Career Paths of Women Entrepreneurs in STEM – Challenges and Opportunities

Julia Schnittker
Research Assistant/PhD Candidate
University of Siegen,
Chair for SME Management & Entrepreneurship
Unteres Schloß 3, 57072 Siegen, Germany
Phone: +49 271-740 3191
Email: julia.schnittker@uni-siegen.de
Website: www.wiwi.uni-siegen.de/welter/

Kerstin Ettl
Junior Professor
University of Siegen
Junior Professor for Entrepreneurial Diversity & SME Management

Key Words:
women entrepreneurs, STEM, career paths, stereotypes, qualitative research

Abstract

Objectives – STEM (Science, Technology, Engineering and Mathematics) fields face a huge skills shortage. In this regard, women are 'untapped potential'. This paper outlines career paths and career experiences of women STEM entrepreneurs in order to derive recommendations and best practices at the academic, entrepreneurial and intermediary levels for fostering STEM entrepreneurship by women in the future.

Prior Work – Both entrepreneurship and STEM are male-dominated fields. Amongst already STEM-sensitized women, the gender gap actually persists: these women are still less likely to foster their careers or even to start businesses in STEM fields compared to men. Given the huge need for talented STEM workers, great opportunities exist in the field for women. Little is known so far about the career paths of women STEM entrepreneurs, so more knowledge about their challenges and opportunities may lead to recommendations for prospective women STEM entrepreneurs.

Approach – This paper is based on 30 semi-structured, qualitative interviews with women STEM entrepreneurs in different phases of their careers. We audio recorded, transcribed and systematically coded the data, taking into account investigator triangulation. Drawing on Krumboltz's Happenstance Learning Theory (HLT), Fiske and Cuddy's Stereotype Content Model (SCM) and results from other studies, we discuss the career experiences and career-related decision-making processes of women STEM entrepreneurs and the role that stereotypes and perceptions play in this regard.

Results – In our sample, women whose parents had a STEM business nevertheless initially chose qualifications in non-STEM fields. According to our interviewees, whether their parents themselves worked in STEM or were self-employed did not determine whether or not their daughter actively aimed to become a woman STEM entrepreneur. In fact, the decisive factor seemed to be the woman's initial intrinsic interest in STEM, developed through hands-on experience. Women STEM entrepreneurs frequently confront stereotypes concerning their positions and roles, though sometimes they can take advantage of these stereotypes. Being aware of multi-layered external perceptions, women STEM entrepreneurs rather perceive being female in male-dominated environments to be an opportunity, as they feel somewhat admired and respected for their successful career paths.

Implications and Value – According to our results, career entry seems to be the most critical milestone for a successful STEM-related career. Therefore, our results support current endeavours to sensitize school-age girls for STEM-related professional paths so that they may explore their interest in STEM hands-on.

1. Objectives

Today's globalized, digitized work environment is characterized by rapid change. Firms face uncertainty and the need to adapt continuously to new structural and situational challenges. In this context, innovation helps companies and economies tackle changes and overcome global competitive constraints. The STEM fields (Science, Technology, Engineering and Mathematics) assume key roles in providing these innovations. Against this backdrop, STEM fields have a huge skills shortage. Empirical data nevertheless show that women are largely underrepresented in STEM in most cultures and countries, including in Germany. Girls and young women still prefer female-dominated professions, resulting in strong gender segregation in more science- and technology-driven fields of study such as IT and engineering (OECD, 2017). Even women who graduate in the same fields of study as men make different occupational choices and have different career paths afterwards. That is, STEM fields have a leaky pipeline of women. With rising educational or professional level in STEM fields comes less participation by women, which is why only 15% of STEM leadership positions, for example, are held by women (Vongalis-Macrow, 2016). Moreover, women with a STEM background are still less likely to launch STEM careers or businesses compared to men with a STEM background (Adams and Kirchmaier, 2016). As a result, STEM fields, business ownership and careers in leadership are perceived as masculine areas (Kawakami et al., 2000; Shapiro and Sax, 2011). Therefore, women entrepreneurs operate in social spaces that are unsympathetic to their gender (Marlow and McAdam, 2015), the effects of which appear to intensify in STEM, as research on women entrepreneurs in high-technology fields has demonstrated (Tan, 2008).

Several studies have discussed women's entrepreneurship and issues of STEM in conjunction with their choice of academic study, but the career development and paths of women entrepreneurs in the context of STEM fields have been rarely discussed. Thus, we aim to outline the career paths and experiences of women entrepreneurs who (almost all) have an educational background in STEM and who are running STEM-related businesses. Drawing on Krumboltz's Happenstance Learning Theory (2009) and Fiske and Cuddy's (2002) Stereotype Content Model, we discuss career paths, career experience and career-related decision-making processes of women entrepreneurs in STEM and the roles that stereotypes and perceptions related to women's entrepreneurship, women in STEM and their combination play in this context. We aim to unlock new insights related to our overarching research question: ***Which challenges and opportunities do women STEM entrepreneurs face during their careers and what influences their career decisions?*** Our overarching goal is to derive recommendations for fostering women's entrepreneurship in STEM in the future.

Krumboltz (2009) recognised the need for studies first to examine how many adults with different demographic backgrounds attribute their current professional situation to an early planned career decision compared to one or more unplanned events and second to address how to adapt Happenstance Learning Theory to people of different cultures, genders and ethnic origins. Listening to the stories of women who are STEM entrepreneurs, we illuminate their possible career paths and challenges they faced during career entry and advancement. We closely look at these women's motives and investigate which opportunities and contextual factors in their biographies led to their (entrepreneurial) career chances and choices, especially related to perceptions and stereotypes regarding entrepreneurship, STEM and their combination.

In this remainder of this paper, we start by briefly overviewing existing research and theoretically framing our study. We then describe our methodological approach, in particular the sample, data collection and coding. After presenting and discussing selected results, we conclude by deriving recommendations and best practices for academics, entrepreneurs and intermediaries.

2. Literature / review

To theoretically frame our investigation of career entry and advancement by women STEM entrepreneurs, we refer to Krumboltz's (2009) Happenstance Learning Theory (HLT), which explains how and why people pursue their individual paths in life, as well as how counsellors can facilitate this process. According to the HLT, human behaviour is based on innumerable learning experiences that result from both planned and unplanned life situations. As a result (or 'learning outcome'), *skills*, *interests*, *knowledge*, *beliefs*, *preferences*, *sensitivities*, *emotions* and *future actions* are formed and determined. Individuals cannot control all factors that influence their life. Krumboltz (2009) terms 'happenstance' the complexity of the interactions, with barely predictable consequences, among planned and unplanned actions in response to self-initiated and circumstantial situations. Accordingly, career paths are primarily determined not by individual's initial career decisions but by unplanned events and situations. Participation in a variety of activities while remaining attentive to alternative opportunities

plays a decisive role. Career counsellors should therefore sensitize their clients to the importance of happenstance as well as to the need to acquire skills to succeed in any new activity (Krumboltz, 2009).

Much work has discussed the impact of stereotypes regarding women's careers, career opportunities and perceived barriers in male-dominated sectors. Deemer et al. (2014), for instance, explored how the 'stereotype threat' negatively influences women's career choices when, for example, female students evaluate their options for career entry in a male-dominated sector. In this situation, women might perceive specific barriers caused by gender-related stereotypes as making their chances for a successful career in STEM fields worse than they actually are. Moreover, as Gnilka and Novakovic (2017) noted, the threat of negative stereotyping inhibits women's engagement in activities that may foster their self-efficacy in career choices. Krumboltz (2009) criticised the custom by which young children are already asked which career they would like to pursue, given that the future is unpredictable and young children cannot yet know what opportunities they will later have given that new career opportunities are constantly emerging, especially in today's digitally driven STEM fields. Krumboltz (2009) also pointed out that children often answer such questions with answers their parents want to hear. In this way, the picture of a career wish is formed and strengthened which does not correspond to the child's actual interests or wishes; yet, since interests and life circumstances change, career options can only be appropriate for a current situation (Krumboltz, 2009). It is not possible to predict future preferences and influencing factors; unplanned events are part of every career and, according to Krumboltz, are even necessary, although every person has to assess the associated risks themselves. However, mistakes need not be feared, because learning from setbacks leads to progress in personal career paths. Unplanned events can be controlled by (1) taking actions in advance that position oneself to gain experience from unplanned events, (2) remaining alert and sensitive to potential opportunities during unplanned events and (3) initiating actions afterwards to benefit from unplanned events (Krumboltz, 2009).

Women's social environments highly influence their career paths and decisions (Abbasi and Sarwat, 2014; Krumboltz, 2009). People continuously observe the world around them, forming impressions and trying to understand what they perceive (Krumboltz, 2009). While much of what is learned in this way may not have great significance or visible effects, it nonetheless affects how later observations are perceived and what feelings are associated with those observations (Krumboltz, 2009). Individual perceptions depend on the respective values that sustain a person's life; more familiar things are more likely to transform into values (Allport, 1954). For women and STEM, then, appropriate role models affect both whether girls become interested in technology, science or engineering (Trauth et al., 2008) and their entrepreneurial propensity (Ndinguri et al., 2014). Prior research has identified that women entrepreneurs positively influence their daughter's entrepreneurial propensity (Greene et al., 2013). The lack of adequate STEM role models for girls and young women may foster their persistent self-selection into non-technical fields (Katz et al., 2006). Young boys and girls already exhibit differences in the use of modern technology. While boys access new media in a more exploratory fashion, girls use the same technology more reactively and consumption-oriented (Hoffmann and Vance, 2007). These initial patterns shape each gender's relationship to technology later in life, with young women showing less interest in technology-driven professions and industries than men and possessing a lower level of technological knowledge. Individuals form generalizations about their own interests, abilities, values and beliefs (Krumboltz and Henderson, 2008). That is, some experiences may evoke memorable interests and passions, while others may not. Kyriakidou (2012) investigated how professional identity is constructed, arguing that professional identity consists of attributes, beliefs, values, motives and experiences. In her study, female engineers were fully aware of existing stereotypes about female engineers but decided anyway to pursue careers in leading positions. Pejić Bach et al. (2016) also detected a strong influence of gender on entrepreneurial intentions. Investigating the ICT industry, they found that which factors influence entrepreneurial intention differs by gender. While male ICT students seem driven by extrinsic factors, female ICT students seem instead to be driven by intrinsic ones. However, they argue, education decisively strengthens women's self-esteem and belief in their own success (Pejić Bach et al., 2016). This implies that women STEM entrepreneurs must first gain exposure to both STEM and entrepreneurship in order to gain relevant learning experiences in both fields. However, what exactly young women learn from their experiences with STEM or entrepreneurship is critical; negative experiences may lead young women to distance themselves from a career as STEM entrepreneurs, whereas positive experiences may encourage them toward a STEM-related entrepreneurial career path.

Societal perceptions of occupations considered 'appropriate' or 'inappropriate' for women also affect career choices and paths. Where a gendered division of labour results in housebound roles for women, they experience longer career breaks (Bijedic et al., 2016), which reduce their social and financial capital and may additionally hinder them from becoming women STEM entrepreneurs in later life stages. Moreover, as Wing-Fai (2016) stated, the decision to found a business involves not just a single person but a whole family and household

behind the founder. Through qualitative interviews, Wing-Fai (2016) examined innovative technology companies in Taiwan, finding that most involved whole families or at least a spouse. Many interviewees stated that the founding has been intensively discussed beforehand among family members. Usually, both partners lead the company and therefore both are entrepreneurs; becoming an entrepreneur is less a matter of gender in this case but is instead a family decision (Wing-Fai, 2016). Comparing women entrepreneurs in industry sectors with those in the trade and service sectors, Machado et al. (2016) emphasised that women entrepreneurs cannot be seen as a homogenous group but are instead diverse in terms of their reasons for self-employment, including, for instance, desire for financial independence, perception of opportunities, personal fulfilment and dedication to what one wants to do.

The Stereotype Content Model (SCM; Fiske and Cuddy, 2002) offers one possible theoretical explanation for the gender gap in STEM. Focussing on perceptions, SCM defines content-related differences in stereotypes and prejudices towards different groups of people, additionally explaining the reasons why and scenarios in which they occur (Fiske and Cuddy, 2002). In this regard, Fiske and Cuddy (2002) examined six characteristics: *gender*, *ethnicity*, *race*, *class*, *age* and *disability*. Concerning *gender*, the authors argue that two subgroups of women differ in how they are socially perceived. So-called 'career women', feminists, lesbians and athletes are more likely to be perceived as disliked, dominant, competent and non-traditional, while homemakers, for example, are more likely to be perceived as likable, dependent, incompetent and traditional. One basic assumption of the SCM is that *competence* and *warmth* are primary dimensions, perceived as the intention (positive or negative) and ability of the subjectively evaluated person. In this context, the goals of the perceived person with regard to the perceiver and their own group (the "in-group") are considered. Other basic assumptions of the SCM are that *high warmth combined with low competence* and *high competence combined with low warmth* are frequently mixed clusters, that the four combinations of in-/competence and warmth/coldness are differentiated by the four emotions *pity*, *envy*, *admiration* and *contempt*, and that, stereotypically, status predicts high competence and competition predicts low warmth. According to the SCM, then, women who pursue careers are often considered *competent but cold* and therefore arouse envy in their social environment. Moreover, Fiske and Cuddy (2002) found, people who are perceived as competent but cold (such as career women) can also arouse admiration in an in-group. They also concluded that some groups of people—aside from career women—who are perceived as less competent or less cold may arouse pity or contempt. Therefore, regarding women STEM entrepreneurs, we suppose that they face envy or admiration in a male-dominated environment.

Considering both the HLT (Krumboltz, 2009) and the SCM (Fiske and Cuddy, 2002), we examine the career paths of women STEM entrepreneurs, the challenges and opportunities that influence their career decisions, their decision-making processes and the influence of stereotypes and perceptions. In detail, we investigate whether and to what extent career paths of women STEM entrepreneurs are influenced by their initial career decisions, unplanned events or stereotypes.

3. Approach/Method

3.1 Sample

Our empirical basis are 30 qualitative interviews with women STEM entrepreneurs in Germany, aged 26 to 55 years at the time of the interview and between 22 and 47 years when they started their companies. Their range of experience as entrepreneurs was between 0 and 20 years. To gain a comprehensive picture in different contexts, we interviewed women entrepreneurs in different regional contexts and at different career phases, some in their start-up phase and others who are leaders of successful, already-established SMEs. Interviewees were selected through a snowball system from our own existing network of contacts. Table 1 overviews the interviewees.

Table 1: Overview of the Sample

No.	Age	Academic/Professional Qualification	Age at founding	Years self-employed	Business sector	Regional context
1(IP6)	41	study: international business	36	5	Mechanical engineering	Rural
2 (IP11)	26	study: bio- & nanotechnology	26	0	Technical Development	Urban
3 (IP14)	50	toolmaker & study: electrical engineering	36	14	Toolmaking in the metal industry	Rural
4 (IP16)	26	study: mechanical engineering	22	4	Mechanical engineering	Rural
5 (IP17)	32	study: industrial engineering	29	3	Process optimisation	Suburban
6 (IP22)	49	industrial mechanic & study: mechanical engineering	33	16	Hydraulics	Rural
7 (IP24)	42	business graduate, heat treatment technician & technical business administration	24	18	Metalworking	Rural
8 (IP25)	41	study: economics & MBA, diploma architectural engineering	29	12	Craft	Suburban
9 (IP30)	48	study: interior design	30	18	Engineering	Suburban
10 (IP31)	29	Interpreter; study: international business communication	28	1	Software	Metropolitan
11 (IP32)	34	study: mathematics & MBA	33	1	Development and production of in-ear headphones	Metropolitan
12 (IP33)	37	study: electronical engineering & MBA	34	3	Software development	Metropolitan
13 (IP35)	31	study: mechanical engineering MBA	28	3	Flow measurement technology	Suburban
14 (IP36)	35	study: industrial engineering	27	8	Consulting for data protection	Suburban
15 (IP38)	47	study: construction engineering	47	0,5	Maintenance and inspection of industrial plants and historical buildings	Suburban
16 (IP39)	32	study: media production & game design	26	6	Game development	Metropolitan
17 (IP46)	31	study: process engineering	24	7	Technology-based wastewater treatment	Metropolitan
18 (IP48)	37	study: communications engineering & master of international business	34	3	Installation of video surveillance technology	Metropolitan
19 (IP49)	36	study: biology & BA	33	3	Electrical and civil engineering company	Metropolitan
20 (IP51)	30	study: computer science	28	2	Software development	Urban
21 (IP58)	37	study: chemistry & mathematics	33	4	Experimental laboratory for children	Metropolitan
22 (IP62)	30	study: technical business administration (focus marketing)	28	2	Production of 360° videos	Metropolitan
23 (IP63)	44	study: chemistry and pharmacy	35	9	Patent attorney in STEM	Metropolitan
24 (IP64)	33	study: industrial engineering	30	3	Development of electroless refrigerators	Metropolitan
25 (IP65)	55	Study: sports economics	44	11	Personnel consulting and recruitment in the fields of (special) mechanical engineering, IT and corporate finance	Rural
26 (IP67)	34	Scaffolding	22	12	Software development	Rural
27 (IP68)	49	technical draughtswoman	37	12	Production and programming of electronic circuit boards	Rural
28 (IP69)	41	study: engineering	40	1	Company builder and venture capital provider for PropTech companies	Metropolitan
29 (IP70)	33	study: geo-ecology	31	2	Climate adaptation consulting	Metropolitan
30 (IP72)	31	Study: jurisprudence & economics	23	8	Software development	Urban

(Source: Own research)

3.2 Data collection and analysis

Given our aim to gain a comprehensive picture of women's experiences in STEM and to identify challenges, barriers and opportunities the interviewees faced during their career paths, our interview guideline focussed on interviewees' current career situations, personal background and influencing factors on their careers, including their social, personal and professional environments. For instance, interviewees were asked to evaluate their own careers and what their careers personally mean to them. In addition, they were explicitly asked to self-describe themselves professionally and to evaluate how they think others in their professional contexts would describe them. We also asked specific questions about stereotypes as actively perceived of interviewees, and we asked for advice for other (or future) women STEM entrepreneurs on the basis of their own experiences. The semi-structured interview guide only served as an orientation guide; not all interviewees were asked all questions.

To maximize traceability and transparency, all interviews were triangulated between investigators. Each roughly hour-long interview was conducted face-to-face with two researchers, then tape-recorded and subsequently transcribed with MAXQDA18, following the rules of Kuckartz et al. (2008). All transcribed interviews were initially coded according to a system previously developed based on topics relevant to our theoretical framework as presented above. Example codes include *career decision*, *unplanned event/opportunity*, *influencing factors*, *addressed stereotypes* and *presumed stereotypes*. While coding the interviews, we identified further relevant

topics to receive further codes, such as *active decision*, *reactive decision*, *perceived scepticism*, *self-confidence* and *special treatment*. As a first step, we investigated each case individually in order to identify patterns within single cases. The second step focused on cross-case patterns in order to create meaningful categories, to each of which we assigned respective concepts ([A1]–[A11], see Table 2). In the third step, we identified superordinate main categories summarizing the categories from the second step: [A] *DECISION-MAKING PROCESSES* and to [B] *STEREOTYPES AND PERCEPTIONS*. Since all interviews were conducted in German, quotations used to highlight results were translated into English.

Regarding [A] *DECISION-MAKING PROCESSES*, we looked at *triggers of initial interest in STEM* ([A1]-[A3] in table 2), women's *socialization within the family environment* ([A4]-[A7]) and *triggers of women's decision to become an entrepreneur in STEM* ([A8]-[A11]). Table 2 shows how constellations of different concepts led to linear or non-linear career paths. In total, we identified three different types by these constellations (classified Type I–III). Unplanned events have no apparent influence on linear career paths of women STEM entrepreneurs, because these are driven only by their intrinsic interest (Type I). Types II and III both involve non-linear career paths, driven by opportunities and with unplanned events playing a major role.

Table 2: Coding concepts and categories in relation to decision-making processes

[A] DECISION-MAKING PROCESSES		
First coding → concepts		second coding → categories
I	[A1] NATURAL INTEREST IN STEM / SCIENTIFIC CURIOSITY	Interest-driven career path (linear)
	[A4] EXPERIENCED ENTREPRENEURSHIP	
	[A5] ACCESS TO TECHNICAL EQUIPMENT AND HAND TOOLS	
	[A8] LOGICAL CONSEQUENCE	
II	[A2] EARLY INSPIRATION OR LATER INTRINSIC INTEREST IN STEM	Opportunity-driven career paths (non-linear)
	[A6] EXPERIENCED EMPLOYMENT & RATHER TRADITIONAL GENDER ROLES AMONG PARENTS	
	[A9] ACTIVE SUPPORT FROM EXTERNAL PERSON	
	[A10] ESCAPE FROM EMPLOYMENT AFTER NEGATIVE EXPERIENCE	
III	[A3] NO EARLY INTEREST IN STEM	
	[A7] EXPERIENCED ENTREPRENEURSHIP OR GENDER-NEUTRALITY IN STEM	
	[A11] FAMILY DECISION / CONSCIENTIOUSNESS	
XXX = attitude towards STEM XXX = socialisation within the family environment XXX = trigger for the decision to become an entrepreneur in STEM		

(Source: Own research)

To illustrate our analytical process, we present as an example the coded statements of case IP17. In her Type II career path, she decided to become an entrepreneur in STEM based primarily on the initiative of an external person. She

- was [A2] EARLY INSPIRATION IN STEM:

  "Actually, the decision to do something like that was already clear when I was two or three. My aunt studies mathematics and she had always been a role model for me." (IP17:16)

- [A6] EXPERIENCED EMPLOYMENT & RATHER TRADITIONAL GENDER ROLES AMONG PARENTS:

  "My dad is an engineer ... I stumbled on this business of engineering and somehow thought, come on, try it!" (IP17:8)

- had [A9] ACTIVE SUPPORT FROM EXTERNAL PERSONS:

  "My colleague approached me at lunch. He said, 'Let's go for a walk – I have an idea." He asked me if I wanted to join in. And then I thought about it for about three minutes and said, 'Yes, sounds cool, let's

do it.' […] Honestly, I had not dealt with it [self-employment] before. ... I figured, 'You'll never do your own business, anyway'. The motivation came because someone believed in me. So, I think the icing on the cake was that my colleague said, 'we can do it'. We have been successful, but ... I myself, alone, would have never been under any circumstances an entrepreneur." (IP17:2,8)

Besides [A] DECISION-MAKING PROCESSES, we looked at [B] STEREOTYPES AND PERCEPTIONS. As became clear in the course of our analysis, these two main categories ([A] and [B]) cannot be clearly separated, since stereotypes and perceptions (depicted in Table 3) also influence decision-making processes. However, based on perceived external perceptions ([B1] and [B2]) and their impact on the personal motivations or behaviour of women in terms of their career path ([B3]–[B5]), we differentiated between career paths of women STEM entrepreneurs that were and were not influenced by stereotypes.

Table 3: Coding concepts and categories in relation to stereotypes and perceptions

[B] STEREOTYPES AND PERCEPTIONS		
First coding → concepts		second coding → categories
I	[B1] DO NOT PERCEIVE SPECIAL TREATMENT OR EXTERNAL PERCEPTION [B3] NO CHANGE IN MOTIVATION OR BEHAVIOUR	Career path not influenced by stereotypes
II	[B2] PERCEIVE SPECIAL TREATMENT AND EXTERNAL PERCEPTION [B4] BENEFIT FROM OPPORTUNITIES [B5] DEAL WITH CHALLENGES	Career path influenced by stereotypes
	XXX = perceived external perception XXX = Impact on personal motivation or behaviour	

(Source: Own research)

We searched for patterns of positive and negative influence by stereotypes, but how the interviewees handled perceived stereotypes seems highly individual. Whilst some women were, for instance, unsettled by the scepticism of their social environment, others felt encouraged to prove themselves to those who had doubted them. We found that perceived stereotypes always influence women's career paths, but stereotypes never influenced a career path only positively or only negatively. Often, stereotypes exerted combined positive and negative influence, as the following example case IP72 demonstrates:

- On the one hand, she [B2] PERCEIVED SPECIAL TREATMENT AND EXTERNAL PERCEPTION:

  "As a female founder in STEM, you attract attention by your rarity. This does not mean that you are less respected by other founders—quite the contrary. People keep you in mind. They also want to help you, perhaps because they think 'women need help or support'." (IP72:68)

- and she [B4] BENEFITED FROM OPPORTUNITIES:

  "You just have to accept that and say, 'Well, then, if you want to help me, help me'. And, so far, my experience has always been positive. […] Personal recognition was always a positive experience for me. That […] I am not only me, I am also the founder of a large company. This has helped me a lot personally in my further development in all areas." (IP72:68,60)

- On the other hand, insofar as she [B2] PERCEIVED SPECIAL TREATMENT AND EXTERNAL PERCEPTIONS:

  "Often, of course, it was the same when we introduced the company, my co-founder and myself. Questions automatically were directed to him, because he was the man and the computer scientist who has, everyone assumes, much, much, much more expertise." (IP72:52)

- Therefore, she had to [B5] DEAL WITH THOSE CHALLENGES:
  "I frequently had to stand up to this, even interrupt him so that I could play an active part in the game. This has decreased over the years, however." (IP72:52)

4. Results/Findings

(a) Decision-making processes

In choosing their study or professional education, the women STEM entrepreneurs in our sample did not apparently primarily aim to become entrepreneurs. Largely, instead, they simply pursued their own interests in STEM subjects. Interviewees emphasized repeatedly that they made their decisions not from a wish to achieve a certain position and/or status but based on concrete, topic-related issues.

> *"I've always been more interested in mathematics than in languages or something. And, ... yes, it was quite obvious early on, that I should go in that direction […] It was not like I said, from the beginning, 'I have to start a business someday' […] Instead, I thought, 'I have this idea and I would like to have this idea implemented and, if I do not do it, who else shall?'" (IP64:11,25)*

> *"To be honest, I never intended to be self-employed. Actually, I always told myself I'm not the type to work for myself. I like regular employment very well, with 30 days of vacation […] and my salary […] However, I was actually driven by a bit of love for the product. On the one hand, I had a lot of fun with T. [co-founder] […] in starting the company and working on the product […]. Someday I think I will simply believe that the product is something good." (IP51:36)*

> *"I think the topic is always more important than the position. […] In case of doubt I would always opt for the more exciting project." (IP30:42)*

Interviewees revealed several reasons why they became entrepreneurs in STEM. Some actively decided to seek self-employment (from their own initiative), while others made a rather reactive decision (meaning they were confronted with the opportunity and encouraged to agree) and still others made a decision jointly with several people, in the latter case often family, such as a spouse.

> *"The background is that my husband is good at programming and has always been asked in the past if he can program something for friends. And once we starting to do that more often, we registered the trade to be on the safe side." (IP68:2)*

In the case of already existing family businesses, the decision was often made jointly with the father, as his successor, or with siblings (e.g., after the father's death).

> *"One of us could not have tried to do it alone." (IP48:14)*

Two significant influencing factors for women in our sample to actively become entrepreneurs in STEM were that they decided to work in STEM themselves and that someone believed in them. Sometimes, in the latter regard, support from a single person was decisive for their career development (as in the cases IP17 and IP46). However, it became clear that support from the family is not always essential.

> *"They said: 'You really want that? Are you quite sure? Can you do that?' […] That was also very difficult for me and my family, because they did not understand many of the things that I did. Nobody understood that I was starting a business, anyway. […] I have founded several. They say, 'You're crazy. How will you do it?' And then, when one business was gone: 'See, it did not work anyway.' […] It was very difficult in the family." (IP69:18,82)*

The fact that the parents have a similar background played a less important role in our sample than existing literature would indicate. Whether the parents are in STEM or self-employed did not determine whether or not the daughter aimed to become self-employed in STEM. Instead, the decisive factor here is that parents in STEM allow the daughter's initial interest in STEM to develop later. Indeed, our results show that women whose parents have a business in STEM are more likely not to have interest in STEM at a young age, initially choosing a qualification in a non-STEM field. These women only came (back) to STEM later in their careers, once they decided to take over the family business. But they made this decision less from their own interest than out of a sense of duty to their families. An unplanned event, such as their father's death, triggered this decision.

> *"I took over a company—there was no question of whether I wanted it or not. I was the only one who had finished an education at the time. Who was old enough to do that." (IP24:14)*

> *"If you have a family business and you are the only daughter and ... if you do not act like you were born yesterday, then you have no choice." (IP25:20)*

If, however, the need to take over the family business is externally determined or predetermined, made not on the daughter's own initiative, women sometimes wanted to start their own innovative businesses in addition to continuing the family business if they had made an early decision to join STEM fields on their own initiative.

In the course of our investigation, it became apparent that the career paths of women STEM entrepreneurs are rarely linear. In line with the Happenstance Learning Theory (Krumboltz, 2009), it seems that unplanned events, in many cases, play an important role in career development, especially regarding another person's active encouragement for the woman to choose entrepreneurship.

> *"During my studies, I never really thought about becoming self-employed. It was somehow so clear that you afterwards apply somewhere and ... then it begins. And through a question from my colleague, I started to think about it … I did not need to think for long whether or not I should do it [start self-employment], because I was somehow in the mood to do it. It sounded exciting. And I also thought, 'Well, what do I have to lose? It will be a great experience ... so let's go!'" (IP46:20)*

Many women STEM entrepreneurs reported becoming entrepreneurs by chance, due to an emerging opportunity or another unplannable situation. Frequently, women we interviewed started their own businesses after negative experiences in employment and in order to self-actualise.

> *"At some point, […] [I thought], OK, you get a very good salary, but you have no say ... where you work, with whom you work ... and at some point, I did not want that any more. So, that was significant, that self-determination plays a role. Then I stopped that thought. […] The patent was already registered, […] but I had no plan for how to start being self-employed. But then I thought to myself: It is such an opportunity. […] If you don't try it now, you'll be annoyed later." (IP32:22)*

Some women were even aware in advance of how these 'windows of opportunity' could impact their career paths and included them in their career planning.

> *"I took it rather as it came, but I thought about it. And it has turned out well, which means that approach has done quite well, but it's just that, I do not want to say it's ... dependent on chance. But I think ... if you're open and taking chances ... or maybe working on certain things or looking at what you could do, then ... that works too. And you do not need this 'yes, I would like to be there or there some day.'" (IP39:38)*

When women had no early interest in STEM, as was usually the case with entrepreneurs' daughters, unplanned events played a decisive role in their decision to become entrepreneurs. As described, the STEM area was then only a side effect. When the initial career decision had a greater impact on interviewed women's career development than unplanned events, they had the opportunity to practically explore and expand their interest in STEM. In such cases, their entrepreneurship in STEM developed as a logical consequence of their interest.

> *"I started in school relatively early, when the Internet became a mass medium […] then I just started to teach myself programming, HTML and CSS web pages. That was somehow at 13. When I was 14, 15 I saw, 'OK, there are people who do that professionally and it looks terrible. I can do it better.' And then I just started to do that a bit at the age of 16, and I thought 'OK, from age 18 I can register my own business', and then I really wanted to do that. And […] when I was 18, I went with my father to the administrative office to register my company." (IP39:22)*

(b) Stereotypes and perceptions

Our investigation revealed that women STEM entrepreneurs' career paths are always influenced by stereotypes, except if the women do not perceive any. However, typically, the women STEM entrepreneurs are frequently confronted by stereotypes concerning their positions and roles, and they have the notion that they must demonstrate their abilities to a greater extent than men to gain respect.

> *"I'm always earmarked as 'the pretty one who cannot do it', as if I am just there as decoration." (IP48:14)*

> *"Women have to stand their ground. […] If we do not do that, then we might as well not start, because we will not be heard, because we are not … it is not equal. […] We, as women, always have to […] work more [than men]. That's how it is. I cannot change it. Well, anyway, I don't think I can change it. But it's the reality." (IP6:39)*

> *"There were some bigger meetings where I was the only woman at the table. The one other woman was the person who brought the coffee into the office. So […] I already noticed: 'OK, here I probably have to hold my ground more to be taken seriously." (IP62:37)*

As a result, the women STEM entrepreneurs experience, it is exceedingly important to show specialist knowledge and to perform professionally.

> *"In the meantime, I managed the tech team on my own, and I would not have believed in my abilities if I did not have a technical background. I also do not know how seriously I would have been taken had I not understood what was going on." (IP69:30)*

> *"As soon as there is something that brings insecurities, I'm definitely fully made-up. Wearing high heels and a tight dress. And then I would never allow myself to go into it without having prepared an agenda." (IP48:36)*

Stereotypes can have both positive and negative influence, leading respectively to admiration, respect and support or to incomprehension and scepticism. Even many stereotypes with negative connotations still positively influence some women when they confront them with defiance.

> *"I could imagine that this would discourage many women. But for me, that's what spurs me on." (IP68:34)*

A self-confident presentation seems to be a good strategy for the women STEM entrepreneurs to counter stereotypes and even benefit from them.

> *"I have experienced moments when I wanted to make contact with other colleagues in mechanical engineering, and then from a man with coffee cup in hand, I hear the comment, 'Yes, I would like to have one more'. And then I look at him and say, 'Yes, I'll take your cup, but you'll take my business card.' And then the man looks at it, turns red and says 'Oh, excuse me.' Well, I mean, you definitely experience things like that. And not seldom. But you really cannot be intimidated, because it happens all the time." (IP6:37)*

Nevertheless, stereotypes often seem to lead to disadvantages in a professional context.

> *"You are disadvantaged as a female founder, because it's hard to get money. And I think that has a lot to do with stereotypes, because the investors sitting there think, 'Oh, a woman and technology—difficult.' Or maybe they say, 'A woman and business—difficult.' I don't know. Maybe the combination is the worst of all." (IP69:34)*

Actually, women STEM entrepreneurs are confronted by stereotypes not only in a professional context but also in their private or family environment.

> *"I actually threw an aunt out of the house who told me I should instead be making bread rolls at the bakery in the morning." (IP68:30)*

Being aware of multi-layered external perceptions, most women STEM entrepreneurs perceive being a woman in male-dominated environments as a kind of opportunity, as they feel somewhat admired and respected for their successful career paths.

> *"My husband always portrayed me very proudly. And that felt really good. And the men also thought it was really great that there is really a woman who has technical know-how ... and manufactures these control systems. […] If you gain respect, especially from the opposite sex, that feels really, really good." (IP68:36,38)*

5. Discussion

Assuming that familiarity influences the strength of the values that determine our perceptions (Allport, 1954), the perceptions of women STEM entrepreneurs were already significantly influenced by their earliest childhood and parents. Other studies have examined how parents influence their daughters' future career decisions (Abbasi and Sarwat, 2014; Ndinguri et al., 2014). According to Krumboltz's (2009) HLT, career decisions depend on an individual's interest, which changes over the course of their life. Hence, it is *not* the initial, earliest career decisions that matter but the specific exploitation of emerging opportunities. Krumboltz stated that very few people end up in the career they imagined in early childhood, but most of our interviewed women entrepreneurs were passionate about STEM from an early age. Their interest, at least, in STEM fields did not seem to have changed over the course of their lives. We therefore conclude that women STEM entrepreneurs' interest in STEM is something that arises rather early in their lives.

In terms of active exploitation of opportunities, we found that unplanned events seem not to have significant influence. The women who actively pursued career paths in STEM had high intrinsic motivation; for women experiencing unplanned 'trigger' events, we therefore argue that becoming an entrepreneur in STEM would have taken place anyway. HLT still applies here, since the theory also states that learning through experience decisively influences career development. Among those women for whom unplanned events played no role in their decision to become an entrepreneur in STEM, we found that their interest in STEM developed practically.

These women entrepreneurs all described how they were able to perform experiments in their childhood, had access to computers and technology or were able to use hand tools. In their self-employment, they then did something with chemical or physical experiments, worked in IT or produced something electronic. By pursuing their careers as a woman STEM entrepreneur, they are thus pursuing their own interests.

An exception are the daughters of parents who were entrepreneurs in STEM. These women showed a striking lack of interest in STEM, emphasising in their interviews that they came to work in STEM later in their lives. Some of these women stated that they had discovered their interest in STEM late in their careers, while others explained that they had decided to work in STEM only to take over the family business, primarily out of a sense of duty to their families. It seems as if these women had not perceived STEM as an option for themselves or had actively decided against it. We argue that the daughters of parents who own a STEM business have learned a traditional understanding of gender roles, contrary to what one might expect. Although a family business in STEM might superficially be associated with both parents' equal involvement in the management of the enterprise, our study indicates that this is very rarely the case. More often, the father was responsible for business operations, while the mother works as a housewife or in an administrative rather than STEM-related role. This means that a family business in STEM does not lead daughters automatically to perceive being a woman STEM entrepreneur as an option for themselves; indeed, in our investigated cases it tends to have the opposite effect. In our cases, unplanned events were the main reason for the interviewed women's entrepreneurship in STEM, and it cannot be assumed that the woman would have otherwise chosen this career path.

Women STEM entrepreneurs are frequently confronted by stereotypes which can have both negative and positive influence. Women's necessary reaction to the stereotypes means they always have influence, either way. According to Fiske and Cuddy (2002), career women are perceived as competent but cold and should therefore arouse envy or admiration in their social environment. Our study has shown that most women STEM entrepreneurs arouse admiration in their social environment. According to Fiske and Cuddy (2002), this is also the case with groups of people who are perceived as competent but warm. Our results suggest that women STEM entrepreneurs are perceived as less cold than theoretically argued by Fiske and Cuddy (2002). This result is unexpected, since women STEM entrepreneurs are operating in an area that is atypical for women in two respects. According to Fiske and Cuddy (2002), this makes it even more likely that they would arouse envy in their social environment. However, following the SCM, women would be perceived as competent and less cold than assumed. This is also unexpected, since several stereotypes of women entrepreneurs, as described by interviewees, refer to a lack of competence attributed to them. Thus, it seems that further research is necessary to shed light on these inconsistencies.

6. Implications

In line with the HLT and according to our findings, unplanned events in most cases significantly influence the career paths of women STEM entrepreneurs. We therefore agree with Krumboltz (2009) that women must be sensitised to and encouraged to actively take opportunities as they arise. Since a self-confident personal presentation is decisive for women in male-dominated fields, it seems advisable to promote both social and professional competence among women. Our study showed that those women for whom unplanned events were not decisive for their decision to become a STEM entrepreneur had discovered an early intrinsic interest in STEM and were able to develop it further through practice. This supports current endeavours to sensitise school-age girls to male-dominated professional paths in order to help them detect unconscious, already-developing interests in those areas. However, we stress that theoretical knowledge is insufficient; girls must be able to test, promote and develop their skills in practice. In this regard, it is crucial to give young women the opportunity to explore the physical objects with which they would work later in life (e.g., a computer or hand tools) on their own. Thus, we explicitly highlight that it is not enough to teach female students how to use such hardware. A sustainable learning experience requires that they have direct experience with these tools themselves and are able to explore them 'creatively'. Furthermore: if we aim to provide more adequate, cross-gender education (related to STEM, but to any kind of topic field as well), there is a need to provide more manifold hands-on experiences during school education, to let children figure out their talents and interests.

Our study further shows that stereotypes influence the behaviour or motivation of women STEM entrepreneurs, thereby also influencing their career paths. Applying the SCM (Fiske and Cuddy, 2002) to women STEM entrepreneurs, we found that women who pursue careers in STEM frequently experience admiration from their social environment, which motivates them extrinsically. According to the SCM, career women are, by contrast, more likely to arouse envy than admiration in their social environment. The fact that women STEM entrepreneurs experience much more admiration than envy is why the stereotypes they face are more likely to have a positive

than a negative impact on their career paths. Of course it might also be that women who are able to turn stereotypes around are more likely to go into STEM, as a kind of self-selection bias. With our data we are unable to prove this. Nevertheless, it is important to sensitise women in male-dominated areas to the presence of stereotypes so that they are well-prepared to face them and that they possibly can actively use these stereotypes for their own positive benefit and career development.

References

Abbasi, M.N., and Sarwat, N. (2014). Factors inducing career choice: Comparative study of five leading professions in Pakistan. *Pakistan Journal of Commerce and Social Sciences* 8(3): 830–845.

Adams, R.B., and Kirchmaier, T. (2016). Women on boards in finance and STEM industries. *American Economic Review: Papers & Proceedings* 106(5): 277–281.

Allport, G.W. (1954). *The nature of prejudice*, 28–47. Reading, MA: Addison-Wesley Publishing.

Bijedic, T., Brink, S., Ettl, K., et al. (2016). Women's innovation in Germany: Empirical facts and conceptual explanations. In: Alsos, G., Hytti, U., and Ljunggren, E. (eds.). *Research handbook on gender and innovation*, pp. 57–71. Cheltenham: Edward Elgar.

Deemer, E.D., Thoman, D.B., Chase, J.P., et al. (2014) Feeling the threat: Stereotype threat as a contextual barrier to women's science career choice intentions. *Journal of Career Development* 41(2): 141–158.

Fiske, S.T., and Cuddy, A.J.C. (2002). A model of (often mixed) stereotype content: Competence and warmth respectively follow from perceived status and competition. *Journal of Personality and Social Psychology* 82(6): 878–902.

Gnilka, P.B., and Novakovic, A. (2017). Gender differences in STEM students' perfectionism, career search self-efficacy, and perception of career barriers. *Journal of Counseling & Development* 95(1): 56–66.

Greene, F.J., Han, L., and Marlow, S. (2013). Like mother, like daughter? Analyzing maternal influences upon women's entrepreneurial propensity. *Entrepreneurship: Theory & Practice* 37(4): 687–711.

Hoffmann, M.E., and Vance, D.R. (2007). Gender difference trends in computer literacy of first-year students. *SIGCSE '07, Proceedings of the 38th SIGCSE technical symposium on computer science education*, 405–409. Covington, Kentucky.

Katz, S., Albritton, D., Aronis, J., et al. (2006). Gender, achievement, and persistence in an undergraduate computer science program. *The DATA BASE for Advances in Information Systems* 37(4): 42–57.

Kawakami, C., White, J.B., and Langer E.J. (2000). Mindful and masculine: Freeing women leaders from the constraints of gender roles. *Journal of Social Issues* 56(1): 49–63.

Krumboltz, J.D. (2009). The Happenstance Learning Theory. *Journal of Career Assessment* 17(2): 135–154.

Krumboltz, J.D., and Henderson, S.J. (2008). Krumboltz Happenstance Learning Theory. In: Leong, F.T.L., and Altmaier, E.M. (eds.). *Encyclopedia of counseling: Changes and challenges for counseling in the 21st century*, 1566–1568. Los Angeles: SAGE.

Kuckartz, U., Dresing, T., Rädiker, S., et al. (2008). *Qualitative evaluation: Der Einstieg in die Praxis*. Wiesbaden: VS Verlag für Sozialwissenschaften / GWV Fachverlage GmbH Wiesbaden.

Kyriakidou, O. (2012). Fitting into technical organizations? Exploring the role of gender in construction and engineering management in Greece. *Construction Management & Economics* 30(10): 845–856.

Machado, H.P.V., Gazola, S., Dos Santos Fabricio, J., et al. (2016). Women entrepreneurs: Reasons and difficulties for starting in business. *Revista de Administração Mackenzie* 17(3): 15–38.

Marlow, S., and McAdam, M. (2015). Incubation or induction? Gendered identity work in the context of technology business incubation. *Entrepreneurship: Theory & Practice* 39(4): 791–816.

Ndinguri, E., Phipps, S.T.A., and Prieto, L.C. (2014). Predictors of entrepreneurial venture exploitation tendencies: Role of gender, emotion, motivation and role model accessibility. *Academy of Entrepreneurship Journal* 20(1): 23–36.

OECD. (2017). *Education at a glance 2017: OECD INDICATORS*. Available at: http://dx.doi.org/10.1787/eag-2017-en (accessed 28 September 2017).

Pejić Bach, M., Merkač Skok, M., and Suša, D. (2016). Determinants of entrepreneurial intentions in ICT industry: Gender and country of origin perspective. *Our Economy* 62(1): 37–45.

Shapiro, C.A., and Sax, L.J. (2011). Major selection and persistence for women in STEM. *New Directions for Institutional Research* (152): 5–18.

Tan, J. (2008). Breaking the “Bamboo Curtain” and the “Glass Ceiling”: The experience of women entrepreneurs in high-tech industries in an emerging market. *Journal of Business Ethics* 80(3): 547–564.

Trauth, E.M., Quesenberry, J.L., and Huang, H. (2008). A multicultural analysis of factors influencing career choice for women in the information technology workforce. *Journal of Global Information Management* 16(4): 1–23.

Vongalis-Macrow, A. (2016). What it will take to keep women from leaving STEM. *Harvard Business Review,* September 2016. Available at: https://hbr.org/2016/09/what-it-will-take-to-keep-women-from-leaving-stem (accessed 28 September 2017).

Wing-Fai, L. (2016). The strengths of close ties: Taiwanese online entrepreneurship, gender and intersectionality. *Information, Communication & Society* 19(8): 1046–1060.