Levels and Differences in Professional Identity in Engineering Undergraduates

V. Putarek and J. Petrović*
*University of Zagreb Faculty of Electrical Engineering and Computing, Zagreb, Croatia
vanja.putarek@gmail.com

***Abstract* - Professional identity is a form of social identity which is developed with the adherence to perform competently and legitimately in profession. It is the basis of professional functioning and socio-cultural capital for employability. Since engineers play a crucial role in today's rapidly accelerating technological development, it is important for them to have a stable and strong professional identity. The aim of this research was to examine the level and differences in professional identity depending on sociodemographic characteristics of Croatian electrical engineering and computing students. Research participants were 431 freshmen students (73.1% male; age: *M* = 18.67, *SD* = 0.57). Participants completed an online survey containing questionnaires measuring three professional identity dimensions (knowledge about future profession, direct experience with future profession, and self-efficacy related to future profession) and socio-demographic characteristics. The results showed that the self-efficacy dimension of professional identity was higher than the other two dimensions. Male students, students informed about the study program, students who have engineer(s) among close family members and who were raised in the place of study, as well as students who work student job have higher levels of some dimensions of professional identity.**

Keywords - engineering education; professional identity; engineering students; engineering undergraduates; self-efficacy

I. INTRODUCTION

Social identity represents the ways in which a person's self-concepts are based on their group membership [1]. According to the Social identity theory [2], [3], people have multiple social identities (e.g., identity related to gender, friends, family, occupations, sports, religion) and a group is defined and it is meaningful only in terms of how it is related or compared to other groups. Social identification shifts between different groups, depending on which social identity is currently most salient [4]. Social identities have an impact on the individual's perceptions, emotions, and behavior [5]. For instance, they can affect choices which people make, the perception of people in other groups (e.g., stereotypes), the norms and values which will be followed [6].

As a form of social identity, professional identity is one of many social identities which people have and usually is viewed as a key component of one's overall sense of identity [7]. Tan et al. [8] define professional identity as "the self that has been developed with the commitment to perform competently and legitimately in the context of the profession, and its development can continue over the course of the individuals' careers". It serves as a cognitive structure that assimilates and integrates information about self and profession [9].

Professional identity begins to develop mostly in adolescence [10]. During this period, most adolescents achieve a mature level of professional identity, but professional identity development for most individuals continues through adulthood. Professional identity helps individuals to make rational career decisions [11] and predicts a successful transition from school to work [12].

A. Dimensions of professional identity

Professional identity is not a unitary construct and there are various approaches to conceptualize its multidimensionality. On the one hand, in some research, professional identity is operationalized via variables, such as self-efficacy and motivation [13]. On the other hand, research on students defined dimensions of professional identity. Tan et al. [14] revealed five dimensions of professional identity. First dimension, "knowledge about professional practices", consists of "knowing that" and "knowing how". Namely, this dimension is related to domain knowledge, as well as the appropriate application of competences in practice. Second dimension, "having the professional as a role model", is described as the contact with people who work in the profession of individual's interest, in order to observe how to behave and reason appropriately in some working role. Powerful role models are teachers who have worked or are still working in the respective industries, family members or relatives and friends. "Experience with the profession" is the third dimension, which depicts students' authentic contact with the future profession. Through that contact students can realize what they really have learnt in the classroom and what the responsibilities of practitioners are in their future profession. Fourth dimension, "preference for a particular profession", describes the personal identification with learning to become the professional, which leads to higher levels of grit and motivation during learning. Finally, "professional self-efficacy" is the fifth dimension that is related to the individual's perception that (s)he has the competences to adequately perform actions required in some situation.

In Croatian validation of Tan's et al. [14] dimensions of students' professional identity, three dimensions were obtained: "knowledge about professional practices", "experience with the profession", and "perception of the role model and professional future" [15]. First two dimensions correspond to Tan's et al. [14] dimensions of the same name, while the third dimension consists of Tan's et al. [14] dimensions labelled as "having the professional role" and "professional self-efficiency". The difference in

the number of obtained dimensions can be related to the differences in samples, that is in [15] study there were more nursing students, while in Tan's et al. [14] study participants were from various fields. Considering that professional fields differ in practices and requirements, it can be assumed that dimensionality of professional identity should be conceptualized for the specific profession.

B. Engineering identity

Rapid globalization and changes in contemporary society are largely stimulated and depend on technological development. In the 21st century science, technology, and innovation are the crucial factors for state and global economy, as well as social well-being [16]. Consequently, education policy makers try to encourage pupils to choose STEM (Science, Technology, Engineering, Mathematics) fields for their career path [17]. Moreover, engineers are highly sought-after employees in many countries [18], but the retention of employees in various professions nowadays is quite challenging [19]. Taking into account that higher levels of professional identity are related to the lower intention to job turnover [9], it would be important to examine the professional identity of engineers.

Engineers primarily base their professional identity on their technical competences [20]. Other important aspects of engineers' professional identity are creativity and innovation, while non-technical aspects, such as communication, ethics, social impact, and lifelong learning, are not seen by engineers as crucial for their professional identity [21]. These aspects represent technical/social dualism. That is, one part of engineers' professional identity relies on the technical aspects of engineering profession, while the other part is related to more heterogeneous, managerial, social and human aspect of abovementioned profession [22].

Considering the relevance of engineers and their professional identity, in our research we were interested in the better understanding of engineers' professional identity, with the emphasis on the professional identity in future engineers. More specifically, we examined the professional identity of engineering undergraduate students in Croatia. We were focused on the level of professional identity dimensions, defined by the Croatian version [15] of Tan's et al. [14] dimensions of professional identity. That is, we examined students' knowledge about engineers' practices, experience with engineering, and perception of the role model and professional future. To our knowledge, there is no research in Croatia regarding the professional identity of engineers, with the focus on engineering undergraduate students. Better understanding of the professional identity of future engineers may help educators and employers to build stable and strong attachment to the profession, which may result in positive professional outcomes and well-being [9].

C. Differences in professional identity

There are numerous personal and contextual factors which shape professional identity and depending on the exposure to those factors, some individual differences in professional identity can emerge [9]. The personal factor, which is extensively explored in scientific research, as a potential influence on professional identity, is gender. Recent studies demonstrated little or no gender differences in the professional identity development or the outcomes of professional identity [9]. These results are explained by the relevance of the working role in overall identity in women nowadays. Moreover, in order to balance the personal and professional life, as well as to solve the conflict between various roles more than men, it is assumed that women need to develop a clear and straightforward career path, interests, and identity.

However, one field, in which gender differences in professional identity are repeatedly demonstrated, is engineering. Over centuries, engineering is described and perceived as a masculine discipline [23]. Women are often seen in the workplace more as women and invisible as engineers [24]. According to [20], there are four ways in which interactions marginalize women's professional identity as an engineers and overly emphasize their gender identity: 1) gender is overly amplified, 2) gendered expectations are imposed, 3) women are tuning out, 4) doubts about technical abilities.

Differences between male and female engineers were observed in the perceived importance of some aspects of work more than in the perceived skill development [25]. That is, women prefer face-to-face communication compared to written communication, which is favored by men. Women place a higher value on social skills and relations than men counterparts. In other words, in terms of technical/social dualism [22], men are more technically oriented, while women are more socially oriented.

Research on engineering graduates demonstrated that male engineering graduates form their professional identities more easily compared to the female ones [26]. Moreover, female engineering graduates perceive the transitions from the study to the workplace a little bit more difficult than their male counterparts, because women struggled more to construct the engineering 'selves'.

Considering previous findings about gender differences in engineers' professional identity, in our research we examined whether gender differences in professional identity could be found as early as in the beginning of the engineering study.

Contextual factors also have an important influence on professional identity development and can yield to individual differences in professional identity. Impact of family characteristics is extensively explored and results are inconclusive [9]. On the one hand, it seems that dysfunctional family characteristics endanger professional identity development. On the other hand, some research (e.g., [27], [28]) demonstrated that family characteristics, such as the quality of family relationships or the degree of control, have very small or no effects on professional identity development. However, one type of influence from family on professional identity, which was not explored, can be rooted in the profession of family members. As Tan et al. [14] suggested, one dimension of professional identity is "having the professional as a role model" and family members can serve as an important work role model. Therefore, we decided to examine whether having engineers among close family members is related to higher levels of engineers' professional identity.

Participation in leisure and organized extracurricular activities or community services can facilitate identity development. However, high school students who are employed usually do not form a more mature professional identity and are not more decisive regarding professional choices compared to their peers who do not have jobs [29]. These results are attributed to the type of work of high school students. That is, high school students usually have unskilled manual jobs unrelated to their professional interests and future profession. However, employment in adolescence can have a postponed effect, helping individuals in psychological transition to work role (e.g., encouragement of responsibility, self-confidence) [30]. In higher education students have more opportunity to have jobs important for their professional development and aspired profession. Taking into account the key role of authentic work experiences for professional identity development in higher education [31], it would be important to explore whether students who work some student job would have higher levels of professional identity.

Finally, one important determinant of professional identity among higher education students can be the place of growing up. That is, students who have to move to the place of study have more mental health problems than students who did not have to move to the place of study [32], [33]. They also have to adapt their identity to a new living context and build a lot of new skills. There is no research on the influence of moving to the place of study on professional identity, but it would be important to explore whether individuals who move to the place of study are at risk to have lower professional identity, which can lead to dropout [34].

D. The current research

The aim of this research was to examine the level and differences in professional identity of Croatian undergraduate engineering students. We conceptualize professional identity as a three-dimensional construct, using the Croatian version [15] of Tan's et al. [14] dimensions of professional identity. That is, we defined professional identity through 1) students' knowledge about engineers' practices, 2) experience with engineering and 3) perception of the role model and professional future. In our research we were interested in the level of professional identity dimensions, as well as whether there are any differences in the level between these dimensions. To our knowledge there are no studies which explored those questions, therefore we are not able to define any specific hypothesis. In Gusar's et al. research [15] the trend of the lowest scores on the dimension "experience with the profession" can be seen, but differences between dimensions were not tested and study was not conducted on the engineering students. Therefore, we can assume a similar trend in our research, but the data on which we make such an assumption are not strong enough to form a specific hypothesis, so we assumed a null hypothesis that there were no differences between professional identity dimensions.

We also examined gender differences in professional identity dimensions. Considering previous research (e.g., [20]), we can hypothesize that female engineering students would have lower levels of professional identity than male engineering students. This hypothesis is supported by the findings that male engineering students have a stronger sense of identification with their future profession even before starting university compared to the female ones [26].

We also explored whether differences in professional identity depend on how informed students were about the study program before enrolling in the study, having engineers among close family members, and working a student job. Engineering professional interests and career plans are relatively stable over the high school period [35]. That is, by the end of high school, students usually have a clear picture that they want to become engineers and they have basic information about their future profession and what they need to master to perform it. Therefore, we can assume that students with higher levels of professional identity would be those students who informed themselves more about the study.

Moreover, considering previously mentioned research [9], [14], we assumed that students who have engineers among close family members and who work at student job would have a higher level of professional identity.

Finally, we examined whether students who had to move to the place of study (i.e., did not grow up in the same place as the place of study) have different levels of professional identity compared to students who grew up in the same place where they started their studies. We can assume that students who had to move to the place of study would have lower professional identity compared to students who did not have to move to the place of study, because they might have identity struggles and consequently their professional identity may not be so in focus. However, there is no research on this question so we cannot define any specific hypothesis, so we assumed a null hypothesis that there were no differences in professional identity between students who moved and those who did not move in the place of study.

In short, our research questions were:

- RQ1: Examine the level of professional identity and whether the dimensions of professional identity have different levels among undergraduate engineering students.
- RQ2: Examine whether the professional identity among undergraduate electrical engineering students differs depending on gender, how informed students were about the study program before they got enrolled in it, having engineers among close family members, working a student job, and place of growing up (is the place of growing up the same as the place of study or not).

II. METHODS

A. Participants

A convenience sample of 431 (73.1% male; age: M = 18.67, SD = 0.57) students of University of Zagreb Faculty of Electrical Engineering and Computing participated in this research. Students were mostly enrolled in the first year (98.6%), and some were enrolled in the second (1.2%)

or the third (0.2%) year of undergraduate study during the academic year of 2022/2023. Most students (75.6%) had achieved the highest possible grade on the final exam in mathematics at the end of high school. Only a few students (5.3%) reported working part-time jobs.

B. Procedure

The Ethics Committee of the University of Zagreb Faculty of Electrical Engineering and Computing had given approval of the study. The survey was conducted online. At the beginning of the survey, it was emphasized that students' participation was voluntary, and that information related to students' identity will only be used to assign them a symbolic amount of assignment credits in the course within which they were invited to participate in the survey. Students were also informed that they were allowed to terminate their participation at any time. Students completed the survey in 15-20 minutes.

C. Measures

In this section we will describe measures that were used. The factor structure obtained in confirmatory factor analysis (CFA), as well as the reliability of the measures in our research, will be shown in section *Data analyses*.

Professional Identity Five-Factor Scale (PIFFS [14]) was used to measure students' professional identity. It consists of 25 items divided in five factors: *knowledge of professional practice* (six items; "I know the nature of the work I will do in my future profession."), *professional experience* (six items; "I know personally some people who work in my future profession."), *role model in profession* (five items; "I admire professionals who are already working in my future work environment."), *self-efficiency* (six items; "I'm confident that I can do an excellent job in the future."), and *affinity to certain profession* (two items; "I am already pretty sure what kind of profession I will enter after completing the polytechnic or university education."). Response scale was from 1 ("definitely not correct") to 5 ("definitely correct"). Tan et al. [14] reported the reliability of the original five subscales $\alpha = 0.65–0.85$. PIFFS was validated in Croatia by [15]. In their research a three-factor solution was obtained, with factors Knowledge ($\alpha = 0.84$), Experience ($\alpha = 0.79$) and Perception of the role model and professional future ($\alpha = 0.84$).

D. Data analysis

In order to examine potential differences in professional identity t-test for independent samples was used, while for testing the differences in the level of the dimensions of professional identity repeated-measures ANOVA was used.

Prior to the aforementioned analysis, instrument exploratory (EFA) and confirmatory factor analysis (CFA) were performed for PIFFS in order to examine whether indicators were loaded to some extent on a latent variable (i.e., factor structures of our measures were examined). The results of EFA and CFA will be shown in this section, while the results that will answer our research questions will be shown in the *Results* section.

For EFA, SPSS statistical package, version 20 was used. Factors were extracted using principal axis factoring, with direct oblimin rotation (delta = 0). Eigenvalues greater than one, scree plot test and parallel analysis were used as the criteria for factor interpretation.

The R statistical package, version 4.1.3 was used to conduct CFA. To interpret models fit, several goodness-of-fit measures were taken into account: (a) χ^2 test (statistical insignificance confirms a good fit) [36]; (b) χ^2/df (good fit: values of less than 5) [37]; (c) comparative fit index (CFI) and Tucker-Lewis index (TLI) (good fit: values greater than .95) [38]; (d) a root mean square error of approximation (RMSEA) (good fit: values of less than .06) [38]; and (e) a standardized root mean square residual (SRMR) (good fit: values of less than .08) [37].

Professional Identity Five-Factor Scale in [14] obtained a five-factor structure, but with one scale with only two items, which represents fewer items than suggested (e.g., [39]). Their study participants were students of polytechnic in Singapore. Croatian validation study [15] obtained three-factor structure on students in different study areas, not only technical studies. Considering differences in previous research in factor structures and samples [14], [15], we conducted EFA using the random half of the sample. Prerequisites for factor analysis were met: KMO = 0.825; Bartlett's test of sphericity $p < .001$ with $\chi^2(120) = 1162.85$). EFA suggested a three-factor structure. The first factor explained 26.86% of variance, the second factor explained 9.58% of variance, and the third factor explained 7.57% of variance. A total of five items with cross-loadings and loadings lower than .3 – .4 [36] were not included in final solution. First factor, labelled Knowledge has seven items (e.g., "I know the nature of the work I will do in my future profession.") and examines students' knowledge of their future profession. Second factor, labelled Experience, has five items (e.g., "I am part of an interest group related to my computing/engineering.") and examines how many direct experiences with their future profession students already have had. Third factor, labelled Self-efficacy, has four items (e.g., I'm confident that I can do an excellent job in the future.") and examines students' level of self-efficacy related to their future work. Using the other random half of the sample, we conducted CFA for two-factor solution and obtained good model fit: $\chi^2 = 177.27$, $p < .001$, $df = 100$, $\chi^2/df = 1.77$, CFI = .927, TLI = .913, RMSEA = .063, RMSEA 90% CI [.047 .077], SRMR = .061. Modification indices indicated that one correlation between errors of items should be included because of items' wording. In our research the result on the subscales was calculated as the mean of all participant ratings. Internal consistency was .85, .68 and .74 for Knowledge, Experience, and Self-efficacy subscales respectively.

III. RESULTS

Regarding the RQ1, the obtained results displayed in the Table 1 suggest students' levels of professional identity vary with the highest level of professional identity being related to the dimension of Self-efficacy, followed by Knowledge, and finally Experience. The data demonstrated that the level of Knowledge dimension was around the average point of the response scale. The level of Self-efficacy dimension was above the average point,

while the level of Experience dimension was below the average point of the response scale.

Regarding the RQ2, the results presented in Table 2 demonstrated that male students score significantly higher than female in dimensions of Knowledge and Experience. Students informed about the study had significantly higher levels of all three dimensions of professional identity. Furthermore, students who have engineers among close family members have significantly higher levels of Experience dimension. Students who are working student job score significantly higher in dimensions of Knowledge and Experience. Finally, students whose place of growing up is the same as the place of study score significantly higher in dimensions of Experience and Efficacy.

TABLE 1. DIFFERENCES IN THE LEVELS OF THREE DIMENSIONS OF PROFESSIONAL IDENTITY (N = 431)

	$M(SD)$	F	$df1,df2$	η^2	$\Delta_{M1,M2}(SE)$	$\Delta_{M1,M3}(SE)$	$\Delta_{M2,M3}(SE)$
1. Knowledge	3.32 (0.80)	822.53	1.89, 812.02	0.66	1.05 (0.04)***	-0.77 (0.4)***	-1.82 (0.05)***
2. Experience	2.27 (0.87)						
3. Self-efficacy	4.09 (0.74)						

Note: ***$p < .001$.

TABLE 2. DIFFERENCES IN PROFESSIONAL IDENTITY

			Knowledge	Experience	Efficacy
Gender	Women (N=115; 26.93%)	$M(SD)$	3.08 (0.84)	1.86 (0.77)	4.06 (0.83)
	Men (N=312; 73.07%)	$M(SD)$	3.40 (0.77)	2.42 (0.86)	4.10 (0.72)
		$t(df)$	3.80 (425)***	6.51 (224.66)***	0.44 (425)
		Cohen's d	0.40	0.69	
Informed about study	Yes (N=202; 46.87%)	$M(SD)$	3.58 (0.78)	2.57 (0.89)	4.25 (0.66)
	No (N=229; 53.13%)	$M(SD)$	3.10 (0.75)	2.01 (0.77)	3.94 (0.78)
		$t(df)$	6.48 (429)***	6.92 (399.70)***	4.42 (428.22)***
		Cohen's d	0.63	0.67	0.43
Engineer(s) in family	Yes (N=170; 39.44%)	$M(SD)$	3.35 (0.78)	2.42 (0.88)	4.06 (0.75)
	No (N=261; 60.56%)	$M(SD)$	3.30 (0.82)	2.17 (0.85)	4.10 (0.74)
		$t(df)$	0.609 (429)	3.04 (429)**	0.541 (429)
		Cohen's d		0.29	
Lived in the place of study	Yes (N=198; 45.94%)	$M(SD)$	3.28 (0.82)	2.16 (0.85)	3.97 (0.78)
	No (N=233; 54.06%)	$M(SD)$	3.36 (0.79)	2.36 (0.87)	4.19 (0.70)
		$t(df)$	0.96 (429)	2.35 (429)*	2.96 (429)**
		Cohen's d		0.23	0.30
Student job	Yes (N=23; 5.34%)	$M(SD)$	3.70 (0.99)	2.83 (1.24)	4.23 (0.87)
	No (N=408; 94.66%)	$M(SD)$	3.30 (0.79)	2.24 (0.84)	4.08 (0.74)
		$t(df)$	2.31 (429)*	2.24 (23.14)*	0.92 (429)
		Cohen's d		0.56	

Note: *$p < .05$, **$p < .01$, ***$p < .001$.

IV. DISCUSSION

The aim of this research was to examine the levels and differences in professional identity of Croatian undergraduate engineering students. The level of professional identity ranges from below average to above average, depending on the professional identity dimension. Students did not have a lot of direct experience with the future profession (e.g., being part of an interest group related to the profession; interaction with professionals in the industry). Their knowledge about future profession, rules and regulation in the industry or roles and responsibilities of future job was on average level, while their self-efficacy about their future professional competences was above average. Differences in levels between three dimensions supported this trend. Just like in [15], Experience dimension is the lowest-scored dimension of professional identity, which is not surprising given that for most students this was their first semester and they didn't have much time to gain experience related to their future profession. Students' level of self-efficacy was the highest and above average. Considering that self-efficacy is related to achievement and occupational aspirations choice [40], it is promising for future employers that first-year students believe in their professional competences. Moreover, self-efficacy is related to students' grit [41], so we can assume that first-year students would have a lower inclination to drop out from higher education. However, students' institution as well as higher education institutions in general should invest in further professional identity development, because recent studies have highlighted that identity status is a dynamic and flexible process of exploration and commitment, rather than a static commitment to some identity [9], [42]. Professional identity in higher education can particularly be fostered by active engagement in activities related to the future profession and authentic experiences [31].

Regarding the differences in professional identity, our data are mostly in line with the hypothesis and previous research results (e.g., [20]) suggesting that male students would have higher levels of professional identity than female students. This difference, however, was not

obtained for the self-efficacy dimension. On the one hand, previous research demonstrated lower self-efficacy, in terms of using knowledge of engineering to solve relevant problems, in female students, including first-year students [43]. Previous research had also showed that, while academic self-efficacy in the context of engineering was higher in male students, female students had higher levels of career self-efficacy [44]. This finding is in line with the interviews with female engineering students who reported high career aspirations at the beginning of their studies [26], which may suggest that they were confident in their abilities. Unfortunately, during studies, their career aspirations declined, which may be attributed to gendered interactions and increase in interest in parenthood. Despite that, it seems that career self-efficacy amplifies during study [45]. Altogether, for future career paths, it is encouraging that female engineering students in our research had a high level of self-efficacy and that this level is as high as the self-efficacy level of their male counterparts. However, as suggested in [31], it would be important to construct activities fostering direct experience with the profession, and female students may profit more from those activities, given their lower knowledge and experience regarding their future profession.

As we assumed, students who were more informed about the study have higher levels of all three dimensions of professional identity. Engineering identity and interest towards engineering are mostly formed by the end of high school [35]. Higher interest is related to in depth engagement in activities associated with the subject of interest [46]. That is, students with higher levels of interest in engineering may search for more information related to their future profession, including study programs. Therefore, more information about the study program may reflect students' already formed professional identity, which has led them to collect more information about it. However, the relationship can be reversed: more information about the study program may lead to higher professional identity because students know what to expect in their future profession and that can facilitate professional identity development. To solve this question, longitudinal studies are recommended and needed.

Students who have engineers among close family members had a higher level only of Experience dimension of professional identity. Similar to previous research [27], [28], it seems that family has a small influence on professional identity. From adolescence onwards, individuals are inclined to question family members' work preferences rather than introject their opinions and work roles [47]. Therefore, it is possible that students in our research who have engineers as close family members wanted to build a career path, collecting knowledge, and fostering self-efficacy, on their own. However, they profit from exposure to engineering in the family, which was apparent from our data. That is, students who have engineers among family members could have easy access to engineering activities, interest groups, and direct experiences related to engineering.

Moving to the place of study is an enormous stressor [32], [33]. It is not surprising that students who had to move to Zagreb to study engineering had lower levels of self-efficacy and experience related to their future profession. These students have to adapt to new surroundings, separate from family and some peers, and promptly acquire some adult skills. Therefore, their self-efficacy related to future profession can be blocked by numerous stressors and skills to which they need to devote themselves. Some students may come from small places in which they perhaps do not have enough opportunity for direct experience with engineering. However, it seems that their professional aspirations and interests lead them to acquire as much declarative knowledge about their future profession as their counterparts from Zagreb.

Finally, our hypothesis regarding differences in professional identity depending on whether student work a student job was partly supported. That is, students who had a student job had a higher level of Experience dimension of professional identity. The partial support of our hypothesis can be explained by the characteristics of our sample. Namely, only 23 students (5.3 %) have a student job, and from those who had a student job, only 10 of them (43.5 % of students who had a student job) work in the field of engineering. A larger sample would be needed to provide support for our hypothesis.

V. LIMITATIONS AND FUTURE DIRECTIONS

Our research had a correlational research design, which makes it impossible to draw causal conclusions. Furthermore, all measures were self-reports, so students could respond socially desirable. The generalization of the results is limited because the participants were students of only one engineering faculty in Zagreb.

For future research it would be important to include longitudinal research design in order to determine possible changes in professional identity during study. It would also be important to have more students who have a student job in engineering field to make stronger conclusions about the relationship between student jobs and professional identity.

VI. CONCLUSIONS

The aim of this research was to examine the professional identity levels and differences in Croatian undergraduate engineering students. Research results were obtained from a sample of 431 electrical engineering and computing undergraduate students. Professional identity differences and levels were assessed using an online survey measuring three professional identity dimensions: knowledge about future profession, direct experience with future profession, and self-efficacy related to future profession, as well as socio-demographic characteristics.

Research results showed that self-efficacy dimension of engineering students' professional identity was higher than knowledge about future profession and direct experience with future profession dimensions. Male students, students informed about the study program, students who have engineer(s) as family members, students who were raised in the place of study, as well as students who have a student job, have all reported a higher level of direct experience with future profession and, in some cases, also one of the other two dimensions of professional identity. In line with [48], our results suggest that pre-professional socialization including having engineer(s) as family members and

having acquired information about the study program positively affects formation of professional identity, especially regarding the Experience dimension.

The obtained results have implications for higher education institutions' policies and practices. More emphasis should be placed on supporting professional identity formation, especially for female students. It might be of best interest for higher education institutions to familiarize their students with their programs, even before they enroll, both for fostering their professional identity, but also to better prepare them for challenges that await them. Finally, opportunities which would enable students to gain practical experience with their future profession would make a valuable addition to higher education institutions to foster professional identity formation, both on institution level, connecting students with their future employers, or on course level, providing students with insights into their future profession.

REFERENCES

[1] H. Tajfel, Differentiation Between Social Groups: Studies in the Social Psychology of Intergroup Relations. European Association of Experimental Social Psychology by Academic Press, 1978.

[2] H. Tajfel, The social psychology of intergroup relations. European Association of Experimental Social Psychology by Academic Press, 1978.

[3] H. Tajfel and J. C. Turner, "An integrative theory of intergroup conflict," in The social psychology of intergroup relations, W. G. Austin and S. Worchel, Eds., Monterey, CA: Brooks/Cole, 1979, pp. 33–37.

[4] T. Mussweiler, S. Gabriel, and G. V. Bodenhausen, "Shifting social identities as a strategy for deflecting threatening social comparisons," J. Pers. Soc. Psychol., vol. 79, no. 3, pp. 398–409, Sep. 2000, doi: 10.1037//0022-3514.79.3.398.

[5] N. Ellemers, R. Spears, and B. Doosje, "Self and social identity," Annu. Rev. Psychol., vol. 53, pp. 161–186, 2002, doi: 10.1146/annurev.psych.53.100901.135228.

[6] S. D. Reicher, R. Spears, and T. Postmes, "A Social Identity Model of Deindividuation Phenomena," Eur. Rev. Soc. Psychol., vol. 6, no. 1, pp. 161–198, Jan. 1995, doi: 10.1080/14792779443000049.

[7] J. Kroger, Identity development: Adolescence through adulthood, 2nd ed. in Identity development: Adolescence through adulthood, 2nd ed. Thousand Oaks, CA, US: Sage Publications, Inc, 2007, pp. xiv, 305.

[8] C. P. Tan, H. T. Van der Molen, and H. G. Schmidt, "A measure of professional identity development for professional education," Stud. High. Educ., vol. 42, no. 8, pp. 1504–1519, Aug. 2017, doi: 10.1080/03075079.2015.1111322.

[9] V. B. Skorikov and F. W. Vondracek, "Occupational identity," in Handbook of identity theory and research, Vols. 1 and 2, New York, NY, US: Springer Science + Business Media, 2011, pp. 693–714. doi: 10.1007/978-1-4419-7988-9_29.

[10] O. Malanchuk, E. E. Messersmith, and J. S. Eccles, "The ontogeny of career identities in adolescence," New Dir. Child Adolesc. Dev., vol. 2010, no. 130, pp. 97–110, 2010, doi: 10.1002/cd.284.

[11] D. Saunders, P. Gary, J. Sampson, and R. Reardon, "Relation of Depression and Dysfunctional Career Thinking to Career Indecision," J. Vocat. Behav., vol. 56, pp. 288–298, Apr. 2000, doi: 10.1006/jvbe.1999.1715.

[12] R. Lapan, "Career development across the K-16 years: Bridging the present to satisfying and successful futures.," Jan. 2004.

[13] E. T. Canrinus, M. Helms-Lorenz, D. Beijaard, J. Buitink, and A. Hofman, "Self-efficacy, job satisfaction, motivation and commitment: exploring the relationships between indicators of teachers' professional identity," Eur. J. Psychol. Educ., vol. 27, no. 1, pp. 115–132, Mar. 2012, doi: 10.1007/s10212-011-0069-2.

[14] C. P. Tan, H. T. Van der Molen, and H. G. Schmidt, "A measure of professional identity development for professional education," Stud. High. Educ., vol. 42, no. 8, pp. 1504–1519, Aug. 2017, doi: 10.1080/03075079.2015.1111322.

[15] I. Gusar, A. Tokić, and R. Lovrić, "Psychometric Analysis of the Professional Identity Questionnaires in Croatian Nursing Student Context," SAGE Open Nurs., vol. 7, p. 23779608211044600, 2021, doi: 10.1177/23779608211044600.

[16] "Science, Technology and Innovation in the New Economy." OECD, Sep. 2020. [Online]. Available: https://www.oecd.org/science/inno/1918259.pdf

[17] M. Caprile, G. Dente, R. Palmén, and P. Sanz, Encouraging STEM studies: labour market situation and comparison of practices targeted at young people in different Member States. LU: Publications Office of the European Union, 2015. Accessed: Apr. 24, 2023. [Online]. Available: https://data.europa.eu/doi/10.2861/519030

[18] T. J. Kennedy and M. R. L. Odell, "Engaging Students in STEM Education," Sci. Educ. Int., vol. 25, no. 3, pp. 246–258, 2014.

[19] "Ageing and Employment Policies: Retaining Talent at All Ages." OECD, 2023.

[20] D. M. Hatmaker, "Engineering identity: Gender and professional identity negotiation among women engineers," Gend. Work Organ., vol. 20, pp. 382–396, 2013, doi: 10.1111/j.1468-0432.2012.00589.x.

[21] J. R. Morelock, "A systematic literature review of engineering identity: definitions, factors, and interventions affecting development, and means of measurement," Eur. J. Eng. Educ., vol. 42, no. 6, pp. 1240–1262, Nov. 2017, doi: 10.1080/03043797.2017.1287664.

[22] K. L. Tonso, "Engineering Identity," in Cambridge Handbook of Engineering Education Research, A. Johri and B. M. Olds, Eds., Cambridge: Cambridge University Press, 2014, pp. 267–282. doi: 10.1017/CBO9781139013451.019.

[23] J. Jorgenson, "Engineering Selves: Negotiating Gender and Identity in Technical Work," Manag. Commun. Q., vol. 15, no. 3, pp. 350–380, Feb. 2002, doi: 10.1177/0893318902153002.

[24] W. Faulkner, "Doing gender in engineering workplace cultures. II. Gender in/authenticity and the in/visibility paradox," Eng. Stud., vol. 1, pp. 169–189, Nov. 2009, doi: 10.1080/19378620903225059.

[25] J. Naukkarinen and S. Bairoh, "Gender differences in professional identities and development of engineering skills among early career engineers in Finland," Eur. J. Eng. Educ., vol. 47, no. 1, pp. 85–101, Jan. 2022, doi: 10.1080/03043797.2021.1929851.

[26] V. Papafilippou and L. Bentley, "Gendered transitions, career identities and possible selves: the case of engineering graduates," J. Educ. Work, vol. 30, no. 8, pp. 827–839, 2017, doi: 10.1080/13639080.2017.1375088.

[27] B. K. Hargrove, A. G. Inman, and R. L. Crane, "Family Interaction Patterns, Career Planning Attitudes, and Vocational Identity of High School Adolescents," J. Career Dev., vol. 31, no. 4, pp. 263–278, 2005, doi: 10.1177/089484530503100404.

[28] B. Hargrove, M. Creagh, and B. Burgess, "Family Interaction Patterns as Predictors of Vocational Identity and Career Decision-Making Self-Efficacy," J. Vocat. Behav., vol. 61, pp. 185–201, 2002, doi: 10.1006/jvbe.2001.1848.

[29] M. J. Zimmer-Gembeck and J. T. Mortimer, "Adolescent Work, Vocational Development, and Education," Rev. Educ. Res., vol. 76, pp. 537–566, 2006, doi: 10.3102/00346543076004537.

[30] J. Mortimer, M. Zimmer-Gembeck, M. Holmes, and M. Shanahan, "The Process of Occupational Decision Making: Patterns during the Transition to Adulthood," J. Vocat. Behav., vol. 61, pp. 439–465, Dec. 2002, doi: 10.1006/jvbe.2002.1885.

[31] F. Trede, R. Macklin, and D. Bridges, "Professional identity development: a review of the higher education literature," Stud. High. Educ., vol. 37, no. 3, pp. 365–384, 2012, doi: 10.1080/03075079.2010.521237.

[32] R. Hechanova-Alampay, T. A. Beehr, N. D. Christiansen, and R. K. Van Horn, "Adjustment and strain among domestic and international student sojourners: A longitudinal study," Sch. Psychol. Int., vol. 23, pp. 458–474, 2002, doi: 10.1177/0143034302234007.

[33] I. Živčić-Bećirević, S. Smojver-Ažić, M. Kukić, and S. Jasprica, "Akademska, socijalna i emocionalna prilagodba na studij s obzirom na spol, godinu studija i promjenu mjesta boravka," Psihol. Teme, vol. 16, no. 1, pp. 121–140, 2007.

[34] D. Verdín, A. Godwin, A. Kirn, L. Benson, and G. Potvin, "Understanding How Engineering Identity and Belongingness Predict Grit for First-Generation College Students," Sch. Eng. Educ. Grad. Stud. Ser., Apr. 2018, [Online]. Available: https://docs.lib.purdue.edu/enegs/75

[35] P. M. Sadler, G. Sonnert, Z. Hazari, and R. Tai, "Stability and volatility of STEM career interest in high school: A gender study," Sci. Educ., vol. 96, no. 3, pp. 411–427, 2012, doi: 10.1002/sce.21007.

[36] T. A. Brown, Confirmatory factor analysis for applied research. in Confirmatory factor analysis for applied research. New York, NY, US: The Guilford Press, 2006, pp. xiii, 475.

[37] S. G. West, A. B. Taylor, and W. Wu, "Model fit and model selection in structural equation modeling," in Handbook of structural equation modeling, New York, NY, US: The Guilford Press, 2012, pp. 209–231.

[38] L. Hu and P. M. Bentler, "Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives," Struct. Equ. Model., vol. 6, pp. 1–55, 1999, doi: 10.1080/10705519909540118.

[39] R. B. Kline, Principles and practice of structural equation modeling, 3rd ed. in Principles and practice of structural equation modeling, 3rd ed. New York, NY, US: Guilford Press, 2011, pp. xvi, 427.

[40] A. Bandura, C. Barbaranelli, G. V. Caprara, and C. Pastorelli, "Self-efficacy beliefs as shapers of children's aspirations and career trajectories," Child Dev., vol. 72, no. 1, pp. 187–206, 2001, doi: 10.1111/1467-8624.00273.

[41] E. L. Usher, C. R. Li, A. R. Butz, and J. P. Rojas, "Perseverant grit and self-efficacy: Are both essential for children's academic success?," J. Educ. Psychol., vol. 111, pp. 877–902, 2019, doi: 10.1037/edu0000324.

[42] A. Brown, S. Kirpal, and F. Rauner, Eds., Identities at Work. Dordrecht: Springer Netherlands, 2007. doi: 10.1007/978-1-4020-4989-7.

[43] K. M. Whitcomb, Z. Y. Kalender, T. J. Nokes-Malach, C. D. Schunn, and C. Singh, "Comparison of self-efficacy and performance of engineering undergraduate women and men," Int. J. Eng. Educ., vol. 36, no. 6, pp. 1996–2014, 2020.

[44] C. Burger, J. Raelin, R. Reisberg, M. Bailey, and D. Whitman, "Self-efficacy in female and male undergraduate engineering students: Comparisons among four institutions," Jan. 2010.

[45] R. Marra, K. Rodgers, D. Shen, and B. Bogue, "Women Engineering Students and Self-Efficacy: A Multi-Year, Multi-Institution Study of Women Engineering Student Self-Efficacy," J. Eng. Educ., vol. 98, Jan. 2009, doi: 10.1002/j.2168-9830.2009.tb01003.x.

[46] M. Ainley, "Students' interest and engagement in classroom activities," in Handbook of research on student engagement, New York, NY, US: Springer Science + Business Media, 2012, pp. 283–302. doi: 10.1007/978-1-4614-2018-7_13.

[47] P. Fadjukoff, L. Pulkkinen, and K. Kokko, "Identity Processes in Adulthood: Diverging Domains," Identity, vol. 5, no. 1, pp. 1–20, Jan. 2005, doi: 10.1207/s1532706xid0501_1.

[48] M. Tomlinson and D. Jackson, "Professional identity formation in contemporary higher education students," Stud. High. Educ., vol. 46, no. 4, pp. 885–900, 2019, doi: 10.1080/03075079.2019.1659763.