is representatief voor het werkveld? Studenten leren op locatie	In hoeverre leren studenten op locatie? In hoeverre is de locatie waar studenten leren representatief voor het werkveld?
	Tijd		

Universiteit Twente, Master Educational Science & Technology, Afstudeeronderzoek Bridge the Gap!: Curriculumanalyse

Interview: Professionele socialiserende ervaringen in het curriculum

Interviewer: Kim Jooss

Naam Geïnterviewde: NA

Datum afname: NA, Locatie: NA

Aanwijzingen

-

-

- Voorafgaand aan het interview moet het consent formulier ingevuld zijn en ondertekend.

Noteer Tijdstip begin:

Inleiding

- Interviewer vertelt inleiding voor het interview, zoals die op de vorige pagina beschreven staat –
- Kunt u iets meer vertellen over uw rol binnen Saxion/UT?
- Wat was uw beweegreden om in de curriculumcommissie deel te nemen?
- Welke vakken geeft u?
- Hoe lang geeft u hier al les?

Vragen

Levels of Engagement

Hoofdvraag knowledge acquisition:

- In hoeverre leren studenten welke soorten beroepen zij later kunnen uitvoeren, op basis van ervaringen binnen het curriculum, waarbij ze nog niet direct blootgesteld worden aan de praktijk?
- In hoeverre is de kennis in het curriculum afgestemd op de kennis die studenten later nodig hebben om hun werk goed uit te voeren, dus bijvoorbeeld bepaalde normen en waarden die gelden in het werkveld?

Bijvragen:

- In hoeverre krijgen studenten inzicht in een bedrijfscultuur
- In hoeverre leren studenten wat voor opdrachten zij later in het werkveld gaan uitoefenen
- Op welke momenten in het curriculum zitten deze ervaringen (1e semester / vaknaam o.i.d.)
- Zitten er nog andere, vergelijkbare ervaringen in het curriculum welke we nog niet besproken hebben, maar waar studenten ook kennis op doen over hun vakgebied?

Hoofdvragen exposure:

- In hoeverre zitten er gastcolleges ervaringen in het curriculum?
- In hoeverre zitten er bedrijfsbezoeken in het curriculum
- In hoeverre zijn de projecten die studenten doen gebaseerd op realistische situaties of casussen aangeleverd door bedrijven?
- In hoeverre zitten er bezoeken aan symposia en conferenties in het curriculum?

Bijvragen:

- Wat is de inhoud van zo'n gastcollege?
- Bij wat voor soort bedrijven?
- Wat is de inhoud van zo'n bedrijfsbezoek?
- Wat is het doel voor studenten wanneer zij naar een symposia of conferentie gaan?
- Zitten er andere, vergelijkbare, ervaringen in het curriculum? Zo ja: Welke?
- Op welke momenten in het curriculum vinden deze plaats?

Hoofdvraag interaction:

- In hoeverre voeren studenten werkzaamheden uit in het werkveld?
- In hoeverre worden bedrijven betrokken bij projecten die studenten uitvoeren?

Bijvragen:

- Zijn stages per definitie altijd bij een bedrijf?
- Wat voor rol heeft zo'n bedrijf tijdens een project?
- En wat voor rol heeft een student tijdens zo'n project?
- In hoeverre zijn deze rollen vergelijkbaar aan hun toekomstige rollen?

- Zitten er nog andere vergelijkwaardige ervaringen in het curriculum?

Hoofdvraag reflection:
- In hoeverre zitten er activiteiten in het curriculum waarin studenten reflecteren op zichzelf als (toekomstig) professional?

Bijvragen:
- In hoeverre zitten er activiteiten in het curriculum waar studenten reflecteren op hun rol als toekomstig professional het werkveld?
- In hoeverre zitten er activiteiten in het curriculum waar studenten reflecteren op ervaringen zoals zojuist besproken in het curriculum?
- Op basis waarvan doen zij dit?
- Wat voor soort opdrachten zijn dit?

Curriculum componenten

Hoofdvraag rationale:
- In de missie/visie van uw studie staat [NADER INVULLEN], hoe zit deze verwerkt in het curriculum?

Bijvragen:
- Kunt u hier nog andere voorbeelden van geven?

Hoofdvraag leerdoelen:
- In hoeverre wordt er in de leerdoelen aandacht besteed aan ervaringen zoals we die net besproken hebben?

Bijvragen:
- In hoeverre wordt er in de leerdoelen aandacht besteed aan competenties en vaardigheden (soft skills) die studenten later nodig hebben in het werkveld?
- In hoeverre wordt er in de leerdoelen aandacht besteed aan het reflectievermogen van studenten?
- Wordt er nog op een andere manier aandacht besteed aan het werkveld in de leerdoelen?

Hoofdvraag content:
- In hoeverre is het curriculum afgestemd op de behoeften van het werkveld?

Bijvragen:
- In hoeverre is dit een continu proces?
- Zijn er nog andere manieren waarop het werkveld input levert voor de inhoud van het curriculum?

Hoofdvraag toetsing:
- In hoeverre hebben professionals uit het werkveld een rol bij de beoordeling van studenten?

Bijvraag:
- Op welke momenten is dit het geval?
- In hoeverre worden studenten getoetst op hun handelen in het werkveld?
- Heeft het werkveld nog een andere inspraak bij toetsing dan zojuist besproken?

Hoofdvraag docenten:
- In hoeverre komen docenten uit het werkveld?
- In hoeverre dienen docenten als rolmodel voor studenten?

Bijvragen:

- Zijn hier vaste regels voor? Dat docenten X aantal jaar werkervaring moeten hebben?
- Wat is uw relatie met het werkveld?
- Hoe ziet het er in de praktijk uit, dat docenten als rolmodel dienen?

Hoofdvraag rol van de professional:
- In hoeverre hebben professionals uit het werkveld een bijdrage aan de projecten van studenten?
- In hoeverre hebben stagebegeleiders een rol in het curriculum?

Bijvraag:
- Zijn er nog andere manieren waarop professionals uit het werkveld een bijdrage leveren aan het curriculum?

Hoofdvraag faciliteiten en bronnen:
- In hoeverre is de software die in het curriculum gebruikt wordt representatief voor het werkveld?
- In hoeverre zijn bepaalde instrumenten (zoals machine's of materialen) die gebruikt worden in het curriculum representatief voor het werkveld?

Bijvragen:
- In hoeverre zijn de boeken die gebruikt worden representatief voor het werkveld?
- Zijn er nog andere manieren waarbij ondersteunende middelen afgestemd zijn op het werkveld?

Hoofdvraag groepering:
- In hoeverre wordt er in het curriculum in teams gewerkt?
- In hoeverre wordt er in het curriculum in multidisciplinaire teams gewerkt?
- In hoeverre wordt er in het curriculum in teams verdeeld met deelnemers uit verschillende jaarlagen
- In hoveverre zijn de rollen die verdeeld worden in een groep representatief voor het werkveld?
- SAX: In hoeverre wordt de interactie tussen mbo en havo alumni gestimuleerd?
- UT: In hoeverre wordt de interactie tussen hbo en vwo gestimuleerd?

Bijvragen:
- Hoe worden deze teams samengesteld?
- Zijn er nog andere manieren waarop de groepering in het curriculum representatief is voor het werkveld?

Hoofdvraag locatie:
- In hoeverre leren studenten op locatie?

Bijvraag:
- In hoeverre is de locatie waar studenten leren representatief voor het werkveld?

Appendix II: Survey questions

Work experience STEM Teachers

Start of Block: Block 2

Q1 You are being invited to participate in a research study titled Professional socialising experiences in STEM curricula. This study is being done by Kim Jooss from the Faculty of Behavioural, Management and Social Sciences at the University of Twente. The purpose of this research study is to provide insight in the extent to which the curriculum pays attention to experiences that introduce students to their possible future workplace. This survey investigates your role as a teacher and will take you approximately 5 minutes to complete. The data will be used to investigate whether teachers have experience in the field. Your participation in this study is entirely voluntary and you can withdraw at any time. You are free to omit any question. We believe there are no known risks associated with this research study; however, as with any online related activity the risk of a breach is always possible. To the best of our ability your answers in this study will remain confidential. We will minimize any risks by assigning numbers to participants and store the data online in a secured environment. Since this study is part of the Bridge the Gap project, the data will be saved for five years. Study contact details for further information: Kim Jooss (k.jooss@student.utwente.nl

- ○ I agree with the terms
- ○ I do not agree with the terms

Skip To: End of Survey If You are being invited to participate in a research study titled Professional socialising experi... = I do not agree with the terms

End of Block: Block 2

Start of Block: Default Question Block

Q1 At which institute do you work?

- ○ Saxion University of Applied Sciences
- ○ University of Twente

Q2 What study do you work for?

- ○ Industrial Engineering & Management / Technische bedrijfskunde
- ○ Mechanical Engineering / Werktuigbouwkunde

End of Block: Default Question Block

Start of Block: Block 1

Q3 Before you started teaching here, did you work in the professional field (teacher field excluded)?

- Yes
- No

Q4 In addition to your current teaching job, are you currently working in the professional field?

- Yes
- No

Display This Question:

If In addition to your current teaching job, are you currently working in the professional field? = No

Q5 When did you start and quit working in the professional field? Indicate in years, e.g. 1997-2010.

_____

Display This Question:

If In addition to your current teaching job, are you currently working in the professional field? = Yes

Q6 When did you start working in the professional field? Indicate in years, e.g. 2010.

_____

Q7 If there are any exceptional situations which cannot be answered through these questions, please describe these here. For example: earlier, you were combining your teaching job and your job in the professional field but nowadays you only fulfil your teaching job.

_____

Q8 What roles or functions have you fulfilled in the professional field?

_____

Q9 What kind of companies have you worked for?

_____

Q10 Is there anything you want to add to your responses?

_____

End of Block: Block 1

Appendix III: Rubric to measure the extent of professional socialisation in the formal curriculum.

	Insufficient	Poor	Sufficient	Good	Excellent
Rationale: The higher goal of the study. Answers the question 'why are they learning?'. This is often described in the mission and/or vision of the program. **Per curriculum**	The mission/vision pays little or no attention to the relationship with the possible field of work.	The possible field of work is mentioned but not or hardly described. (i.e.: Dealing well with software commonly used in the business world. In addition, a student must be able to communicate with various professionals in the field.)	The possible field of work is clearly described (i.e.: The working field of this study focuses on the manufacturing industry in the East of the Netherlands, which is characterized as technologically innovative (high-tech) and unitwise..)	The relationship between the possible field of work and the graduate student is described. For example, by concretely describing (using examples) what a graduate student does in the work field. (i.e.: Graduates have great added value because they are practice-oriented. This means, for example, that they go to the production floor and build relationships with, and between, a large diversity of employees within the entire organization.)	The possible field of work for which education is provided is described. In addition, the relationship between the possible work field and the graduated student is described, for example by concretely describing (using examples) what a graduate student does in the work field. (i.e. combination of sufficient and good.)
Aims & Objectives: Answers the question 'Towards which goals are they learning?'. These are often specified as learning goals or competencies which are described or summed up. **Per course / module**	In little or no learning objectives / competences a link is made between having certain knowledge or skills and being a professional. (i.e.: Acts like an engineer by applying a certain design strategy.)	In the learning objectives / competences it is included that students gain knowledge about the future profession / work field. (i.e.: On the basis of evidence of being able to show that he is aware of the specific mechanical competences.)	In the learning objectives / competences it is included that students get a realistic impression of the professional practice. (i.e.: The project assignments are designed to represent a realistic practical situation. Some of these assignments are comissioned by a company.)	The learning objectives / competencies states that students should be able to interact with professionals. (i.e.: Realizing an engineering design and being able to collaborate with engineers.)	In the learning objectives / competences it is included that students should be able to reflect on their experiences in professional practice. (i.e.: The student is able to reflect based on their own strong and weak points in the role of a mechanical engineering student as well as future professional and is able to translate the reflection into clear action points.)

Content: Answers the question 'what are they learning?'. These are often specified as the knowledge, skills and atitudes related to the profession. **Per course / module**	Adjustments to the subject are hardly or not at all coordinated with the work field. (i.e.: In the event of a change to the curriculum, this will not be submitted to the work field committee by default..)	The course contains knowledge about the work field. For example, something is said about different professions, norms and values and/or about the company culture. This also include cases. (i.e.: In order to let students make the right choices and to prepare them for the work field, we work on their personal development throughout the entire program. This is reflected in modules such as "Personal development" and "Orientation on study and profession" and during the last two years of study.)	Data from the work field is used as an example. For example, annual reports that are used for calculations. (i.e.: The context for the assignment will be provided by the annual reports of several companies, the Investopedia platform, and publicly available financial data sources.)	The work field provides a practical assignment. (i.e.: To touch upon the 'real' complexities in product development, students participate in a development project with a factual problem formulation. This means that -each study year- a new problem is formulated in co-operation with a company (or organisation).)	The work field co-creates content for the profession. For example, a company has developed a course in cooperation with the study that is included in the curriculum. (i.e. this course is developed in collaboration with Thales)
Teaching & learning: Answers the question 'How are they learning?'. These are often specified as the activities through which students learn. **Per course / module**	There are activities in the profession where students learn about the future profession, but students do not yet come into contact with the work field. (i.e.: students search for vacancies and write a cover letter, students work out a realistic case.)	There are activities in the course in which students are exposed to a simulated environment. (i.e.: Serious game, VR.)	There are activities in the profession in which students are exposed to the work field. Here the student is in the role of student. (i.e.: guest lectures, site visits.)	There are activities in the course in which students interact with the work field. Here the student is in the role of a professional. (i.e.: internship.)	Activities are included in which students reflect on an experience related to the work field. (i.e.: Writing a reflection report on an internship.)
Teacher role: The percentage of teachers that have recent (<= 5 years ago) working experience in the profession and **Per Year**	Less than 20% of the teachers have recent work experience in the field they are teaching in.	At least 20% but less than 40% of the teachers have recent work experience in the field they are training in.	At least 40% but less than 60% of the teachers have recent work experience in the field they are training in.	At least 40% but less than 60% of the teachers have recent work experience in the field they are teaching in.	More than 80% of the teachers have recent work experience in the field they are training in.
Teacher role: the percentage of teachers that is currently combining their teaching job with a job in the profession. **Per year**	Less than 20% of the teachers are working in the field they are teaching in , in addition to their job as a teacher.	At least 20% but less than 40% of the teachers are working in the field they are teaching in, in addition to their job as a teacher.	At least 40% but less than 60% of the teachers are working in the field they are teaching in, in addition to their job as a teacher.	At least 60% but less than 80% of the teachers are working in the field they are teaching in, in addition to their job as a teacher.	More than 80% of the teachers are working in the field they are teaching in , in addition to their job as a teacher.

Role of professional: How and to what extent is a professional (who is not an alumnus) from the field contributing to the curriculum? **Per Year**	Professionals make little or no contribution to the curriclum.	A professional contributes to the curriculum, but interacts hardly at all with students. (i.e.: a professional provides a guest lecture.)	Multiple professionals contribute to the curriculum, but interacts hardly at all with students (i.e.: at various times there are guest lectures from other companies.)	A professional contributes to the curriculum and interacts with students. (i.e.: A professional serves as client for a project and is involved during the project.)	Several professionals contribute to the curriculum and interact with students. (vb: In various projects we work with other professionals who act as clients who are involved during the project.)
Role of professional: How and to what extent is an alumnus from the field contributing to the curriculum?**Per Year**	Alumni make little or no contribution to the curriculum.	An alumnus contributes to the curriculum, but interacts hardly at all with students.(i.e.: an alumnus provides a guest lecture.)	Alumni contribute to the curriculum but interacts hardly at all with students (i.e.: at various times there are guest lectures from alumnus)	An alumnus contributes to the curriculum and interacts with students.(i.e.: An alumnus serves as client for a project and is involved during the project .)	alumni contribute to the curriculum and interact with students(vb: In various projects we work with other alumnus who act as clients who are involved during the project)
Assessment: Answers the question: 'How is their learning assessed?'. This refers to the specific types of assessment. **Per course / module**	Only knowledge tests are used in the course.	Assessment of knowledge or competencies in a standardized but realistic situation such as a case, simulation or practical test.	Assessment of a reflection in which students reflect on an experience and link this to their possible future career, such as a reflection on an internship.	Assessment on a product which could also be made in the work field like a professional product as a result of a project.	Assessment on an authentic professional activity such as an internship-practice assignment or graduation project.
Facilities and resources: Answers the question: 'With what are they learning?'. This often refers to the specific materials, devices and software which are used. A distinction is made between the setup and the novelty. **Per year**	Little or no use is made of supporting resources that are (partly) representative of the work field.	Students use outdated but representative resources in a test setup. (i.e.: Part of an outdated production line.)	Students use outdated yet representative tools in an arrangement that is representative of the work field. (i.e.: A complete but outdated production line)	Students make use of new, representative resources in a test setup. (i.e.: Part of a new production line or the use of SolidWorks with fictitious data.)	Students make use of new, representative resources in a setup that is representative of the work field. (vb: A complete and new production line or the use of SolidWorks with real data.)

Grouping: Answers the question 'With whom are they learning?'. This often refers to the type of group compositions. A distincion is made between the mono- and interdisciplinarity of a group and the extent to which students in a group have the same background. **Per course / module**	Students do not or hardly work in (monodisciplinary) groups. (vb: Students only participate in self-study activities)	Students with the same background work in a monodisciplinary group (i.e.: Technical business administration students with the same background work together on a project.)	Students with a different background work in a monodisciplinary group. A group contains, for example: - Students with a different prior education - Senior year students - Professionals in the field - International students (i.e.: First-year students work together with second-year students.)	Students from the same profession with the same background work together with other students in an interdisciplinary group. (i.e.: Mechanical engineering students with the same background work together with industrial product design students.)	Students from the same profession with a different background work together with other students in an interdisciplinary group. (i.e.: First year mechanical engineering student works together with a second year mechanical engineering student and an industrial product design student.)
Location: Answers the question 'Where are they learning?'. A distinction is made between the variety of different locations and the time spent on location. **Per year**	Students are not or hardly active in the work field during the year. (i.e.: Throughout the year, there are only courses within the college or university.)	Students visit one company.	Students visit several companies from the same specialist field.	Students visit several companies from two different specialist directions.	Students visit several companies from three or more different specialist directions.
Time: Refers to the amount of time which is reserved for activities in connection with the profession. A distinction is made between stand-alond and long-term experiences. Separate experience: The experience has a total reserved duration of one day or less. Long-term experience: The experience consists of a continuous period of at least six working days. **Per year**	There is little or no time set aside for activities that have a connection with the field of work.(i.e.: There is only time reserved for theoretical courses.)	Time is reserved for several separate experiences.(i.e. there is time reserved for several guest lectures)	Time is reserved for one long-term experience.(i.e.: Time is reserved for a semester internship or for a module project commissioned by a company.)	Time is reserved for one or more separate experiences and one long-term experience.(i.e.: Time is reserved for a semester internship and for a number of guest lectures.)	Time is reserved for several long term experiences (possibly in combination with several separate experiences).(i.e.: Time has been reserved for an internship and a module project commissioned by a company. Possibly with a number of guest lectures.)

Appendix IV: Results Formal curricula

Technical programme university

There are two curricular components where no distinction can be made among different years. These are the rationale and the teacher role. In the rationale, they mention that the programme covers the broad field of engineering, no further connections with the professional field are made. For the teachers, almost 38% of the teachers has recent (< 5 less years ago) relevant working experience, and 23% of them is combining their teaching job with a job in the field.

General

In the programme document, several professional socialising experiences are described. Related to the aims and objectives, several goals describe that students gain knowledge about the field and that students are able to apply 'engineering tools' when these are relevant to the engineering practice. Further, it is described that students should be able to communicate with other professionals. This is especially covered in the first- and second year projects and in the graduation. Related to content, the project assignments are designed to represent a realistic situation, sometimes a company is involved and serves as a client. Related to teaching and learning, it is described that the programme uses field work, excursions and internships. At a general level, nothing is described about the role of the professional. Related to assessment, it is stated that a test could be a written test, assignment, oral test, or the assessment of practical exercises. Related to facilities and resources, it is written that students should be able to use engineering tools. These are not further specified. Related to grouping, it is specified that students should be able to work in a multidisciplinary and international team. There is nothing specified related to location and time.

Year 1

In the aims and objectives of the first year, it is mentioned that students are familiarized with the language of ME. Further, students should be able to reflect on their work and themselves as future professional and they should be able to present a poster to a technical public. Related to content, students learn something about the context in terms of the language of ME and using engineering design principles. Further, the content of a project is adapted to the latest issues in the field. For teaching and learning, students have an excursion to a manufacturing facility, meaning that they are exposed to the working field. Furthermore, students have to present the outcomes of their project to a technically educated public multiple times. However, it is not it is not specified who participates in this public. During a project, students will take the role of a project group to redesign an energy system. Last, students have to complete an individual assignment where they have to reflect on their work and on themselves as future professional. For the role of the professional, an employer attends the presentations of students. Further, students have to write a technical report for a technically educated client multiple times. For assessment, written exams are primarily used. Sometimes, practical assignments or have to presentations are used as assessment methods. For projects, assessment is organized by a report and an oral exam. Related to facilities and resources,

the use of Solidworks which is technical drawing software is mentioned as well as Matlab. In grouping, students work in teams, but there is nothing mentioned about the formation of these groups. For location, one described activity takes place in the field; the excursion to a manufacturing facility. The total reserved time on experiences in relation with the working field are the presentation session, excursion and writing a report.

Year 2

In the aims and objectives of the second year, it is described that students obtain a realistic representation of the field. An example of an aim related to this is that students need to re-formulate a problem specification by a client, thus formulate the real assignment. For content, companies provide assignments. This is done in module six where each year, a new problem is defined by a company or organisation, related to consuming products. Further, students gain knowledge about the three different possible profiles for a mechanical engineer. Related to teaching and learning, during the project in module six, the company is involved during the project when this is possible. Further, students have to write an essay about the three different possible profiles and describes which fits them best. For the role of the professional it is described that professionals introduce the problem and could be involved during the project in module six. For assessment, several types are used. Besides written exams and oral exams, peer reviews regarding the participation in a project are used. Last, there are also practical assignments and a demonstration. Students also have to write a reflection which is assessed. Regarding the facilities and resources, several Matlab scripts and a CAD programs are used. For grouping, students work in teams in several projects, during one of these projects the group is interdisciplinary. Related to location, students are not active in the field. Related to time, students are involved in a project with a company for one module.

Year 3

This last year consists of two parts, a minor and graduation. Before the graduation module, there is a preparation module. Related to aims and objectives, it is described that students should be able to analyse a problem with some complexity in the field of ME and that they should obtain an overview over constituting parts and disciplines. In content, a project is placed in a realistic situation and during their graduation, students solve an existing research problem. Last, students participate in a project which is based on a realistic situation. In teaching and learning, students execute a project in a realistic situation and they execute their graduation. It is not specified what roles professionals have. Related to assessment, written assignments, exams and FEM assignments are used. During their graduation, they get assessed on their presentation and defence, on the assignment itself and a paper. Related to facilities and resources, students use a Finite Elements program. Related to grouping, students conduct their literature research together. Related to location, students do not spent time at an external location. Related to time, no time is reserved for activities involving the profession.

Technical programme University of applied sciences

There are two curricular components where no distinction can be made among the different years. These are the rationale and the teacher role. In the rationale, they describe the possible working field and make connections between the graduated mechanical engineer and the working field. They describe that they educate students to serve both national and international companies. Graduates are able to translate customer wishes to technical feasible solutions. For the teachers, only the teacher team as a whole is investigated. Therefore, no distinction can be made in the results although there could be a distinction in the different years. Approximately 38% has recent (< 5 less years ago) relevant working field and approximately 13% is combining their teaching job with a job in the field.

General

In the aims and objectives in the programme document, it is described that students need to be able to work together with engineers, in both an international and a multidisciplinary environment. Students also need to develop themselves as a reflective practitioner. Further, it is stated that students should be able to deal with software which is used in the field. Last, one of the end competencies is professionalisation, which refers to staying up to date with the skills related to engineering competencies. Concrete, this refer to, for example, having an international orientation. Related to content, it is stated that assignments are used which are representative for the professional field. This is also the case in projects. Related to teaching and learning, it is described that from the second year on, projects are more placed in the authentical context and that students are able to participate in the international project week and the smart solutions semester where they learn to work in an interdisciplinary and international environment. In the smart solutions semester, students work on an assignment which is relevant for society. Related to the role of the professional, it is described that several professionals participate in the field committee. The field committee aims to ensure that the curriculum fits and is attuned to the professional practice. have a role when the curriculum changes. Related to assessment, four forms of assessment are primarily used. Namely; written exams, presentations, professional products and the dossier of career conversations. Related to facilities and resources, it is mentioned that students should be able to work with software and tools from the profession and that the facilities and tools in the programme characterize the professional field. Related to grouping, they mention that students participate in an interdisciplinary project as well as an international project. Related to location, graduation and internship take place at a company. Related to time, no concrete statements were made. However, during the internship and graduation, students work in a company which is one year in total.

Year 1

In the aims and objectives of the first year, there is a goal stated that students have to act as a junior engineer. Further there is a focus on gaining knowledge about the profession. An example

is that students need to prove that they are aware of several ME competencies. There is also one learning goal described towards reflection. Here, they describe that for students, it is important to reflect on their own actions and those of others. Related to content, students take the courses orientation on study and profession and personal development. This aims to prepare students for their possible future working field. Related to teaching and learning, there are several experiences this year: one visit to a career fair, three company visits, five guest lectures, a personal profile test with a reflection and lastly, students need to reflect on their own actions and those of others. Professionals have a role during the company visits and guest lectures. Related to assessment, several forms are used. Besides written exams, practical assignments are used, for example in Matlab. For a project, the final product is assessed. For the career conversations, assessment is based on several exhibits. Related to facilities and resources, several software packages are used, such as Matlab, MapleTa and a CNC programme as well as various machines in the workshop. Related to grouping, groupwork takes place in four courses. One of these courses includes the international project week, where students from different backgrounds, studies, and even from secondary education, work together. Related to location, the visit to the career fair and company visits are on an external location. It is not specified whether these company visits are to different companies. Related to time, there is time reserved for the career fair, company visits and the guest lectures.

Year 2

In the aims and objectives of this year, it is described that a connection will be made between theory and practice and that they learn a design method which is widely used in ME. Students need to work together as engineers and students obtain experience in engineering work. Related to content, students do a project this year for a client. In another project, a real-life situation is simulated. Related to teaching and learning, students have several experiences where they get exposed to the working field, including three mandatory company visits to different companies from which one is optional (arranged by the study association) and a visit to the business days. Related to the role of the professional, professionals have a role in the various company visits and during the business days. Related to assessment, written exams and reports are used as well as practical assignments, project assignments, presentations and group assignments. The end results of a project are also assessed. Related to the facilities and resources, Matlab Simulink, Ms-Basic are used as well as SolidWorks to create several CAD designs. Related to grouping, working in groups is mentioned in every module. For only one course, it is specified that the group is formed with students in the same class. For other courses, it is not described how these groups are formed. Related to time, time is reserved for the project, two company visits and the business days. Related to location, students visit two companies. They also visit the business days which are on an external location.

Year 3

This year consists of two parts, first the smart solution semester and an internship. In the formal curriculum documents, the internship is described. The smart solution semester is mentioned during the preparation in the second year. There are no aims and objectives described which have a relation to the working field. Related to content, it is described that the internship takes place in a company and thus provides content for this. Further, companies provide assignment for the smart solutions semester. Related to teaching and learning, there is an internship this year and the smart solution semester. During the smart solution semester, companies are involved during the project. Professionals play a role here in that they contribute to the curriculum and interact with students. Further, in the smart solutions semester, students are executing an assignment for a company. Related to assessment, it is not specified how assessment takes place. This is also the case for facilities and resources. Related to grouping, the smart solution is executed in interdisciplinary groups. Related to time, a semester is reserved for the smart solution semester and a semester is reserved for the internship. Related to location, the internship takes place in a company.

Year 4

This year consist of two parts, a minor and the graduation. In the aims and objectives, it is described that students need to be able to properly function in the practice, both professional and in the profession. Related to content, the graduation assignment is created in cooperation with a company. Related to teaching and learning, the student actually executes the assignment and gets a view of the culture of the company. In the end, the student has to write a learning report in order to reflect on their own knowledge and skills. Related to the role of the professional, professionals are present during the internship. Further, the internal supervisor has a role, who needs to have at least five years working experience. Related to assessment, various aspects are assessed during the graduation. For example, on their professional functioning, the product, their report, their presentation including the defence and their learning report. Related to facilities and resources, there are no statements made. Related to grouping, students do their graduation individually. Related to location, student execute their assignment at the company and related to time, the assignment takes a semester.

Intersection programme University

There are two curricular components where no distinction can be made among the different years. These are the rationale and the teacher role. In the rationale, no connection with the working field is made. For the teachers, 12.5% is combining their teaching job with a job in the professional field. Further, nobody has recent (<5 years ago) relevant working experience.

General

Related to the aims and objectives, several end-qualifications relate to the professional practice. For example, students need to be able to communicate both oral and written with stakeholder. Further, two end-qualifications state that students are able reflect on their professional development and behavior. Related to content, it is described that practical exercises and relations with the working field play an important role, especially during projects. Further, the end qualifications are partially designed by professionals from the field. Related to teaching and learning, it is described that during all four multidisciplinary modules in the second year, students have to solve a real-life case. Related to the role of the professional, professionals have a role in formulating the end-qualifications. Last, the graduation takes place in a company or institution. Related to assessment, it is described that various assessment forms are used in the programme. They mention individual and group assignments, individual written tests, group papers and presentations. Related to facilities and resources, nothing is described. Related to grouping, it is described that students work in multidisciplinary teams in various modules. Related to time, it can be stated that students do their graduation in a company, for a period of 10 weeks. Related to location, the graduation takes place in a company.

Year 1

In the aims and objectives of the first year, several goals state that students acquire knowledge about a particular topic in a business context. Further, students should be able to interview an alumnus in order to obtain a clear view of the working field. Related to the content, there are several assignments where the working field provides input. The first module is about the batavierenrace. The data from the batavierenrace is also used here. In the second module, students do an assignment about operations at new balance and another project for a company. In the third module, data from companies is used in assignments. Regarding to teaching and learning, several experiences take place in this year. Students do an assignment about the batavierenrace. Here, they get an idea about the breadth of the field of IEM. Students also have to build a simulation of the batavierenrace. In the assignment with a company, managers introduce themselves, there is a factory tour, a question hour and students have to present their recommendations to the company. Furthermore, student have to conduct an interview with an alumnus and then reflect on this interview. They have to write a report about what they learned about their future career, based on the interview. There is also a guest lecture from an alumni included. Lastly, students participate in a serious game in which a real-life situation is simulated. Related to the role of the professional, managers have a role when they have to introduce themselves and when alumni serve as interviewees. Related to assessment, various forms are used in this first year. Besides written reports and assignments, students also get assessed on their delivered products and several professional skills assessments, for example a reflection assignment. Related to facilities and resources, students participate in a web-based management learning environment. Further, students use a BI tool, Monte Carlo

simulation, mySQL and an application development platform. Related to grouping, students work in groups every module. Two modules are shared with the BIT programme. In the last module. Students also take a representative role, for example VP sales. Related to location, students only visit one company where they have a factory tour and a question hour. Related to time, in the first module there is time reserved for the batavierenrace project, in the second module, time is reserved for the project for a company, in the third module, time is reserved for activities where data serves as input for an assignment. In the last module, time is reserved for the serious game.

Year 2

In the second year, there are several aims which have a relationship with the professional practice. For example, student have to interpret annual reports of companies and students should be familiar with successful examples of online businesses. Students should also be able to re-formulate a problem, provided by a specific client. Further, there is also a goal described related to communication with professionals; students should be able to inform and convince others. Last, students should be able to reflect on their own discipline. Related to content, students have to use annual reports of companies for assignments and a company provides an assignment for a project. Further, two cases provide context for a project. Related to teaching and learning, there are several activities where students get exposed to the professional practice. Students participate in an investment game. Further, during the project for a real client, there are guest lectures, a meeting in between with the client and at the end a project fair. There are more guest lectures during other modules. There is also an project where students set up an online business. Last, there is an opportunity to attend a symposia. Related to the role of the professional, professionals have a role in the project during the introduction, guest lectures, meetings and feedback. In another module there are also guest lectures where professionals have a role. Related to assessment, there are several forms used. Besides written tests and oral exams, students get assessed on several products and documents of the project in module 6. This project ends with a project exam and a project fair. Further, peer reviews, a demonstration and reflection assignments are used. Related to facilities and resources, students use several software tools, for example CAD and annual reports of companies. Related to grouping, students work in three modules in multidisciplinary teams. In the fourth project, students work in monodisciplinary teams. Related to location, students do not visit a company. Related to time, in module five, students use annual reports. In module six, students do an assignment for a real client and have several guest lectures. Last, in module seven, there are also several guest lectures.

Year 3

The last year consists of two parts, the minor and graduation. Related to aims and objectives, there are several goals described related to the professional practice. For the graduation, students do an assignment for an external company. During the preparation of their internship, students have

to present a poster where they address both interest of the client and the university. Students have to write a reflection about their professional construct, based on their experiences. Lastly, students should be able to cooperate and function properly in practice. Related to content, students do an assignment for a company. Related to teaching and learning, when students prepare for their assignment, they have to write a project plan. Here, students have to involve different stakeholders. They also need to visit the company when writing this plan. In the end, they make a poster of this plan. Students are also executing their bachelor project and writing a reflection on their critical construct. Related to the role of the professional, students have an external supervisor for daily guidance. He serves for example as a sparring partner and process supervisor. Related to assessment, students get assessed on various written reports (project plan and thesis), an essay assignment, their personal development plan and an academic poster. During graduation, students also get assessed on their oral presentation including a defence and their performance in professional practice. Relating to facilities and resources, there is nothing described. Related to grouping, students act individually, but cooperate with buddies. Related to location, students usually execute their graduation inside a company. This means that one module is completely reserved for activities connecting to the professional practice, which relates to the time component.

Intersection programme university of applied sciences

There are two curricular components where no distinction can be made among the different years. These are the rationale and the teacher role. In the rationale, the future working field is described properly as well as the relation between this field and the student. It is described that graduates have an added value because they are practical orientated. This means that they build relationships with colleagues in the whole organization. For the teachers, 66.6% has recent relevant working experience. Based on a sample of three teachers, two of them had recent relevant working experience, one teacher is currently combining his teaching job with a job in the professional field.

General

At a general level, much is described about the curriculum. Related to aims and objectives, it is described that students should act as an engineer by using a specific research method, further students get insight in the international working environment. Related to content, there is a structural collaboration with the professional practice, for example through the field committee. It is described that expertise from the field is used to improve both the content and organisation of the curriculum. Furthermore, the first year is focused on orientation on the future profession. Further, several projects are based on real-life situations. Related to teaching and learning, various activities are mentioned. There are guest lectures, practical assignments, company visits and serious games. Students also receive feedback from professionals about their professional behaviour. There are also several more longitudinal experiences mentioned, for example the smart solution semester and

the international project week, both with assignments from real companies. There is also an internship and a graduation, which is also done in a company. Students also have to reflect on the internship and graduation.
Related to the role of the professional, professionals add value by offering guest lectures, serve as clients for projects and participating in the field committee. Related to assessment, many forms are used in this study. Besides the normal written tests, they use tests where students have to solve a case, essays, reflection assignment, project assignments, performance assessments, portfolio assessment and presentation. Related to facilities and resources, there is described that students participate in a management game in the second year. Related to grouping, it is described that almost every project is a group project. Groups are more often multidisciplinary. Related to location, it is described that there are several excursions in the curriculum and internships and graduation also take place in a company. Related to time, the two internships as well as the graduation can be specified in time, in total three semesters.

Year 1

Related to aims and objectives, it is described that students should have knowledge about the origins and developments in industrial production. Students should also be able to learn from their experiences and reflect on their own behaviour. Related to content, students gain knowledge about different facets of a company. In another course, they get to know a company. Here, they are defining the internal and external environment of that company. In two other courses, cases are used to provide context. Last, in a course, information of real companies is used to execute an assignment. Related to teaching and learning, there are two guest lectures and two excursions, from which one excursion is optional. Students participate in a project which is based on a real-life example and they visit a second-year student during his internship. Professionals have a role during the guest lectures. Related to assessment, many written tests are used. Further, several assignments and reports as well as oral presentations are used to assess students. During some courses, the assignments are based on cases. Related to facilities and resources, Excel, Access, MS project and Power BI are used this year. Related to grouping, students work in groups in several courses. The composition varies from two to six students. Related to location, students visit two, maybe three different companies this year. Related to time, there are several short experiences, for the guest lectures, excursions and interview.

Year 2

This year consists of a semester at school and one semester internship. There are no documents analysed related to the internship. Related to aims and objectives, it is described that students should take into account the interests, working methods and results of colleagues. Related to content, a project is based on current developments in practice. Further, there are three courses in which cases are used and one course is related to a practical context. Related to teaching and

learning, students have to conduct an interview with a professional. Further, there is one guest lecture embedded and a role play. Professionals have a role when they serve as interviewee. Related to assessment, several courses use written tests. Other courses use assessments, sometimes based on cases. For the project, the results are assessed. Related to facilities and resources, several books are mentioned. Related to grouping, students work in groups multiple times. During a project, students have the opportunity to choose for an international version. Related to location, there are no activities described which take place at an external location, except for the internship. Related to time, there is time reserved for connection to the professional practice during the (international) project, and during the internship.

Year 3

This year consists of a semester at school and one semester minor. Related to aims and objectives, it is described that students should take into account the interests, working methods and results of colleagues and that they are able to learn from their experiences and reflect on their behaviour. Related to content, companies provide case assignments for a project related to industry 4.0, students need to solve an innovation case and another course is completely based on cases. Related to teaching and learning, students participate in the project related to industry 4.0. Connected to this project are a company visit, guest lecture, and pitches at the company in the end. In another course, there are three more guest lectures embedded. Further, students participate in a serious game where they have to run a soda factory, conduct an interview with a manager. Related to the role of the professional, professionals can participate in the serious game, by participating in the director board. Professionals also contribute by serving as an interviewee or as a guest lecturer. Related to assessment, this year there are several forms used. Besides written tests, students have to participate in a mini-colloquium, give a workshop, solve several cases and write reflection reports. Related to facilities and resources, several cases are used, and a management game is included. Related to grouping, students work multiple times in groups. During the management game, students also have to divide several roles. Related to location, students visit only one company this year. Related to time, only during the project, time is reserved for activities related to the professional field.

Year 4

This last year consists of an internship and graduation. There were no documents available for this year.

Appendix V: Method and data teacher role

Research design

To investigate the teacher component in the curriculum (Thijs & van den Akker, 2009) more properly, the working experience of teachers is investigated. Working experience here is defined as working experience in the profession in which they are teaching. To do so, a survey is used. By using a survey, a much more representative view can be created instead of only using interviews and asking those respondents about the working experience of their colleagues.

Participants

Teachers of all four participating degree programmes were invited to fill in the survey. Three cases were excluded because of missing data. From the complete 45 cases, three were from the intersection programme at the UAS, eight were from technical programme at the UAS, eight were from intersection programme at the university and 26 were from the technical programme at the university.

Instrumentation

A survey was made to investigate the working experience of teachers. The survey contained questions such as: “Before you started teaching here, did you work in the professional field (teacher field excluded)?” and “What roles or functions have you fulfilled in the professional field”. In total, the survey contained 10 questions. The complete survey can be found in Appendix II. The survey was created and distributed via Qualtrics software (Qualtrics, Provo, UT).

Procedure

At the same moment of conducting the interviews, surveys were distributed among the teachers of the participating degree programmes. An invitation to participate in the study was first sent to the participating teachers. In some cases, they were not able to distribute the survey. In that case the invitation was sent to their supervisors.

Data analysis

For the survey, the aim was to investigate what experiences teachers have in the professional field. The data here is analysed both quantitative and qualitative. For the quantitative part, it is investigated how many years teachers had working experience. This data was used to fill in the ‘teacher role’ in the rubric. For the qualitative part, it is investigated which roles teachers fulfilled and in what type of companies.

Technical degree programme University

26 teachers of this degree programme participated in the survey. six of them were combining the teaching job with a job in the profession he was teaching and 12 others had working experience, of which four had recent working experience. So 23.1% of the teacher is combining their job with a job in the field and 15.4% has recent working experience in the field in which they are teaching. Those teachers fulfilled roles as engineer and researcher at various companies, such as engineering companies and software companies.

Technical degree programme university of applied sciences

Eight teachers of this degree programme participated in the survey. One of those was combining the teaching job with a job in the profession he was teaching and five others had working experience, of which three had recent working experience. So 12.5% of the teacher is combining their job with a job in the field and 38% has recent working experience in the field in which they are teaching. Those teachers fulfilled roles as managers and engineers in manufacturing and production companies.

Intersection degree programme university

Eight teachers of this degree programme participated in the survey. One of those was combining the teaching job with a job in the profession he was teaching and one other had working experience, but this was not recent. So 12.5% of the teacher is combining their job with a job in the field and 0% has recent working experience in the field in which they are teaching. Those teachers fulfilled roles as researchers in hospitals and designed devices and prototypes.

Intersection degree programme university of applied sciences

Three teachers of this degree programme participated in this study. One of those was combining the teaching job with a job in the profession he was teaching and the other two had working experience, of which one was recent. So 33% of the teacher is combining their job with a job in the field and 33% has recent working experience in the field in which they are teaching. Those teachers fulfilled engineering roles and management roles in different companies in the making industry.