The Development of Engineering Students Professional Identity During Workplace Learning in Industry: A study in Dutch Bachelor Education

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Abstract

Workplace learning in industry is perceived to have a powerful influence on the development of students engineering identity. But, teachers also observed vast developmental differences between students during workplace learning. To find explanations for these differences, we studied students identity development during workplace learning using a self-guiding and mentoring model. Research questions are: (1) To what extent do bachelor engineering students develop their engineering identity during workplace learning? (2) What are students developmental models? (3) Can different effects of these models on student identity development be found?

Participants were 256 third-year bachelor student engineers. The data were collected with two written questionnaires, one before and one after workplace learning.

Results showed, first, a significant incline and decline on the two aspects of identity development, clarity and identification. Second, combined achievement on the two aspects showed a sort out into four different development groups.

Students entering workplace learning with a low identity score proved to catch up, while those entering with a high score slowed down and developed less, indicating a non-successful preparation for workplace learning.

We recommend that students professional identity development should be acknowledged and explicated in the course design so it gets greater and explicate attention during the preparation, during workplace learning, and in the final year. For this purpose a system of career conversations could be used.

Keywords: professional identity development, workplace learning, undergraduate education
Introduction

Engineering graduates of Dutch universities of applied sciences are expected to be able to directly enter the engineering profession. Therefore, orientation on and preparation for professional practice resulting in professional identity development is an important aim for all engineering courses. This preparation for professional engineering practice consists of all course activities aiming at: (1) the profession or the occupation as a social role and (2) the professional practice or the occupational environment (Mertens 1980, Bronneman-Helmers 2006). Although a variety of course activities exist, workplace learning in industry has been perceived as an important course element since the beginning of the 20th century. Virtually all engineering courses comprise a period of workplace learning for one or two semesters during the third course year. Students and teachers perceive this workplace learning as valuable as it connects theory with professional practice and contributes to students professional identity development. But, the Dutch Inspectorate of Education criticised the diversity of student learning outcomes of workplace learning and highlighted the missing link with the course design (Inspectie van het Onderwijs 1996, Bronneman-Helmers 2006).

Our previous research among teaching staff (Dehing et al. 2013) revealed that student engineering identity development in general showed a quantum leap during workplace learning in industry, but also revealed that vast developmental differences between individual students occur. Teaching staff observed that most students transformed from engineering students to student engineers. In the teachers' observations we could also recognise two theoretical developmental models for student identity development. The first is the mentoring or alignment model defined by Sullivan (2004) and Sheppard et al. (2008). The second is the self-guiding, provisional selves model described by Ibarra (1999). The key differences between the two models are the guidance students receive during the process of identity development and the accompanying roles of students and their supervisors. In addition, teachers observed that students developed more if they were perceived as student engineers and received engineering tasks that they were responsible for. This observation indicates two important workplace conditions affecting student identity development: (1) the supervisors' perception of the student as an engineer and (2) the responsibility awarded to the student.

We mentioned previously that teachers observed large developmental differences between students during workplace learning. As we are interested in understanding the cause of these differences, in this study we explore identity development during workplace learning from the students perspective. Our overall research questions are:

1. To what extent do bachelor engineering students develop their engineering identity during workplace learning in industry?
2. How do students develop their identity? What are the developmental models?
3. What are the influences of different workplace conditions?
4. How do the variables of our research design influence identity development?

Theoretical framework

Theories on professional identity

Professional identity is widely discussed in the literature. Although the theories are diverse, there are some overarching theories about professional identity and its development. First, professional identity is a part of the complex multifaceted process of personal identity.
development. In this process students simultaneously develop several identities such as, for example, religious believer, partner, citizen and engineer (Wenger 1998, Gee 2001, Beam & Pierrakos 2009). Second, professional identity is an ongoing construction process of becoming a professional (Beijaard et al. 2004, Tonso 2006b) and at the same time a state of being a professional (Bilodeau 2004, Sullivan 2004, Stevens et al. 2008). In other words, professional identity development is a continuous process of becoming a professional via stages as junior professional, professional and senior professional.

Third, authors agree that the concept of professional identity has both a social and an individual dimension. The social dimension comprises the requirements associated with the engineering profession such as education, behaviour skills, knowledge and attitudes. This social dimension is usually defined by professional engineering organisations. The individual dimension is the commitment of a person with the profession: the feeling of being an engineer (Ibarra 1999, Sullivan 2004, Tonso 2006a, Sheppard et al. 2008, Stevens et al. 2008, Beam & Pierrakos 2009). The intensity of this identification can range from strict functional and normative identification to emotional identification as the sense of belonging to a certain group (Giddens 1991, Wenger 1998, Gee 2001). In this study, we focus on the individual dimension of student identification with the profession because the social dimension has been studied well as the object of course accreditation by the Dutch–Flemish Accreditation Organisation (NVAO 2010).

Finally, the development of professional identity is explained using a variety of models, which are briefly described in the next sections. In these models, student characteristics and workplace conditions influence the development process.

**Theories of professional identity development**

In the previous section we concluded that professional identity can be perceived as a process of becoming a professional, but also as a state of being a professional at a certain level. In this section we focus on the process of becoming an engineer; a construction process whereby the would-be engineers try to position themselves in relation to the engineering profession (Stevens et al. 2008). Most authors agree on the importance of reflection in this process of identity development. As students constantly reflect on new experiences, earlier commitments can be re-examined in the perspective of new information (Marcia 1966, Ibarra 1999, Tonso 2006b). Marcia distinguished two aspects of identity development: (1) exploration of (elements of) existing identities and (2) rejection of, or commitment with, these identities based on their reflection on new experiences and an evaluation of the results of this exploration. So, students can develop simultaneously on both aspects and therefore identity development is not always a continuous increasing process of commitment with the profession. Exploration can challenge previously made commitments which can be re-examined and possibly rejected. An example of this is that students can re-examine their initial choice for engineering as a result of conflicting educational experiences during the first-year programme.

Two main groups of theories on identity development can be found in literature on socialising. The first group of theories perceives professional identity development as a construction process, part of the social embedding during a mentoring process or cognitive apprenticeship (Schön 1983, Collins et al. 1989, Gee 2001, Sullivan 2004, Sheppard et al. 2008). The other group of theories perceives students as active self-guiding participants in the process of identity construction (Wenger 1998, Ibarra 1999, Gee 2001). The main discriminating variable between the two groups of theories is the way guidance is organised during the identity construction process. In the first group, guidance is provided by a mentor or supervisor, while students are perceived to guide themselves in the second group of theories. We will describe two examples to illustrate both groups: (1) the
mentoring model of Sheppard et al. (2008) and Sullivan (2004, 2008) being an example of the first group of theories, defined for undergraduate engineering education in the United States, and (2) the self-guiding, experimenting ‘provisional selves’ model of Ibarra (1999), which was grounded on two qualitative studies of career switches to more senior roles of junior consultants and bankers.

The mentoring model

The mentoring model described by Sheppard et al. (2008) and Sullivan (2004, 2008) is based on research on professional development in law and medical schools (Sheppard et al. 2008) and is currently used to restructure professional engineering education in the US. The core of this new educational approach is the so-called networked course in which the acquisition of knowledge, skills and professionalism are taught in an interwoven manner. Identity development, or the development of professionalism, is located in the professional apprenticeship, an application of the cognitive apprenticeship model described by Collins et al. (1989). This process is highly structured and guided. Collins et al. perceive the cognitive apprenticeship as an instructional model for higher education derived (but different) from the traditional craft apprenticeship. The main objective of instruction is to make implicit or tacit knowledge visible. To do so, teachers (or professionals) externalise their professional thinking process in order to make it visible to students. Instructional strategies/methods in this model are modelling, coaching, scaffolding, articulation, reflection and exploration. The instructional aim of modelling is to let students observe the execution of a professional task, which is performed, explicated and made ‘visible’ by a teacher/professional. During coaching the students get feedback when executing the same task. Scaffolding is the process in which the teacher or professional helps the student to perform a professional task. Learning starts as the teacher asks students to externalise or verbalise their thinking and the teacher supports this process with articulation. Articulation is required to compare the execution of the professional task by different students. The final instructional strategy is exploration, in which the student is challenged to show his/her solution for an unknown professional task.

In conclusion, in this developmental model the mentor is a professional model for the student, demonstrating professional behaviour to the student, who explicates professional considerations for typical engineering tasks and the values and mores of the professional community of engineers. The student is perceived as an active observer of the professional, resulting in insight into what it means to be a professional in professional engineering practice. Students construct their identity as part of this socialising process and ethical issues are an explicit part of this process. Sheppard and Sullivan stress the importance of preparation for professionalism during the professional apprenticeship and argue that it should be an integral part of student preparation for professional practice. Furthermore, professional identity can frame the teaching and learning activities during the course (Sullivan 2004, Sheppard et al. 2008).

The self-guiding model

An example of the second group of theories is the self-guiding model of Ibarra (1999), who states that identity development is a process in which individuals (re-)construct their personal and professional identities by cyclic experimentation towards more senior professional roles. The reference point is that individuals can clearly define what they do not want, what does not fit them and what is required for the professional role. Identity construction becomes a process of active experimentation with and evaluation of professional roles – Ibarra defines them as ‘provisional selves’ – before they are accepted and internalised by the student. Ibarra identified three basic (student) activities in this
adaptation process towards professional identity: (1) observing role models to identify potential identities, (2) experimenting with provisional selves, and (3) evaluating the results of these experiments against internal standards and external feedback.

Ibarra found that the dominant form of experimentation was the imitation of observed behaviour of professional models. Some students will imitate other professionals’ behaviour virtually without amendments, and imitate the complete self-presentation of one single model (Ibarra defines this as ‘wholesale imitation’). Others will construct a provisional self out of observed elements of a number of models (Ibarra defines this as ‘selective imitation’).

In contrast to imitation, which starts in successful imitation of professional behaviour of others, students can also experiment with professional behaviour that best fits themselves (Ibarra defines these as ‘true-to-self strategies’). Students can then gradually shift to the successful professional behaviour that fits them. Imitation and experimenting strategies result in new behaviour and possible rejection of behaviour of the previous professional role. These experiences are evaluated against internal and external standards. Internal standards refer to ‘will it fit to me?’ while external standards are the standards of the professional role the person wants to perform in.

According to Ibarra, in the provisional selves model the student is the actor who constructs professional roles and experiments with them in cycles. Professional role models are required, but they do not have to guide or interact with the student. The process can temporarily stop if the student is satisfied with the developed identities because they meet his/her own expectations (the internal dimension) and professional standards (the external dimension).

**Applicability of both theories**

We think that both theories fit our research on workplace learning since both theories were developed for learning in authentic professional situations and both have an explicit orientation on professional identity development. But, the models differ in the roles and activities of both students and professionals. Gibson (2004, p137) characterised the differences between the mentoring and the self-guiding model in terms of the interpersonal relation between the student and the mentor and/or model. In the mentoring model “interaction and involvement, based on an active interest in and action to advance the individual’s career” is the defining process and both parties are usually explicitly aware of their relationship. In the self-guiding model, the defining process consists of “identification and social comparison, based on perceived similarity and desire to increase similarity by the individual”. Awareness is now typically a one-way activity of the observing person. In contrast to the mentoring model, the student has to take all initiatives in the development process.

**Conclusion**

In this study we perceive identity development as a cyclic process of exploration and evaluation. Exploration of identities can result in more clarity of identity alternatives whereas reflection and evaluation may lead to new commitments with identities. With regard to the development of professional identity during workplace learning we argue that the mentoring or guided learning model (Sullivan 2004) and the self-guiding constructing model (Ibarra 1999) are complementary. In the mentoring model the teacher guides/controls the student’s process of professional development. In the self-guiding model the student guides him/herself, which requires the student’s initiative and self-regulation. Both the mentoring and self-guiding situations will occur side by side in on-campus educational
practice, but also during off-campus learning. In the beginning teachers define the course design and learning activities, but from then on, students are required to become more self-directing, for example during design projects, off-campus workplace learning and the final project. But also during workplace learning and final projects, industry supervisors can perceive students either as mentee or as a self-directed learner. Students for their part can perceive their industry supervisor as a mentor or as one of their professional models.

Student characteristics and workplace conditions

From previous research we know that professional identity development in general is influenced by student characteristics such as age, gender, personality, personal motives, agency, experience and self-efficacy (Marcia 1966, Beijaard et al. 2000, Rots et al. 2010). In addition, in identity development research among student-teachers motives to enter education were identified as influencing identity development (Derrick & de Kat 1993). In generic terms, a student’s choice for an education can be perceived as either a choice for a specific profession within a discipline or for the discipline as knowledge field, without having a specific profession in mind. The first choice to enter education connects more to identity development.

Besides student characteristics, conditions like education, work experience and exposure to professional models (in their personal life or work environment) influence students identity development as well (Ibarra 1999, Bilodeau 2004, Adams et al. 2006, Sheppard et al. 2008). To achieve identity development, students need to be perceived as professionals and the awarding of professional responsibility for the task they perform. Schön (1983) and Wenger (1998) found that students who wore white coats and a stethoscope were perceived as doctors by others and as a result they behaved like doctors and identified themselves with doctors.

In engineering education these conditions are intentionally created in design projects (Lindsay et al. 2008) where students in a team perform authentic engineering tasks and are not only responsible for their individual contribution, but also for the team result. In our previous study on teachers’ perception of engineering student identity development during workplace learning in industry, we also found that students who were perceived as professionals by others and were awarded responsibility for professional tasks developed better (Dehing et al. 2013).

In this research we include student characteristics, self-efficacy and student motives to enter education. Age is presumed to be a constant as our research is among full-time engineering students. Gender is perceived as important, but the percentage of women in engineering courses is generally low. As workplace conditions we include the role of professional models, the awarded responsibility and students perceived role as student engineer. These conditions are assumed to influence identity development during workplace learning.

Method

Research design

Figure 1 shows the research design for this study. Identity development can be understood as the difference between identity after and before workplace learning. We therefore chose a repeated measures design with a measurement at the brink of workplace learning (before) and directly after workplace learning (after).
As our research is exploratory, we acquired data from students in the existing educational practice and therefore did not manipulate the preparation or the workplace learning conditions. Figure 1 also shows how student professional identity development is the result of their learning activities in interaction with professionals in the workplace. We included: (1) the students characteristics, self-efficacy and motives to enter a course and (2) the workplace conditions such as the student's awarded responsibility and the supervisor’s perception of the student as an engineer, as described previously.

**Participants**

Participants were 256 third-year, full-time students from mechanical and electrical engineering bachelor courses of six Dutch universities of applied sciences. As part of a repeated measures design, two questionnaires were filled out by a total of 256 student engineers. Two hundred and sixteen students responded to the first questionnaire and 100 students to the second. Finally, 60 respondents could be identified that responded to both questionnaires, of which 59 could be used for analyses. These 59 respondents proved to be a representative sample of both the 216 respondents on the first questionnaire and the 100 on the second. Students average age was 20 years and the gender distribution was 12% female and 88% male, which is normal for engineering courses.

Engineering departments of the Dutch universities of applied sciences were invited to participate in this study with their engineering students. Mechanical and electrical engineering students were chosen because they are preparing for engineering professions with long, strong professional traditions and lived professional identities. This is important because during workplace learning students will observe and interact with these professionals and therefore we needed clear professional models to investigate the effect. Six out of 14 universities of applied sciences participated in this study.

**Measurement instrument**

We used various scales for measuring the variables as indicated in the research design: (1) the dependent variable: student professional engineering identity on the aspects clarity and identification, (2) student characteristics, (3) student learning activities – derived from the mentoring and self-guiding developmental model – and (4) workplace conditions: responsibility given to the students for their tasks and workplace supervisors’ perceptions of students as engineers.
Professional identity

In the literature we found two scales for measuring the two aspects of professional identity: (1) clarity of the professional identity and (2) identification with the profession. Both scales comply with our theoretical perspective and could be adapted to engineering education. The scale measuring student ‘clarity of their professional identity’ was developed by Dobrow and Higgins (2005). They studied the relation between MBA students developmental network density and the clarity of their professional identity. Their four-item scale has a Cronbach's alpha of 0.86. For our research we translated the items into Dutch and the answers were collected on a five-point Likert scale. The items are shown in the Appendix.

The scale measuring ‘identification with the profession’ was developed by Hekman et al. (2005). They used the scale designed by Mael & Ashforth (1992) to measure the extent to which physicians identify themselves with their organisation and profession. The scale has a Cronbach's alpha of 0.80 for both contexts. For Hekman's adapted new scale for professional identification, he replaced the term ‘organisation’ with ‘doctors’ and reported an alpha of 0.75. For our research we translated the items into Dutch, substituted ‘doctors’ with ‘engineers', and reversed the five-point Likert scale. The complete scale is shown in the Appendix.

Student characteristics

Two items refer to students motives to enter engineering education. The first item refers to the choice for engineering as a discipline, while the second item refers to the choice for the engineering profession. Self-efficacy was measured using a self-assessment item. The three items are listed in the Appendix.

Developmental model

Student's learning activities are influenced by their interaction with professionals in the workplace and the workplace conditions. We use these learning activities as indicators for the students developmental model. The scales for measuring the developmental models in this research were constructed using the theories of Ibarra (1999) (self-guiding model) and Sullivan (2004) (mentoring model). The two scales focus on students perceived guiding during the learning process, which can range from low: ‘I found out myself what the engineering profession is’ to high: ‘My colleagues have taught me what the engineering profession is’.

In the self-guiding model the student is surrounded by professional models, but no guidance from them is expected. Students direct the learning process themselves aiming at acquiring knowledge about the profession and professional practice. The scale for the self-guiding model contains items such as ‘I found out myself what the engineering profession is’ and ‘I reflected on my development on a regular basis’. The complete seven-item scale can be found in the Appendix.

In contrast, students developing according to the mentoring model can be characterised by the presence of a professional model in the workplace, whose guidance is expected to be high. The scale representing the mentoring model scale has items such as ‘My close colleagues gave me regular feedback on my professional behaviour’ and ‘My colleagues have taught me what the engineering profession is’. The complete ten-item scale can be found in the Appendix.

Both scales are not expected to be independent as they measure two dimensions of the same learning process and most students experience both self-guidance and mentoring elements in their workplace learning.
Workplace conditions

Bachelor courses in Dutch higher education courses comprise of four years (240 EC). In the first two years students typically acquire the body of engineering knowledge and skills. In the first semester of the third year, students do a workplace-based placement in industry. The aim of this full-time placement is working and learning in an authentic engineering environment. The learning objectives are: (1) orientation on the profession and the professional practice and (2) application of theory into practice. Next to the submersion in professional practice students usually get an authentic engineering assignment that they have to solve and report on.

We measured two conditions of workplace learning: (1) responsibility awarded to the student and (2) the supervisor’s perception of the student as an engineer. The awarded responsibility scale consists of four items, such as ‘I was given engineering tasks which I was responsible for’ and ‘I would have liked more responsible work’ (reverse coded).

The second scale, supervisor’s perception, consists of three items, for example ‘My colleagues perceived me as a junior engineer’ and ‘Workers who did not know me perceived me as a (junior) engineer’. Both scales are provided in the Appendix.

Data analyses

The analyses were performed on the data from the 59 students who completed both questionnaires. Data were analysed in two ways. First, descriptive analyses were carried out and significant differences in the identity aspects identity and clarification were identified. Second, hierarchical linear regression analysis was used to analyse the influence of the blocks of variables as indicated in the research design. As a preliminary step, the reliabilities of the scales were determined and the scale scores were computed. All scales showed reliabilities between 0.61 and 0.82, as shown in Table 1.

<table>
<thead>
<tr>
<th>Variable block</th>
<th>Scale</th>
<th># items</th>
<th>Cronbach’s alpha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identity development</td>
<td>Clarity</td>
<td>4</td>
<td>0.82 (t1) /0.86 (t2)</td>
</tr>
<tr>
<td></td>
<td>Identification</td>
<td>6</td>
<td>0.82 (t1) /0.84 (t2)</td>
</tr>
<tr>
<td>Developmental model</td>
<td>Self-guiding model</td>
<td>7</td>
<td>0.63</td>
</tr>
<tr>
<td></td>
<td>Mentoring model</td>
<td>10</td>
<td>0.78</td>
</tr>
<tr>
<td>Workplace conditions</td>
<td>Student’s responsibility</td>
<td>4</td>
<td>0.62</td>
</tr>
<tr>
<td></td>
<td>Perception as an engineer</td>
<td>3</td>
<td>0.61</td>
</tr>
</tbody>
</table>

The measurements before workplace learning were labelled with t1, after workplace learning with t2.

Descriptive analyses

Q1: Do students develop professional identity?

Identity development was computed as the difference between the score after and before workplace learning and tested for significance with a paired t-test for the aspects of clarity and identification. As the mean differences were low and both standard deviations were considerable, the scores before and after workplace learning for both aspects were
evaluated with scatter plots, and development in both directions was tested with a paired t-test.

**Q2: Developmental models, how do students develop their engineering identity?**

Students scored on both the self-guiding and mentoring scales. The scores were used in two different ways: (1) to assign the students to their preferred developmental model for the descriptive analyses and (2) as raw interval scores for use in the regression analyses (see p16). For the descriptive analyses, a new variable ‘preferred developmental model’ was created. A student’s highest score on both scales was used to assign him or her to one of the two categories: self-guiding or mentoring. The differences between the self-guiding and mentoring model on the aspects clarity and identification, before and after workplace learning, were tested with t-tests.

**Q3: What are the influences of the workplace conditions?**

A box-plot was made to assess the distribution of scores on the scales awarded responsibility and perception as engineer.

**Hierarchical linear regression**

**Q4: What are the contributions of the variable blocks of the research design on identity development?**

Stepwise hierarchical linear regression was used to estimate the contribution of the variable blocks of our research design. The dependent variables are (1) development for the aspect of clarity during workplace learning and (2) development for the aspect of identification during workplace learning. Both were defined as the score after workplace learning corrected for the score before workplace learning. Therefore the score before was entered in analysis step 1 in the regression equations. The other independent variables were grouped in blocks and then entered block by block in the equations so the delta $R^2$-squared for each block was calculated. Block 2 contained the student characteristics, block 3 the scores on the self-guiding and mentoring scale. Finally, the workplace conditions were entered in the regression analysis as block 4.

**Results**

**Q1: Do students develop their professional identity?**

Table 2 shows the results for identity development on the aspects clarity and identification at the brink of workplace learning, before and directly after workplace learning.

<table>
<thead>
<tr>
<th>Aspect</th>
<th>n</th>
<th>M</th>
<th>SD</th>
<th>M</th>
<th>SD</th>
<th>Cohen’s d</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clarity</td>
<td>59</td>
<td>2.78</td>
<td>0.79</td>
<td>3.08</td>
<td>0.91</td>
<td>0.4*</td>
</tr>
<tr>
<td>Identification</td>
<td>59</td>
<td>2.78</td>
<td>0.56</td>
<td>2.85</td>
<td>0.73</td>
<td>0.1</td>
</tr>
</tbody>
</table>

Note: * $p < 0.05$. 

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We see that, on average, students had significant positive growth on the aspect clarity ($M = 0.30, SE = 0.12$), $t(58) = 2.51, p <.05$, with a moderate Cohen’s $d = 0.4$. In contrast, there was no significant growth on the aspect identification. This indicates that students acquired more insight in what the profession and professional practice means for their future professional life. They did not yet identify more with the engineering profession. To get more insight into the development of the individual respondents we used scatter plots (see Figure 2 for clarity and Figure 3 for identification).

![Figure 2 Scatter plot clarity](image)

**Clarity**

Figure 2 is the scatter plot for clarity before (rows) and after (columns) workplace learning. A considerable variance can be observed. Two groups of respondents can be recognised.

The first group is situated above the $y=x$ line and their clarity increased. The second group is situated below the line and their clarity declined during workplace learning. The results of this split of the 59 students on clarity showed 34 positive developers (incliners), 19 negative developers (decliners) and six students who did not change. Table 3 shows the mean scores and variance for incliners and decliners on clarity. We see that the incliners started workplace learning with a score below the scale mean ($M = 2.58$) and ended with a score above the scale mean ($M = 3.47$). In contrast, decliners started with a clarity score above scale mean ($M = 3.13$) and ended after workplace learning with a score below scale mean ($M = 2.47$). After testing we see that the incliners showed a significant growth on clarity during workplace learning ($M = 0.89, SE = 0.11$), $t(33) = 6.75, p <0$, Cohen’s $d = 1.1$. The decliners showed a significant decline on clarity during workplace learning ($M = -0.66, SE = 0.12$), $t(18) = -5.64, p <0$, Cohen’s $d = 0.9$. For both groups the average incline ($M = 0.89$) and the average decline (M = -0.66) were significantly different from 0 and consequently the difference between the groups was significant.
Identification

Figure 3 is the scatter plot for the aspect identification which was analysed in a similar way. Again we could distinguish two groups of respondents: those above the $y=x$ line whose identification increased and those below the line whose identification declined.

The results of this split of the 59 students on identification showed 29 positive developers (incliners) and 25 negative developers (decliners). Five respondents scored the same before and after workplace learning. The development on identification was tested for both groups separately and is presented in Table 4.

Table 4 shows that the incliners started workplace learning with a score below scale mean ($M = 2.65$) and ended with a score above scale mean ($M = 3.31$). In contrast, the decliners started with an identification score on scale mean ($M = 2.99$) and ended with a score after workplace learning below scale mean ($M = 2.34$). After testing we see that the incliners showed a significant growth on identification during workplace learning ($M = .66$, $SE = .08$), $t(28) = 8.01$, $p < .01$, Cohen’s $d = 1.5$. The decliners showed a significant decline on
Identification during workplace learning ($M = -0.65$, $SE = 0.08$), $t(24) = -8.18$, $p < 0.01$, Cohen’s $d = 1.5$. Both the average incline ($M = 0.66$) and the average decline ($M = -0.66$) in identification were significantly different from 0 for each group, and consequently the difference between the groups was significant.

**Clarity and identification combined**

The previous sections provided the results with regard to the direction and magnitude of the development of clarity and identification independently. As most students had valid scores on both aspects, these scores were individually matched in Figure 4.

The result is the distribution of the respondents over the four possible developmental scenarios. One third of students (35%) showed overall positive achievement and inclined on both aspects. These students apparently acquired an improved insight into their future career in engineering. As this complied with their personal values, they strengthened their identification with engineers. The second largest group (31%) inclined on clarity but declined on identification, indicating that they got a better insight into their possible professional future in engineering. But, apparently, this better insight did not match their personal values and this resulted in a decrease in their identification with engineers. The third group of students (18%) showed the opposite and inclined on identification and...
declined on clarity. The decline on clarity indicates that these students possibly got confused about their professional future as it became less clear. It is, however, confusion in a positive way for example, as a result of the diversity of engineering roles they observed during workplace learning. These students cannot yet make a choice for one of these roles as more than one looks attractive. Although clarity declined, their overall feeling of the professional community of engineers is positive and their identification with the engineering professionals inclined. Finally, the forth group (16%) showed overall negative achievement and thus declined on both aspects clarity and identification.

The overall result was that less than half of the students (35%) showed overall achievement and, for them, workplace learning was a full success. For a group of 16% workplace learning was not successful at all as they showed overall negative achievement. For the remaining two groups workplace learning was a partial success.

Q2: Developmental models: how do students develop their engineering identity?

Table 5 shows the scores of all students on the mentoring and the self-guiding model (column Total). As can be seen, all students scored above the scale means with a limited standard deviation (SD). In addition, the scales showed an expected, significant correlation \((r = 0.61)\). Based on the criterion ‘highest score’, two-thirds of the students showed a preference for the mentoring model. We further see that the assignment to the preferred model resulted in an increase of the contrast between the groups.

Next, the identity development aspects were broken down with the new variable preferred developmental model as presented in Table 6 for clarity and Table 7 for identification.

### Clarity

Table 6 show the breakdown of clarity for the preferred developmental model before and after workplace learning. From Table 2 we know that clarity overall increases significantly. In Table 6 we see that both groups increase their clarity. T-tests on the clarity scores between the developmental models, showed no significant differences either before or after workplace learning. This indicates that clarity was not influenced by the developmental models, and students developing according to the two models showed the same score on clarity.
Identification

Table 7 shows the breakdown of identification for the preferred developmental model. From Table 2 we know that overall identification did not grow significantly during workplace learning. Table 7 shows a small decline of identification for the mentoring model and an average growth for the self-guiding model. T-tests on the identification scores between the developmental models showed no significant differences either before or after workplace learning. This indicates that identification was not influenced by the developmental models and students developing according to the two models developed equally on identification.

<table>
<thead>
<tr>
<th>Preferred model</th>
<th>Before</th>
<th>After</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mentoring</td>
<td>38</td>
<td>2.83</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.50</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.77</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.76</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.1</td>
</tr>
<tr>
<td>Self-guiding</td>
<td>20</td>
<td>2.71</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.65</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.98</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.66</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.4</td>
</tr>
<tr>
<td>Total</td>
<td>58</td>
<td>2.78</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.55</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.82</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.73</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.1</td>
</tr>
</tbody>
</table>

Development of clarity; identification combined with preferred model

Tables 6 and 7 provide the average results of direction and magnitude of the development of clarity and identification independently for both developmental models. We can add the information of the students preferred model to the four scenarios shown in Figure 5. This results in the distribution of the preferred model per possible scenario as can be seen in Figure 5.

Table 5 showed that one-third of the students preferred the self-guiding model. The other two-thirds were in favour of the mentoring model. We see in Figure 5 that, for the students with inclined identification – in both clarity categories – the self-guiding is overrepresented.
In contrast, in the clarity categories with declined identification we see an overrepresentation of students assigned to the mentoring model.

Q3: What are the influences of the workplace conditions?

Virtually all students scored above the scale means of the scale ‘student’s awarded responsibility’ and ‘supervisor’s perception of the student as an engineer’, indicating that they all perceived satisfying conditions during workplace learning. Therefore, it is not possible to test the influence of both conditions on clarity and identification by simply comparing growth for ‘satisfying’ and ‘not satisfying’ conditions. Consequently we cannot confirm the teachers’ observations.

Q4: What are the contributions of the variable blocks of the research design to identity development?

The regression summary table for clarity is shown in Table 8 and the regression summary table for identification in Table 9.

Table 8 Summary table clarity model

<table>
<thead>
<tr>
<th>Analysis step</th>
<th>Block entered</th>
<th>R</th>
<th>R Square</th>
<th>Change statistics</th>
<th>R Square Change</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Clarity score before</td>
<td>0.411</td>
<td>0.169</td>
<td>0.169</td>
<td>0.001*</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Student characteristics</td>
<td>0.517</td>
<td>0.267</td>
<td>0.098</td>
<td>0.086</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Develop model</td>
<td>0.534</td>
<td>0.285</td>
<td>0.018</td>
<td>0.537</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Workplace conditions</td>
<td>0.541</td>
<td>0.292</td>
<td>0.007</td>
<td>0.786</td>
<td></td>
</tr>
</tbody>
</table>

Note: * p < 0.05

Table 9 Summary table identification model

<table>
<thead>
<tr>
<th>Analysis step</th>
<th>Block entered</th>
<th>R</th>
<th>R Square</th>
<th>Change statistics</th>
<th>R square change</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Identification score before</td>
<td>0.317</td>
<td>0.101</td>
<td>0.101</td>
<td>0.017*</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Student characteristics</td>
<td>0.383</td>
<td>0.146</td>
<td>0.046</td>
<td>0.444</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Develop model</td>
<td>0.526</td>
<td>0.277</td>
<td>0.131</td>
<td>0.017*</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Workplace conditions</td>
<td>0.544</td>
<td>0.296</td>
<td>0.019</td>
<td>0.532</td>
<td></td>
</tr>
</tbody>
</table>

Note: * p < 0.05

In analysis step 1 the scores after workplace learning were corrected for the scores before workplace learning. We see in Table 8, column R square, that 17% of the variance of clarity after workplace learning was explained by the score of clarity before workplace learning and, consequently, not by workplace learning itself. For identification this correction was 10% (see Table 9).

In analysis step 2 the block ‘student characteristics’ was entered into the equation. The results show an additional 10% variance explained for clarity and 5% (not significant) for identification. This indicates that the student characteristics – self-efficacy and choice for the engineer discipline – explain 10% of the variance in clarity.
In analysis step 3 the block ‘developmental model’ was entered. The developmental models in the regression equation account for 2% (not significant) for clarity. In contrast, the self-guiding model contributed to 13% additional explained variance on identification. Finally, in analysis step 4 the block ‘workplace conditions’ were entered, showing no significant change in the R-square. This was expected as variance was too low in the scores on both variables in the block conditions.

So, overall results of the regression analysis are: first, 17% of the variance in clarity after workplace learning can be explained by clarity just before workplace learning. In addition, two student characteristics (self-efficacy and choice for the engineering discipline) explain a further 10%. Second, 10% of the variance in identification after workplace learning can be explained by the identification score just before workplace learning. The self-guiding model explained an additional 13% of variance in identification.

Conclusion and discussion

In this study we explored student identity development during workplace learning in industry, with specific attention to the influence of their developmental model. First, with regard to their overall development (both incline and decline), students can be divided into four different achievement groups based on identity aspects ‘clarity’ and ‘identification’. For 35% of the students, workplace learning was a full success. Second, for both the aspects clarity and identification, we found that students entering workplace learning with a low identity score catch up and develop more, while those entering with a high score slow down and develop less. Third, the development models show no difference with regard to students development on clarity or identification. Fourth, the influence of the conditions could not be tested. Finally, in the regression analyses, student characteristics explained 10% of variance in clarity, while the self-guiding model explained 13% of the variance in identification.

We can conclude that workplace learning has an overall positive effect on engineering students development of clarity. This indicates that, in general, students acquire a clearer image of their professional future during workplace learning. At the same time students show no overall growth on the aspect identification with the profession. The moderate effect size for clarity and the substantial variance was in line with the observations of teaching staff that students development shows large individual differences (Dehing et al. 2013). These substantial differences in student development on clarity and identification can be explained by distinguishing students as ‘positive’ or ‘negative’ developers. Following the idea of Sheppard et al. (2008) of the function of professional identity as a framework for education, we expected that students with a high score on identity at the start of workplace learning would develop more. Contrary to our expectation, we found that students entering workplace learning with a high score slowed down and developed less, while those entering with a low identity score proved to catch up. This might indicate that students starting point at the end of the preparation for workplace learning is not adequate. Apparently, identity development does not get much attention during the preparation for workplace learning in the first two course years. Students with an initially high identity score may have had wrong expectations of the profession that were not corrected or put in the right perspective before workplace learning. As a result these initial expectations were corrected during workplace learning, resulting in lower identification. Another indicator that education on identity might not have been intense is the low score at state 1 combined with a large variation on both aspects clarity and identification. As education is intentional, it should raise the overall level and make groups more homogeneous with respect to the educational aims. So a higher level and less variance for clarity before workplace learning were expected.
As expected there was no relation between the aspects of clarity and identification. This confirmed Marcia’s theory (Marcia 1966) that exploration resulting in clarity and identification, are two independent dimensions of the identity development process. Apparently, during workplace learning students divide into four achievement scenarios. The first scenario is that students show overall positive achievement, which means that these students increase the clearness of their professional identity and they identify more with the engineering profession. In the second scenario, students explore professional practice and get a clearer image of the profession and the consequences for their personal professional future. But if this clearer image does not comply with previous expectations of the profession, students reconsider and reduce their initial identification with engineers. In the third scenario students perception of their professional future become less clear as they possibly get confused during exploration because of the diversity of engineering roles and/or the wealth of professional opportunities. But, these students react positively and increase their identification as they might think: ‘I do not care that I do not know my exact professional future now’ or ‘I do not make a choice yet’. They like the engineering professions and professionals and want to belong to them. In contrast, the forth scenario consists of students who react negatively on both aspects and reduce their initial identification. They might think: ‘I do not know what my professional future will be, but I feel even less commitment to the engineering profession than before workplace learning’. This group of students shows overall negative achievement.

So we can conclude that the division of students during workplace learning creates more diversity in their state of identity. This conclusion seems to confirm one of the critical observations of the Dutch Inspectorate of Education on workplace learning in higher professional education (Inspectie van het Onderwijs 1996).

The two developmental models show no difference in the process of getting a clear picture of the profession. This seems understandable as clarity is the result of the exploration of the profession and professional practice, and this is merely a process of acquiring information. During workplace learning all students interact with and observe professionals in their professional environment regardless of their developmental model. Students evaluate this information and assess what it means for their future professional life. In addition, the developmental models did not show significant differences in the growth of identification, although the self-guiding model showed a small significant contribution to growth of identification in the regression model. Student active participation and self-guidance in the process of becoming an engineer might result in more growth of identification compared to the students developing according to the more educational mentoring model. This might indicate that self-guidance is an important learning mechanism for professional identity development.

Although the study provides insight into student identity development and the role of the preferred developmental model, there are limitations related to the sample size. The individual analysis of the development for the aspects clarity and identification required matching pairs of questionnaires before and after workplace learning. A limitation of the study is the high non-response on the second questionnaire leading to a decrease of matching pairs. However, analysis of key variables such as clarity and identification as measured before workplace learning showed that the group with matching pairs was representative for the whole group responding on the questionnaire before workplace learning.

A further limitation is the limited use of the characteristics of the industrial placement environment. In the questionnaire, industry characteristics such as: industrial product sector, main industrial activities, size, percentage of engineers in the firm and the department, were measured but more in-depth analysis was not realistic for methodological reasons.
Practical applications and recommendations

In this study we found that engineering student identity development during workplace learning showed a low starting point and considerable variation in development. This suggests that apparently the preparation for workplace learning in the first two course years was not effective. Therefore, we recommend that students professional identity development should be acknowledged and explicated in the course design so it gets greater and explicit attention during the preparation, during workplace learning, and in the final year. For this purpose a system of career conversations could be used (Kijpers & Meijers 2008).

So, before workplace learning, all students should acquire at least a clear picture of the engineering professions and engineering practice. Teaching staff could perform as their professional models and add more professional engineering practice examples in their teaching. In addition, short prepared visits to industry and guest lecturers could contribute to students developing clarity and identification. To make these activities successful, students have to acquire communication and research skills to observe professional roles and processes in engineering practice and professional communities. These observations have to be discussed to develop realistic images of both the profession and the professional practice.

Before students start looking for a placement in industry, they could be invited to formulate their expectations and aims with respect to their professional identity development. The process of matching students with industry will improve as students with realistic images and expectations will make better choices for placements.

During workplace learning teaching staff could monitor the students process of identity development more closely and discuss it with them. Furthermore, it could be considered to do two placements in different industrial environments because this could improve professional identity development as students can learn from the diversity. Furthermore, a second placement can counterbalance the possible negative growth in the first placement.

For the phase after workplace learning we recommend that the observed diversity in students identity development gets explicit attention in the final year programme. Students need the final curriculum year to complete their professional identity to the level of a starting engineering professional. Inviting students at the start of the final years to explicate the learning aims and discuss their development regularly could contribute to their professional identity development.

Suggestions for further research

Based on our results and discussion some issues with regard to the preparation for workplace learning and the final year programme arise. How can preparation during the first two years be redesigned to an adequate starting point for workplace learning? The aim should be to: (1) raise the level of clarity to an acceptable level and (2) reduce the variance between students.

With respect to the final year programme, research is needed into the consequences for students further educational career. As workplace learning increases the diversity between students develops, what should be the aim of the final curriculum year? Students with decreased identification apparently become less connected/committed to the overall course aim, namely becoming a competent professional engineer. These students are three-quarters of the way through their four-year course and switching
to another career/course is not easy. So, what are the consequences for the final year course?

Finally, engineering is a profession with internationally comparable standards. Within the European Higher Education Area (EHEA), professional engineers are educated at the bachelor level within national educational systems with their own traditions. Therefore an international survey could make clear what the effect of different but comparable educational systems is on engineering identity development.

Scale: (1) completely disagree (2) disagree (3) neutral (4) agree (5) completely agree.

<table>
<thead>
<tr>
<th>Item</th>
<th>Scale: Clarity of professional identity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>I have developed a clear career and professional identity</td>
</tr>
<tr>
<td>2</td>
<td>I am still searching for my career and professional identity (reverse coded)</td>
</tr>
<tr>
<td>3</td>
<td>I know who I am, professionally and in my career</td>
</tr>
<tr>
<td>4</td>
<td>I do not yet know what my career and professional identity is (reverse coded)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Item</th>
<th>Scale: Identification with the engineering profession</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>When someone criticises engineers, it feels like a personal insult</td>
</tr>
<tr>
<td>2</td>
<td>I am very interested in what others think about engineers</td>
</tr>
<tr>
<td>3</td>
<td>When I talk about engineers, I usually say ‘we’ rather than ‘they’</td>
</tr>
<tr>
<td>4</td>
<td>Engineers’ successes are my successes</td>
</tr>
<tr>
<td>5</td>
<td>When someone praises engineers, it feels like a personal compliment</td>
</tr>
<tr>
<td>6</td>
<td>If a story in the media criticised engineers, I would feel embarrassed</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Item</th>
<th>Scale: Students characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>I chose an engineering course because I’m interested in engineering</td>
</tr>
<tr>
<td>2</td>
<td>I chose an engineering course because I want to become an engineer</td>
</tr>
<tr>
<td>3</td>
<td>I am quite self-confident</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Item</th>
<th>Scale: Self-guiding model</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>I have learned a lot by observing execution of professional tasks by engineers</td>
</tr>
<tr>
<td>2</td>
<td>I have learned a lot by experimenting with observed behaviour of other engineers</td>
</tr>
<tr>
<td>3</td>
<td>I found out myself what the engineering profession is</td>
</tr>
<tr>
<td>4</td>
<td>I found out myself how to behave as an engineer in professional practice</td>
</tr>
<tr>
<td>5</td>
<td>I found out myself how to behave as an engineer in society</td>
</tr>
<tr>
<td>6</td>
<td>I reflected on my development on a regular basis</td>
</tr>
<tr>
<td>7</td>
<td>I increasingly behaved more consciously as an engineer</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Item</th>
<th>Scale: Mentoring model</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>My close colleagues gave me regular feedback on my social behaviour</td>
</tr>
<tr>
<td>2</td>
<td>My close colleagues gave me regular feedback on my professional behaviour</td>
</tr>
<tr>
<td>3</td>
<td>I have learned a lot as tasks were demonstrated and explained</td>
</tr>
<tr>
<td>4</td>
<td>I have learned a lot by observing execution of professional tasks by engineers</td>
</tr>
<tr>
<td>5</td>
<td>I have learned a lot by asking my direct colleagues how and why engineers performed their tasks like that</td>
</tr>
<tr>
<td>6</td>
<td>I perceived my coach as a professional role model</td>
</tr>
<tr>
<td>7</td>
<td>I have learned a lot by behaving as my colleagues</td>
</tr>
<tr>
<td>8</td>
<td>My colleagues have taught me what the engineering profession is</td>
</tr>
<tr>
<td>9</td>
<td>My colleagues taught me to behave as an engineer in professional practice</td>
</tr>
<tr>
<td>10</td>
<td>My direct colleague/coach was a professional engineer</td>
</tr>
</tbody>
</table>
Appendix: Measurement scales

Acknowledgements

We thank the participating universities of applied sciences for their constructive support of the data collection.

References


### Item Scale: Responsibility
1. I got engineering tasks I was responsible for
2. I would have liked more responsible work
3. I got tasks that met my educational level
4. I felt responsible for the tasks

### Item Scale: Perception as engineer
1. My colleagues perceived me as a junior engineer
2. I tried to behave as junior engineer
3. People, who did not know me, perceived me as junior engineer


Inspectie van het Onderwijs (1996) Werk maken van stages in het hoger beroepsonderwijs [Focus on workplace learning in higher professional education]. De Meern; The Hague, the Netherlands: Inspectie van het Onderwijs; Sdu DOP [distr.].


