Mechanisms of students’ engineering identity development during workplace learning in the bachelor curriculum

ABSTRACT
Our previous research among teaching staff revealed that students’ engineering identity development showed a quantum leap during workplace learning in industry. But teaching staff also observed vast developmental differences between individual students. Therefore, we are interested in understanding the models and conditions for this identity growth during workplace learning. Simultaneously we want to test the observations from the teaching staff by confronting them with the student perspective. These insights might provide suggestions for improving the engineering curriculum in cooperation with teachers [1]. Although teachers can provide some explanatory clues on students’ identity development during workplace learning, research from the engineering students’ perspective is scarce. Our previous research identified two theories on models of identity development suitable to explain identity development. The first theory is the mentoring- or alignment model defined by Sheppard [9] and Sullivan [10]. The second theory is the provisional selves model, defined by Ibarra [7]. In this study, these two theories were used to develop instruments and questionnaires for assessing: 1) students’ identity development and 2) developmental models of identity growth. In a repeated measurement design, data were collected twice using questionnaires among 216 third-year bachelor student engineers. The results of the first questionnaire, just before workplace learning, showed that students on the average did not yet identify with engineers as a professional group and only one third of them showed starting identification. The preliminary results of the second questionnaire reveal: 1) Students show significant average growth in clarity of their professional identity but not in identification; 2) Students developing according the Ibarra model show significantly more growth on identification compared to students developing according the Sullivan model; 3) For most students, the workplace conditions for successful identity development, as identified in our previous research, were met. But, the effect on identity development could not be tested as there was not enough variance in the data. The presented findings are the result of a preliminary analysis. Further analysis is planned and will be reported at the conference.

Keywords
Professional identity development, Workplace learning

1. INTRODUCTION
Our previous research among teaching staff [3] revealed that students’ engineering identity development showed a quantum leap during workplace learning in industry, part of the third year of the four-year bachelor curriculum. They observed that students in general, transformed during workplace learning from engineering student to student engineer. Teaching staff also observed two important workplace conditions affecting students’ identity development. Observed were: first, the supervisors’ perception of the students as an engineers and second, the awarded responsibility to the students. So engineering teachers in general observed that students developed more if they were perceived as student engineers and got awarded responsibility. Furthermore, they observed vast developmental differences between individual students. Teachers explained the observed large differences between the students pointing at student’s characteristics like self-esteem and self guidance and the match between student and placement.

1.1 The context in engineering education
Dutch universities of applied sciences educate bachelor professional engineers in a four-year course. Graduates are expected to be fit to directly enter the profession. Therefore preparation for professional practice, resulting in professional identity development, is an important element of the engineering courses. Preparation for professional engineering practice consists of all course activities aiming at and preparing students for the entrance to: 1) the profession, the occupation as a social role and 2) the professional practice, the occupational environment [7].
Since the end of the nineteenth century, workplace learning in industry has been seen as an important, critical course element of the preparation for professional practice. Workplace learning remained ever since and therefore, the engineering curriculum today still comprises a period of 6-10 months of workplace learning in industry. Students and teachers perceive this workplace learning as valuable as it connects theory with professional practice and contributes to students’ professional identity development. Professional identity development perceived as the dual process of increasingly meeting the requirements of the engineering profession as defined in the professional competency profile and the identification with the profession. In addition, workplace learning is for most students the first longer working period in industry where they are introduced in the world of work and expected to behave as future engineers. Industry is also interested in workplace learning as it provides the opportunity to attract and assess new potential staff and gives access to expertise at the universities. Although the models of workplace learning are not fully understood, the output is seen as satisfying for students, universities and industry [8].

1.2 Research question
We are interested in understanding the models and conditions of engineering identity development during work-place learning in industry as part of the engineering courses at universities of applied sciences. Therefore in this study our 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 this identity development? What are the developmental models?
3) What are the workplace conditions influencing students’ professional development?

Besides the theoretical relevance of the findings, the insights can provide suggestions for improving the engineering curriculum in cooperation with teachers [1].

2. THEORETICAL FRAMEWORK
2.1 Theories on professional identity
Professional identity is widely discussed in the literature. Although the theories are diverse, there are some overarching concepts about professional identity and its development. First, professional identity development is a part of the complex multifaceted concept of personal identity development. Consequence is that full time university students will develop several identities simultaneously. Second, professional identity is an ongoing process of becoming a professional [2] and at the same time a state of being a professional. In other words, professional identity is a continuous process of becoming a professional via stages as junior professional, professional and senior professional. Third, most authors agree that the concept of professional identity has a social and an individual dimension. The social dimension comprises the requirements associated with the engineering profession like education, behaviour skills, knowledge and attitudes.

The individual dimension is the identification with the profession; the feeling to be an engineer [11]. In this study we perceive professional identity as one facet of the multifaceted perspective on identity and perceive professional identity as an ongoing process but at the same time a state that can be reached. Furthermore, we focus on the individual dimension of professional identity development, as the individual dimension has not been researched well. In contrast, the social dimension of the qualification process, meeting the requirements, is monitored on a regular basis.

2.2 The development of professional identity
In the literature we see complex and simple theories on identity development. Authors like Gee [5] and Wenger [12] describe a more complex model as they perceive professional identity development as a multifaceted concept. In the more simple theories we can distinguish two main groups of theories on identity development. The first group perceives professional identity development as a process of social embedding during a mentoring process [9, 10]. The other group of theories perceives the person who develops an identity as an active participant in the process of identity construction and students guide themselves in this process [7].

We describe two examples to illustrate both groups. First, the mentoring model of Sheppard et al. and Sullivan [9, 10], which was developed for undergraduate engineering education in the US. Here, professional identity is perceived as the result of a mentoring process during the professional apprenticeship. Sullivan uses the term “professional apprenticeship” as a metaphor for the working relation between professional and student, aimed at aligning students with the way of thinking of professionals. Second, the provisional selves model of Ibarra [7], which was grounded on two qualitative studies of career switches to more senior roles of junior consultants and bankers. Ibarra states that acquiring professional identity is the process in which individuals actively experiment with professional roles, called provisional selves, before they are accepted and internalized. Ibarra identified three basic tasks in this adaptation process towards professional identity: 1) observing role models to identify potential identities, 2) experimenting with provisional selves, and 3) evaluating these experiments against internal standards and external feedback.

With regard to the development of professional identity during workplace learning, we argue that the models of Sullivan and Ibarra are complementary. In the mentoring model the teacher is in control of students’ professional development process while in the provisional selves model the student is self guiding, which requires students’ initiative and self-regulation. Both mentoring- and self guiding situations will occur side by side in on-campus educational practice but also during off-campus learning. In the beginning, teaching staff will define the course design but onwards, students are required to become more self directing for example during 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. On their turn, students can perceive their supervisor as a mentor or as one of their professional models.
3. METHOD

3.1 Participants
Engineering departments of the Dutch universities of applied sciences participating in the Cluster Engineering were invited to participate in the study. This study focuses on full time engineering students. The questionnaires were filled out twice as part of a repeated measurement study among 216 third-years student engineers from the mechanical and electrical engineering departments of six universities of applied sciences.

3.2 Research design
Students’ growth of professional identity is the result of personal learning activities during workplace learning. These learning activities depend on the students’ characteristics, their preparation for workplace learning and the workplace learning conditions. Our aim is the research of identity development of students in the existing educational practice. As we had no influence on neither preparation nor workplace learning conditions, we chose for a repeated measurement design.

For research question 1, growth of engineering identity is the dependent variable. The development of the identity can be understood as a time series model and assessed as the difference between state 2 minus state 1.

For the second and third research question, students’ learning activities during workplace learning and the workplace conditions have to be measured.

3.3 Procedure

3.3.1 Sampling
The first questionnaire (June 2010) was used to measure students’ identification with the engineering profession at the end of the preparation during the first two years of the curriculum. On the brink of their six-month term of workplace learning. In addition, some student characteristics were measured. The second questionnaire was administered to the same student groups just after workplace learning (February 2011). We measured the development of professional identity, students’ learning activities at the workplace and the workplace conditions.

3.3.2 Measurement instruments
We had to find instruments for measuring 1) students professional engineering identity 2) students’ learning activities, derived from the Ibarra and Sullivan developmental model and 3) conditions like students’ awarded responsibility for their tasks and workplace participants’ perception of students’. The latter were identified as important conditions for identity development in our previous study.

First, we found two instruments measuring two aspects of professional identity: 1) clarity of the professional identity and 2) the identification with the profession. Both instruments could be adapted to engineering education.

Ad 1. The instrument measuring the clarity of professional identity was developed by Dobrow and Higgens [4]. They researched the relation between individuals’ developmental network density and clarity of professional identity of MBA students. Their constructed 4 item instrument has a reported Cronbach’s alpha of 0.86. The items are shown below:
1. I have developed a clear career and professional identity;
2. I am still searching for my career and professional identity (reverse coded);
3. I know who I am, professionally and in my career;
4. I do not yet know what my career and professional identity is (reverse coded);

The answers were collected on a five-point Likert scale (1=“disagree completely” to 5=“agree completely”).

Ad 2. The instrument measuring identification with the profession was developed by Hekman [6]. He used the scale designed by Mael and Ashforth in 1992 to measure the extent to which physicians identify themselves with their organization and profession. The instrument has a reported alpha of .80 for both contexts. For Hekmans’ adapted, new scale of professional identity, he replaced the term “organization” with “doctors” and reported an alpha of .75. We adapted the scale by substituting “doctors” by “engineers”, and reversed the scale (1=“disagree completely” to 5=“agree completely”). The items for the identification with the engineering profession are listed below:
1. When someone criticizes engineers, it feels like a personal insult;
2. I am very interested in what others think about engineers;
3. When I talk about engineers, I usually say ‘we’ rather than ‘they’;
4. Engineers’ successes are my successes;
5. When someone praises engineers, it feels like a personal compliment;
6. If a story in the media criticized engineers, I would feel embarrassed.

Second, instruments for assessing the models of identity development were constructed using the theoretical models of Ibarra and Sullivan. Scoring on the stereotype Ibarra model is indicated by the presence of professional models, but no guidance from them is expected. So, as guidance from the industry supervisor is expected to be low, the students direct themselves the learning process aiming at acquiring knowledge about the profession and professional practice. Students scoring on the stereotype Sullivan model are indicated by the presence of a professional model in the workplace who guides the student in the learning activities aiming at the acquisition of knowledge about the profession and professional practice. So, the student is educated and supervisors’ guidance is expected to be more intense.
Third, two instruments for measuring the conditions of workplace learning were developed. The first scale awarded responsibility consist of 4 items, like “I got engineering tasks I was responsible for” and “I would have liked more responsible work (reverse coded). The scale students’ perception as an engineer consist of 3 items like “My colleagues perceived me as a junior engineer” and “workers who did not know me perceived me as a (junior) engineer”.

4. RESULTS AND DISCUSSION

For the first questionnaire, 216 respondents from six universities could be analysed (male 193, female 23). Data collection for the second questionnaire is still in progress and the results provided in this paper are based on the data of 100 respondents available at the moment. From these 100 respondents 59 pairs could be formed with the first questionnaire, necessary to analyse identity development at the individual level in the time series model. As data collection is still in progress, the current results are provisional and result of the initial analysis. The data were analysed using SPSS.

4.1 Some overall results

Students in general appreciated workplace learning and perceived it as a valuable experience (M = 4.40, SD = .62). They also believed that the placement in industry made the more engineer (M = 3.81, SD = .83). They perceived the preparation on workplace learning as ok (M = 3.07, SD = .91) although preparation on “Knowledge of the engineering profession” (M = 2.32, SD = .69) and “Knowledge of the engineering practice” (M = 2.42, SD = .53) scored insufficient. Guidance from the workplace in terms of quality and quantity (M = 4.05, SD = .75) was evaluated better than guidance from university (M = 3.0, SD = .95).

4.2 Identity growth?

The first research question was: To what extent do bachelor engineering students develop their engineering identity during workplace learning in industry? The results on both aspects of engineering identity, clarity and identification, are presented in the table below.

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<th>Table 1. Identity growth during workplace learning</th>
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The reliability of the instruments measuring the two aspects of identity, clarity and identification, proved to be the same as the instruments they were derived from. (Cronbach alpha 0.82, respectively 0.81). Table 1 shows that on the average there is significant growth on the aspect clarity (sign 0.005, 1-sided). But, there is no growth on the aspect of identification. This means that during workplace learning students have become more aware of their professional identity but not yet identified more with the engineering profession.

The results at state 1 show that the average student on the brink of workplace learning does not yet identify with engineers as a professional group. The data further show that only one third of the students shows starting identification. Indicated by the data we suggest four possible reasons for this. First, engineering students’ initial choice for their engineering course is stronger oriented at engineering as a discipline (M = 4.61, SD = .59) than the choice for a professional career in engineering (M = 3.78, SD = .91). Second, students think that the curriculum does not provide them with enough knowledge of the engineering profession (M = 2.42, SD = .53) and the real engineering practice (M = 2.32, SD = .60). Third, 41% of the engineering students has no engineers in their social environment as professional models. Forth, students have limited working experience as they are initial full time students with an average age of around 20 years.

The results at state 2 show for the aspect identification no growth and surely not the quantum leap as observed by teaching staff. But we can see a substantial variance which indicates vast individual differences. To find a reference point for the level of identification, we asked teaching staff (n=26) to score on the identification instrument themselves. Staff scores an average of 3.44 (SD = .47). This score is .4 above the scale mean and 0.6 above the students mean score. Furthermore the variance for staff is considerable lower. The staff score places the student average score more in perspective.

4.3 Influence of developmental models

How do students develop their identity? What are students’ developmental mechanisms of identity development? In the theory we found the mentoring model of Sullivan and Ibarra model on provisional selves and we developed scales for both. Students scored on both scales. If the score difference is >= + 0.25 the student is assumed to develop according the Sullivan model. If the score difference (Sullivan-Ibarra) is <= -0.25 students are assumed to develop according the Ibarra model. This coding results in three student groups of n=14 (Ibarra) and n=23 (Sullivan). The remaining 21 students score in between.

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<th>Table 2. Growth related to developmental models</th>
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Table 2 shows no significant difference in the aspect clarity, but a significant difference in the aspect identification (sign .022, 1-sided). The explanation could be that during workplace learning both groups become more aware of the engineering profession and the impact on their personal professional development. The difference is the way they acquired this clarity. The students developing according the Ibarra model are more active and self guiding in their development whereas the students according to the Sullivan model are more educated by others. Students’ active participation and self guidance in the process of becoming an engineer could explain the growth of identification compared to the students developing according the less active, more educational Sullivan model. So active participation and self guidance seem to be important drivers for professional identity development.
4.4 Conditions
What are the workplace conditions influencing professional development? In our previous research teachers reported that students’ professional identity develops more if students get awarded responsibility and were perceived as students engineer by their industry supervisors. The results from the second questionnaire show that the mean score on the scale awarded responsibility is 3.84 (SD = .47) and the mean score on the perception as a student engineer is 3.70 (SD = .45). So both mean scores are well above the scale average. Testing their influence on identity aspects, clarity and identification, fails as there are too few respondents with a low score (=< 2) on both scales to compare with the high scores (>= 4). Preliminary conclusion can be that for most students the conditions for developing identity during workplace learning were positive.

5. CONCLUSIONS
Our research questions were: “To what extent do bachelor engineering students develop their engineering identity during workplace learning in industry?”; “How do students develop this identity development? What are the developmental models?” and “What are the conditions? We can conclude that: first, engineering students do develop their professional identity during workplace learning, but only at the aspect clarity we find significant growth. The quantum leap in growth of professional identity, reported by their teachers in our previous survey, could not be supported with the identification instrument. The substantial variance indicated large individual differences and further analysis is required. The students’ low level of identification after workplace learning could be put into perspective if referred to the scores of experienced staff scoring on the identical instrument for identification.

Second, the developmental models of Ibarra and Sullivan could be recognised in the data and their influence on clarity and identification was tested. Students developing according both models show equal growth of clarity, but the students developing according the Ibarra model show significantly more growth in identification. The explanation could be found in the difference in active participation, learning perspective and learning activities. The students developing according the Sullivan mentoring model are guided by the mentor and do not have to find their own way. The students developing according the Ibarra model, with professional models but with no or limited guidance, are thrown back on themselves. These students have to be active developers and this active development might explain their growth of identification.

Third, virtually all students did their workplace learning in good conditions. Students got awarded responsibility and their colleagues perceived them as student engineer. As there were too few respondents with low scores on one or both conditions, the effect on professional identity development could not be tested.

The findings are the result of a preliminary analysis. Further analysis is planned and will be reported at the conference in September. In addition to the quantitative analysis, we have planned to triangulate the findings with interviews with students and staff to further understand the reported mechanisms. After that we will, in cooperation with teaching staff, develop curriculum modifications as final stage of the educational design approach [1].

6. ACKNOWLEDGEMENTS
We wish to thank all students and staff of the participating universities of applied sciences, who participate in this study.

7. REFERENCES