2023-10-10

Can Students' Self-Efficacy Beliefs Explain Academic Motivation And Career Intentions?

Anna-Kathrin WIMMER
Ludwigs-Maximilians-Universität Munich, Germany, anna.wimmer@lmu.de

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A.-K. Wimmer
Ludwig-Maximilians-Universität München (LMU Munich)
Munich, Germany
anna.wimmer@lmu.de
ORCID: 0009-0004-2150-1231

Conference Key Areas*: Recruitment and Retention of Engineering Students, Curriculum Development*
Keywords*: self-efficacy, motivation, academic performance, career intention, competences*

ABSTRACT

In our technologized and increasingly complex world, jobs in STEM make a crucial contribution to innovation and sustainability. However, there are still many vacancies in this field. To tackle the shortage of professionals, it is even more important to successfully prepare qualified young people for engineering careers and foster competences that promote innovative and creative solutions. In addition to cognitive abilities, research has shown how self-efficacy, which describes confidence in one's own abilities to successfully overcome obstacles, can influence students' motivation, interest and therefore academic and vocational training success. Studies show that people with a strong belief in their own competence have greater persistence in completing and problem-solving tasks. Hence, this paper discusses how the students' own perception of self-efficacy can influence their interest in the subject, academic retention, and subsequent career intentions and success. To gain further empirical insights, data from the mixed-methods study "digiMINT" will be collected using narrative interviews with female pupils, STEM students and employees, as well as industry representatives. The aim is to understand conditions of engineering education and jobs, and additionally the perception of self-efficacy as a predictive

factor of career intentions. Furthermore, it will be evaluated how self-efficacy can be cultivated as a valuable skill in engineering education and teaching additionally to cognitive skills. In long term, promoting a positive experience for students' own self-efficacy could support a sustainable integration into the labor market and equip future engineers with an interdisciplinary which is particularly relevant for complex tasks in an increasingly complex world.

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1 INTRODUCTION

1.1 Background to the Research

A lack of mechanical and plant engineers as well as a high female dropout rate is a concern in Germany. The current challenges of our complex and sustainability-oriented world, such as demographic change, digital transformation or mobility turnaround in the face of the climate crisis, intensify the ongoing shortage of skilled workers. Particularly in the field of mechanical and plant engineering, which is a key industry sector for Germany, enormous disruptions due to advancing digitalisation processes can be observed and are still to be expected (Kagermann et al. 2013). In addition, there is a high dropout rate in STEM fields, where many potential STEM graduates get lost (Chen 2015). Digitalisation is accelerating in many areas of society, including industry, work, education and social life. This makes STEM, and especially key STEM occupations, increasingly important. (cf. Frielingsdorf 2019) Therefore, the subjects of electrical engineering, information technology, computer science and mechanical engineering as well as process engineering are of particular interest.

In addition, women are still under-represented in STEM subjects, particularly in engineering and computing, which are central to mechanical and plant engineering, although the number of female students and graduates is increasing. While the proportion of women in the first semester of these subjects increased from 13.39 per cent in winter semester 1998/99 to 21.62 percent in winter semester 2019/20 (Destatis 2021a), the proportion of women graduating in these subjects increased as well from 8.8 percent in 1999 to 19.73 percent in 2019. Only 18.5 percent of female graduates were found in core production and manufacturing jobs 12-18 months after graduating. (Destatis 2021b) Although there is an increasing share of women, not many of them are choosing careers in this field (Thomsen, Schasse, and Gulden 2020, 20). For that matter women still do not participate to the same extent as men, who dominate this field (Bandura et al. 2001). Hence, there are still wide gender disparities in career intentions and pursuits (Smith and Fouad 1999).

An explicit analysis of how women choose these STEM subjects and careers is particularly worthwhile valuable in the context to potentially disruptive trends and changes affecting the core STEM sector of mechanical and plant engineering. Since

the under-representation of women engineers in mechanical and plant engineering is thought to have both cultural and structural causes (Jeanrenaud 2020, 22–30), the aim is to gain a better understanding of the factors that influence individual career and life trajectories and how they relate to social and organisational contexts. Research will also focus on how to attract and retain women in STEM careers in a sustainable way.

1.2 Theoretical Framework / State of Research

Most career choice theories explain the necessary steps involved in choosing and implementing a career. Individuals must be aware of their skills, interests, individual characteristics and needs. However, personal self-efficacy and expected outcomes are mostly neglected. Despite existing talents, a person may doubt their own talent and suitability for the job. Consequently, their self-efficacy and individual outcome expectations would be low. The social-cognitive career model (Lent, Brown, & Hackett, 1994), based on Bandura's (1997) social-cognitive theory, explicitly includes these factors.

Hence, a very important dimension in the causal structure of this theory is the central role of self-efficacy. Self-Efficacy beliefs do not only affect adaptation and change themselves, but also by influencing other determinants. As a theoretical framework it explains career intentions through the influence of interests, outcome expectations and their evaluation, self-efficacy expectations, and contextual factors. (Bandura et al. 2001) Following Bandura (1977) we differentiate between self-efficacy expectations and outcome expectations. Self-efficacy is described as confidence in one's own ability to overcome obstacles and perform certain tasks successfully in the future. Outcome expectations are personal beliefs about the imagined consequences of certain actions. Self-efficacy can influence expected outcomes, but not the other way round. (Bandura and National Inst. of Mental Health 1986) Both outcome expectancies and self-efficacy beliefs are assumed to predict interest in a specific area. (Smith and Fouad 1999) Self-efficacy beliefs were found to contribute even more to career preferences than expected outcomes. This was particularly the case for women. They based their career preferences more on their perceived efficacy than on the attractiveness of the potential benefits of the occupation. (Bandura et al. 2001) But even with comparable prerequisites and identical professional self-efficacy as men, women still tend to expect lower outcomes. They expect to face greater difficulties and therefore are satisfied with less. (Abele-Brehm and Stief 2004)

In addition, a significant correlation has been observed between academic self-efficacy and persistence in higher education. (Gore 2006) Consequently self-efficacy beliefs play a major role for career development and aspirations (Abele-Brehm and Stief 2004). Self-efficacy beliefs correlate with career intentions, such as choice of occupation and career field, but also with success in the career field. However, there was no correlation found between gender and career intentions, when controlling for self-efficacy. Moreover, self-efficacy is correlated to career intentions when controlling for objective performance. (Epstein and Fischer 2017) Additionally, Self-

efficacy beliefs, when controlling for differences in ability, prior educational attainment and aptitude, and career interests, predict career choice and mastery of the educational requirements for those careers. (Lent, Brown, and Hackett 1994)

If self-efficacy is high, one sees oneself as capable to master educational requirements and job-related skills, and expects positive results. As a result, the range of career options becomes wider. (Bandura et al. 2001) This leads to the development of interests relevant to that particular choice of work life, better preparation for the career path, and persistence in pursuing a career in that field. So self-efficacy mediates between skills and performance. Moreover, interests, together with self-efficacy and outcome expectancies, predict aspirations. (Smith and Fouad 1999)

Lower self-efficacy beliefs and consequently lower interest in maths and science could therefore explain the under-representation of women in technical professions such as mechanical and plant engineering to a certain extend. Thus, direct interventions targeting one's self perceived attributions and self-efficacy ought to have a significant impact on individual aspirations and career choice. Within the context of mechanical and plant engineering, self-efficacy based interventions could therefore help to promote interest in that specific area. (Smith and Fouad 1999) However, it is assumed that self-efficacy is by no means the only factor influencing the career intentions of graduates but can serve as a valuable skill to be taught and trained.

Though the research project is still in the process of conducting the survey and interviews. Consequently, the first empirical results are not yet available. Therefore, this paper presents the background of the research project, the methodological approach, and the theoretical framework for exploring self-efficacy in engineering education and professional development.

1.3 Research objective

The intention of this paper is to emphasize the perception of students' self-efficacy as a predictive factor and its relevance for academic capabilities and expected outcomes, such as career intentions and trajectories. The evaluation of self-efficacy expectations in the survey want provide context-specific insights into the factors that influence self-efficacy in this field. (Bandura and National Inst of Mental Health 1986).

In-depth questions inspired by the BSW scale (Knispel et al. 2021), which is a validated instrument for use with students and employees that measures expectations of vocational self-efficacy in an economic way. Conceptually, this scale reflects motivational and skill-related aspects of occupational self-efficacy. (ibid.)

The project aims to investigate the perceptions of self-efficacy among students in mechanical and plant engineering. Specifically, it will focus on their beliefs about their ability to meet educational requirements, possess relevant skills, and maintain interest in the field. The project will also explore how students' confidence in their

abilities influences their study-related intentions and expected outcomes. Additionally, the project will examine the motivational and competence-related aspects of vocational self-efficacy.

It is particularly interesting to explore the significance of self-efficacy perception for women engineers in decision-making processes related to their study course, career intentions, and persistence in pursuing a career in the field. It seeks to understand how self-efficacy influences choices of occupation and career field, beyond objective performance measures. Additionally, the study will investigate the impact of learning experiences and contextual factors on self-efficacy, as well as potential indirect effects of self-efficacy on career behaviour.

1.4 Research Question

The research seeks to gain a comprehensive understanding of the factors that contribute to self-efficacy of female students and professionals in mechanical and plant engineering. The focus lays on exploring the perception and relevance of self-efficacy for female students in this field, as well as their experiences in learning, working, social, and motivational contexts. The emphasis will lay on identifying the various factors, such as social, cultural, learning, and working contexts, support systems, and resources, that promote or hinder the development of self-efficacy in female students and professionals in mechanical and plant engineering. This includes exploring the role of stereotypes, gender biases, and societal expectations in shaping self-efficacy beliefs.

Therefore, the following research questions will be addressed:

1.) *What influencing factors (e.g. social, cultural, learning or working contexts, support systems or resources) and how do they promote or hinder the development of self-efficacy in female students and professionals in mechanical and plant engineering?*

2.) What are the potential barriers and challenges faced by female students in mechanical and plant engineering in terms of their learning, working, social, and motivational contexts, and how can these be addressed to promote self-efficacy?

3.) How does the perception of self-efficacy among female students in mechanical and plant engineering influence their motivation, career aspirations and persistence in the field?

In addition, the focus will be on how these findings can be implemented in engineering education and teaching as well as in business contexts. There is evidence from empiric research that self-efficacy develops with experience on task and can be influenced by positive feedback and causal attributions. In particular, feedback and attributions about how well one performs is suspected to directly affect self-efficacy, and consequently, aspirations and possible outcome expectations. Thus, self-efficacy and aspirations can change over time any may be subject to intervention. This is particularly in line with the predictions of social cognitive theory of Bandura which suggest that individuals are motivated to perform at higher levels

as long as they feel capable of achieving their set goal. This is especially decisive who attribute their performance to internally controlled factors, who sees the positive outcomes as a result from individual's own ability. As shown, self-efficacy is positively correlated with individual aspirations, hence changes in perceived self-efficacy lead to changes in outcome expectations. The art of feedback can have a direct impact on how high persons set their individual goals. (Tolli and Schmidt 2008)

This suggests the importance to build students' self-efficacy as a valuable skill additionally to cognitive skills. Regular, constructive feedback could be one way in engineering education and teaching. Interventions that focus on feedback, attributions and self-efficacy can have a valuable practical impact (Tolli and Schmidt 2008) to reduce drop-outs and enable a smooth transition from the study to work life for graduates. The upcoming survey will provide more insight to how individuals experience their study and the teaching regarding her own perception of self-efficacy, how they achieve in the subject as well as how they assess their own performance during the study. It is therefore up to research to what extend feedback could be more integrated in engineering education and teaching in order to positively influence students’ self-efficacy.

2 METHODOLOGY

2.1 Empirical Concept and Research Design

This paper is based on our ongoing project, funded by the German Federal Ministry of Education and Research (BMBF) (01FP22M01). It focuses on the under-representation of women in STEM, particularly in mechanical and plant engineering, in order to address the shortage of skilled workers in this sector, which plays a vital role for the German industry. The aim is to analyse the factors that contribute to the successful recruitment and retention of women in mechanical and plant engineering. The main objective is to investigate the decision-making processes that encourage or discourage women engineers from taking up certain types of jobs in the engineering sector. The methodological approach focuses on which socio-cognitive, cultural and contextual factors are most likely to explain individual career and life trajectories of women engineers in this field.

The study began in October 2022 with an extensive literature review. This will be supplemented by a mixed-method-design, combining qualitative and quantitative empirical methods, which is particularly suited exploring these issues in depth.

2.2 Data Assessment and Analysis

Five cohorts of female students in different semesters, graduates and young professionals were interviewed as well as people in management positions at companies were surveyed with a questionnaire. Both will be recruited via snowball system and contact persons of the companies of various actors in the field (e.g. associations, universities, national and local women engineers' networks).

As the research focuses on cultural and structural reasons, qualitative, problem-focused interviews will be used to explore how these affect individual professional

and career paths (Dröge 2020) with female students and engineers. The survey is based on telephone and/or video interviews with these five cohorts of around ten people each who are studying or have graduated in a STEM subject relevant to mechanical and plant engineering, with a significantly low proportion of women even among STEM fields. The research thereafter will survey and retrospectively analyse the choices of female STEM students and reflect on the active orientation of female pupils in their choice of study. Moreover, we want to gain more detailed insight into the factors that influence the course of STEM studies and the transition to work. Self-efficacy is a crucial aspect and should always be addressed and evaluated as a cross-cutting issue. The aim is to understand the influence of learning experiences and contextual variables on self-efficacy, as well as the possible indirect effects of self-efficacy on career behaviour of women engineers. It will be focused to what extent self-efficacy perception is a predictive factor to improve women' participation in STEM, thus self-efficacy is correlated to interest and development of skills relevant of that field, as well as career intentions and persistence, as already mentioned. This will provide valuable insights into the role of self-efficacy in shaping the career trajectories of STEM graduates.

Furthermore, the questionnaires also aim to include the business perspective by gathering insights from individuals in management positions. This helps to understand how organizations and employers can support and enhance self-efficacy, career development, and the successful transition of STEM graduates into the workforce as well as their retention. This includes identifying the specific technical and non-technical skills that are valued by employers, and understanding the organizational policies, frameworks and practices that support the career development, job satisfaction, and engagement regarding self-efficacy. Therefore, a standardised online questionnaire for management positions within the fields of Mechanical and Plant Engineering is planned to gather further information. We are expecting to receive around 380 responses in order to get a representative picture of the situation in mechanical and plant engineering for Germany. The aim is to gather more insight to their perspective and to better understand the factors that contribute to fostering self-efficacy in the context of mechanical and plant engineering.

The total of approximately 50 interviews will then be transcribed and analysed using qualitative content analysis. (QIA) (cf. Schreier et al. 2019; Schreier 2014) according to Philipp Mayring (cf. 2016) and Udo Kuckartz (cf. 2016). The analysis software MAXQDA[1] is used for this purpose (cf. Steinke 2007). The open source software Limesurvey[2] is used for the online survey of companies in the mechanical and plant engineering sector.

[1] www.maxqda.de

[2] https://community.limesurvey.org/

3 RESULTS

Detailed analysis of the data collected through qualitative interviews and statistical analysis of responses to the online questionnaire will be conducted and collated once the survey is completed. Final results are expected by the end of 2025, but first first interim results arising from the interviews shall be presented beforehand. The findings ought to provide insights how the perception of self-efficacy among female students in mechanical and plant engineering influences their motivation, career aspirations, and persistence in the field. This includes exploring the relationship between self-efficacy and career decision-making, goal-setting, and career advancement. The research will shed light on how social and cultural factors influence the development of self-efficacy in female students in mechanical and plant engineering. This includes exploring the role of stereotypes, gender biases, and societal expectations in shaping self-efficacy beliefs. First insights into the learning and working environments that promote or hinder the development of self-efficacy in female students will be provided. This includes examining e.g. the role of supportive learning environments, access to resources or opportunities for hands-on experiences in fostering self-efficacy.

Overall, we expect the findings will uncover the challenges and opportunities faced by graduates during their study and transition from academia to workforce. Understanding these challenges will help in developing strategies to address them and promote self-efficacy. Furthermore, the anticipated findings will provide valuable information on the employer perspective, helping to bridge the gap between the expectations of employers and the experiences of STEM professionals. The findings and insights from the analysis can help educational institutions and policymakers align their curriculum and training programs. Furthermore, the results can guide employers in creating a supportive and engaging work environment for STEM professionals that enhance the alignment between the needs of employers and the experiences of STEM graduates, ultimately contributing to the successful integration of STEM talent into the workforce. Appropriate measures, actions to be taken and, where necessary, further research will be identified. In this way, a cultural change should be initiated and promoted in the long term to attract and retain more female STEM graduates in industrial companies, considering the diversity of women’s specific life situations. We aim to develop empirically based recommendations for industry, academia and politics to address the underrepresentation of women in STEM based on findings from the project itself. (cf. Jeanrenaud 2020)

4 ACKNOWLEDGMENTS

The project on which this paper is based was funded by the German Federal Ministry of Education and Research (BMBF) under the funding code 01FP22M01. The responsibility for the content of this publication lies with the author. The project continues from October 2022 until September 2025.

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