The "Missing Species" – Female Students in STEM-Fields
A qualitative study on young Austrian female students in gender-typical disciplines and STEM-fields

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Abstract: - Even though women in Europe, nowadays, have reached the highest education level ever in history, they are still underrepresented in STEM-fields. This study tries to identify factors that make young women opt for a gender-typical or gender-atypical study discipline. Especially the impact of teachers is focused on. 36 young women (n=36) were interviewed on motives related to their choice of academic studies. Various career choice theories form the theoretical framework. Recommendation on how to possibly raise the number of females in STEM-fields by improving the conditions in the school context conclude the study.

Key-Words: - Technical education, gender gap, female students in STEM-fields

1 Introduction

1.1 General remarks

Even though women in Europe, nowadays, have reached the highest education level ever in history [1] [2], they are still underrepresented in STEM-fields [3]. STEM refers to the areas of science, technology, engineering, and mathematics. These are the disciplines that encompass the highest potential both in development and for future employment opportunities [4]. In spite of these positive perspectives Austria is one of the countries that shows the largest gap when it comes to gender in technical fields. Whereas more female students (54 %) than male ones graduate from Austrian universities [5], they by far less often hold a degree in a technical discipline. Only 25 % of all graduates in engineering are women, 32 % in physics, 36 % in natural sciences, mathematics, and statistics and 15 % in computer science. Respective figures from other OECD countries exceed beyond these rates by up to more than 10 % [6]. On the other hand, Austrian women are overrepresented in study disciplines like education, psychology, teacher education, arts, and health professions. There are various reasons for the huge gender gap in these areas and efforts to change this situation have so far been as plentiful as ineffective in most cases. In order to provide sufficient professionals of STEM areas in the future, there is great demand for making these fields increasingly sought after study disciplines – especially for women [7].

1.2 Career choice theories

The professional development of young people is a very important phase in their lives. A comprehensive theoretical framework tries to explain how young people develop their professional interests and as a consequence opt in favor of or against an academic major and thereafter a related professional field [8]. But what factors lead to the fact that young women opt for gender-typical or gender-atypical studies and there are differences between women who are interested in a gender-typical studies and women who are interested in a gender-atypical studies?

Several theoretical models try to explain the influence of interests, motivation, abilities or the socio-cultural environment on the choice of study disciplines and professional careers. Among these different theoretical approaches are Frank Parson's Trait-Factor Approach at the beginning of the twentieth century [9], the Theory of Work Adjustment, Holland's Theory of Vocational Personalities in Work Environment, the Super's and more recently Savickas' Self-concept Theory of Career Development, Gottfredson's Theory of Circumcription and Compromise and the Social Cognitive Career Theory [10]. According to the Theory of Work Adjustment "career choice and development is (…) conceptualized as a continual

process or cycles of work adjustment initiated by dis-satisfaction and dis-satisfactoriness" [11].

1.2.1 Holland's Theory of Vocational Personalities in Work Environment

For some decades now, Holland's concept has given direction on the evaluation of career interests [12]. The concept is a rather simple one and an easily interpretable context involving career interests and environments. In his theory, Holland suggests that career interest is an expression of the nature of an individual. Career interests could be hypothesized into six classifications which are Realistic (R), Investigative (I), Artistic (A), Social (S), Enterprising (E), and Conventional (C). A 3-letter code (e.g. SIA, RIA) that explains one's career interest can be obtained if an assessment is done on the individual's level of resemblance to the six classifications of career interest types. One's primary interest type is represented by the initial character in the code. This has a huge impact on career selection and fulfillment. The secondary career interest types are represented by the second and third letters. Their roles are minor but still very critical in the selection process.

Similar to the conceptualization of career interest types, Holland's theory [13] suggests that career environments could also be classified into suchlike categories. During the career selection and growth course, individuals usually pursue fields where they are able to build on their abilities and show their character. There exists a certain trend in any job-related environment where its composition is structured so that the leaders fit into its characteristics; those who differ with the leaders will probably be upset. Holland uses the idea of "congruence" to symbolize the interaction between individuals and the environment. A high-level congruence will most likely bring about career satisfaction and fulfillment. The idea of the person-environment similarity explained in Holland's concept is parallel to TWA's idea of correspondence.

The six career interest classifications in Holland's concept are positioned in a hexagon following the arrangement RIASEC. The association between the types in relation to their similarities and differences can be described by assessing the distance separating similar types in the hexagon. The idea of consistency can be used as a scale for self-harmony of one's type scores [14]. As a result, the highest level of resemblance with respect to behavioral characteristics and professional preferences occurs in the types that are adjacent in the hexagon. Minimal levels of resemblance happen in types that are opposite one another in the hexagon while a reasonable level of resemblance occurs in types divided by a single interval. Apart from congruence and uniformity, Holland's theory also acknowledges differentiation as a key concept. Differentiation is whether you can openly differentiate high interest and low interest types in an individual's outline of interests. An interest profile which is low in differentiation is similar to an almost flat line where it is difficult to differentiate between low and high interest types. Holland's theory is of enormous impact on research and career interest assessment [15].

1.2.2 Self-concept Theory of Career Development

According to Super [16], career selection and growth is a vital step for one to grow and realize his/her own self-concept. Super again states that self-concept is manifested after several factors such as bodily and mental growth, personal encounters, etc. have acted together. Although Supper purported that an organic mechanism working after the growth and development process exists, fresh articulations in this theory have placed more weight on the effects of a social setting \and the joint impact between the individual and the surroundings. Taking into consideration the idea of Super that self-concept theory was basically a personal construct theory; Savickas [17] later adopted a constructivist point of view. According to his point of view "the process of career construction is essentially that of developing and implementing vocational self-concepts in work roles" [18].

During the late adolescence stages, one should develop a rather strong self-concept to help in career selection. Self-concept is, however, not a stationary entity and will remain progressing as an individual grows and meets fresh encounters in life. Life and job satisfaction is an ongoing process of realizing the ever developing self-concept through employment and several other activities in life.

A life phase development context was suggested by Super [19]. An individual has to accomplish the career advancement activities in each of the phases assigned for individuals in that age group. An all-inclusive context is readily available that explains the process of career growth which in turn could lead career involvements.

More emphasis was placed by the writers on the importance of a school-based intervention to enable the learners to select appropriate careers of their choice. The following features were present in the intervention scheme: self-consciousness, adjudication, career survey and career preparation and development.

To raise an individual's self-satisfaction and social support, one has to relate with the surroundings so as to make decisions that are best suited. Subsequently, career selection and progress is not a direct activity of the execution of self-concept; it is a course full of dialogues and compromises that involves both the individual and the environment.

1.2.3 Gottfredson's Theory of Circumscription and Compromise

From Gottfredson's assumption [20], career selection is an activity that requires critical knowledge. Lately, in her reviews, Gottfredson has greatly expounded on the dynamic interaction between an individual's genes and the environment. One's genetic composition is very important in determining the simple features in an individual such as his or her likes, abilities, and values. The surroundings, on the other hand, where one is exposed to will tend to limit their expression. Gottfredson argues that although an individual is molded by both the surroundings and the genetic composition, a human being is a dynamic being that can make great affects in his/her environment. The progress in one's career is therefore seen as a self-creation process where people searched for paths within the restrictions of their cultural surroundings in order to display their genetic proclivities.

Gottfredson's theory [21], in opposition to the idea that choice is a process of selection, states that career choice and progress should be seen as exclusion or a restriction process where certain job-related options are excluded from an individual's path. Major aspects of self-concept coming up at the various growth phases usually give guidance throughout the Circumscription process. As explained by Gottfredson, the public has more impact on career ambitions of children (such as gender, social class) as compared to their own personal aspects of self-concept (such as abilities, interests).

Compromise is also another career growth process. Reacting to external realities like variations in the labor market structure, economic despair and biased employment practices, people have to be wise in their career selections so as to make wise choices that can be realized. This entails a very difficult process where the compatibility with the ambitions of a person is usually compromised in order to obtain a higher correspondence level with the individual's liking for prestige and gender.

It is extremely hard to use trial and error method to examine Gottfredson's theory [22]. It, however, provides exceptional views to experts in career guidance. For example, in several traditions an individual's life fulfillment is determined by his/her accomplishments in learning and occupying high ranking and powerful posts in their careers. Gender stereotype equally exist in a number of traditions and people are advised to choose careers that suite their respective genders.

Career guidance interventions are happening in primary and secondary schools for the moment [23]. Gottfredson's assumption can be adopted as a theoretical guide for program advancement. The assumption constitutes counselor approaches and tools that could be essential to enhance: (a) Studying and the application of complex job-related data, (b) Familiarity and the processes that allow children and the youth to get to know their personalities in relation to their careers, (c) Self-insight in order to begin and develop a career path that is practical and can be realized, (d) Knowledge in self-investment so as to be able to heighten the possibilities of accomplishing career choices[24].

1.2.4 Social Cognitive Career Theory

Bandura's [25] self-efficacy theory anchors the Social Cognitive Career Theory that suggested a mutual association between individuals and the environment. Three segmental process models are offered by SCCT on growth of one's career that are tasked with clarification of the growth of both educational and vocational interests, (b) the way in which people settle on academic and career selection, (c) academic and career performance and firmness. The three models place varied weights on three fundamental variable i.e. self-efficacy, potential results and individual goals.

Adopting and maintaining of certain behaviors in reaction to the problems and hurdles one faces is influenced by the prospects of self-efficacy. In 2005 Lent defined self-efficacy as "a dynamic set of beliefs that are linked to particular performance domains and activities" [26].

Relying on Bandura's [27] past findings and other assessments [28], a theory formulated by SCCT stated that there are four principal sources of information that model the self-efficacy expectations. These are: individual performance fulfillments, vicarious learning, social influence and physiological and emotional situations. According to Lent's [29] suggestion, individual performance fulfillments bear the strongest influence over the others on the status of self-efficacy. By Lent, Brown and Hackett outcome expectations are defined as "personal beliefs about the consequences or outcomes of performing particular behavior" [30].

Self-efficacy, results anticipation and individual ambitions acted as the fundamental variables in the interest, choice and performance models of SCCT. As per the interest models, there was a high chance of people gaining interest in processes which (a) they find to be effective and (b) they expect to get positive results in relation to their undertakings. The lively relationship between interest, self-efficacy and expected results brings into place the creation of objectives and plans which will be in place to keep up with behavior over time. This in turn creates a reliable interest pattern in the youthful stages.

The growth in career objectives and options is viewed by the SCCT choice model as functions of the association between self-efficacy, result anticipations and interest over time [31]. Career choice is a developmental process involving an individual and his/her environment where they jointly impact on each other. The fundamental career objectives are described here together with the activities that should take place in order to attain the goals and performance experience giving response to a person on how the objective is best suited. Additionally, SCCT theorized that compromises in individual interests could be useful in the career selection course because of the immediate background of the individual [32].

An all-inclusive framework is provided by SCCT to help comprehend the growth of vocational interest, career choice, and performance. All these are based on the self-efficacy theory. Generally, global career guidance professionals and scholars can obtain an all-encompassing structure from SCCT that controls their practice and other tangible suggestions [33].

2 Problem Formulation

2.1 Method

2.1.1 Procedures

Several causes are suspected that influence the choice of a study discipline. The still prevailing prejudices about the talent of women in STEM subjects and that this area is considered “male-dominated”, are just two of the suspected causes [34]. But what other factors contribute to the decision of young women to opt in favor of or against a gender-typical field of studies especially in the context of schools? Based on this research question the study tried to find out more about the motives of 18 girls studying a STEM-subject and 18 girls majoring in a non-STEM-subject by means of structured interviews (n=36). All girls were in the first semester of their studies. So it was possible to prevent distortions of the results due to retrospective perceptions. Accordingly, the mean age of the interviewed students was 18.9 years. They have all graduated from academic high-schools with only little room to specialize in certain subjects. A concentration on mathematics, natural sciences, and humanities was possible though, however did the numbers of hours dedicated to the chosen field of concentration only mount up to about six hours per week per year. Austrian academic high schools in contrast to vocational ones try to offer a wide range of a comprehensive education and refrain from too specialized study tracks.

2.1.2 Measures

The study was based on 12 different items that were investigated by structured interviews, which were recorded and afterwards transcribed and analyzed in a quantitative manner. By interpreting the results a scale was developed rating from 1 = very good to 5 = very bad. Students also had to give demographic data like age, selected study discipline and parental professions.

The 12 different items investigated as presumably having some kind of influence on their choice of a specific study discipline were didactics and methodology in teaching, teaching material, motivation and support by teachers, personal hobbies and interests, knowledge of different professions, access to job fairs offered by schools, knowledge of job market, grades in mathematics and natural sciences, gender-bias of teachers, interest in STEM-subjects, and other influential factors such as family and peer group. The interviewed students also were asked if they would recommend going into their field of study.

3 Problem Solution

3.1 Results

3.1.1 Testing for normal distribution, Variance analysis, and Correlations

The Kolmogorov-Smirnov test showed that the items were highly significant indicating that these distributions were not normal [35]. This means for example that the teaching methodology assessed by students of STEM-subjects deviated significantly from normal ($df\ (18) = 0.353$, $p < 0.001$). The same was true for students of non-STEM-subjects. Even though there was no normal distribution among the items, the ANOVA could still be implemented because both groups – students in STEM-subjects and students in non-STEM-subjects – were the same

size and the chosen sample was significantly larger than ten. As all of the students answered all questions, there were no incomplete data from the interviews.

Everything was calculated in a two-factorial analysis. A three-factorial analysis was not suitable because the sample size of 36 students would have been too small.

Not differentiating between their choice of study discipline, 29 of the 36 students would recommend their field of studies. 7 out of the 36 students would not recommend their choice, which means that the overall satisfaction with the chosen major can be regarded as high in the case of more than 80 % of all interviewed students.

To determine the relevance of the values, their significance was put in order ranking from highest to lowest.

3.1.2 Influence of schools on the choice of study disciplines

Interests and abilities

Gender specific differences in interests, abilities, and passions can already be observed during a person's school years [36]. Even though several nationally representative longitudinal studies indicate very few differences in interests and attitudes towards STEM-subjects in elementary and lower secondary schools, the gap starts to grow in high schools [37]. This could also be verified by this study.

The group of students that have their major in a technical field already showed much more interest in mathematics, physics, chemistry, biology, and computer sciences during their school years than their counterpart in non-technical study disciplines. These findings correspond with similar ones by Maltese and Tai (2011) [38] and Holland (1997) [39]. In both cases did women who studied STEM-subjects mention mathematics and natural sciences more often as their favorite subjects in school than their colleagues in traditional study fields. Interests are very robust [40] and whenever possible, students choose subjects that match their interests and abilities in school [41]. More than 90 % of the students decided in favor of a STEM-study discipline due to positive learning experiences in STEM-subjects, a finding that also corresponds with the ones by Berweger et al. (2014) [42].

On the other hand, do subject-related interests beyond natural or technical sciences neither prevent a major in technical fields, as 20 % of the interviewed students in STEM-subjects also showed interest in humanities and arts. 25 % of the girls who indicated mathematics as their favorite subject, however, still opted for a traditional study discipline in natural sciences, mostly medicine or pharmacy. Students of STEM-subjects also had better grades in mathematics and sciences than their counterparts in non-STEM-subjects and rated their abilities in these subjects slightly higher than students of the other group.

Motivation and support by teachers

According to the results of the ANOVA students in STEM-subjects feel less motivated by their teachers to study a technical subject than students of other disciplines, who reported more often respective support by teachers for their choice of studies (F =). Engaging teachers that offer creative and motivating lessons with a connection to practical features can have a very positive impact not only on the learning outcome of their students but also on their further interests and eventually their chosen career path [43]. Therefore social support and positive feedback by teachers plays a crucial role when students decide in favor of or against a study discipline [44], as they influence self-efficacy, the self-assessment of abilities and outcome expectations [45].

The better the respective support system by teachers, the higher is the probability that girls opt for a technical study discipline [46]. In this study girls who ended up in non-technical study fields received considerably less positive feedback in mathematics and natural sciences than students of STEM-subjects. Many of them indicated that this fact also contributed to the choice of a more female-connoted study discipline.

Teaching material

There was a positive correlation between the teaching material and the high motivation of STEM-students for studying a technical discipline. Non-STEM-students rated the teaching material less favorably. Especially mathematics, chemistry, and physics books were regarded as too complicated and non-self-explicatory by this group, whereas they rated books of biology almost a high as their more technically oriented colleagues.

Didactics and methodology

A major impact on the motivation for studying technical subjects was the lesson planning and the way of teaching. Students of STEM-subjects reported more often that they had experienced well designed mathematics and science lessons. This corresponds with other findings [47] that proved that teachers have a major impact on the learning success and the motivation of their students.

Knowledge of study programs and professions

The knowledge about their later fields of study and the respective professions was much better in the case of students of non-STEM-subjects. According to the interviewed students of both groups their schools offered much more information on non-STEM-fields by either direct information by teachers, or job fairs and career counselling in- and outside of schools.

3.1.3 Role models

None of the students in technical field mentioned a specific role-model in this area. Those who reported about people with some respective influence talked about either their father or their mother who all work in a technical profession. Teachers did not function as any kind of role model in either group.

3.1.4 Influence of family and friends

Among the main causes for gender-biased vocational choices are a gender-specific socialization and the conservation and the on-going transfer of culturally based gender-specific norms, values, and expectations [48]. According to Trautner (2010) [49] and Bleeker & Jacobs, 2004 [50] gender attitudes and expectations of parents therefore exert an important influence children.

In addition do male and female siblings alike play a role in the professional development of their younger or older sisters [51], as they significantly influence the development of gender settings [52]. Many of the interviewed girls reported that they did not feel comfortable when showing too much interest in technical fields among siblings and peer groups. This corresponds with the findings of Diekman et al. (2010) [53], according to which girls interested in technical subjects often felt unfeminine, lacked friends that would have similar interests and simply did not have the respective support needed from their environment.

Eccles (2005) [54] shows that the careers of parents influence the career path of their children. This also proved true in this study. If at least one parent had a job in a technical field, chances were much higher that their daughter would also choose a technical study discipline compared to girls of who none of the parents worked in a technical field (χ^2 = 9.03, df = 1, p = .003). When parents worked in technical fields, also the students' grades in mathematics and natural sciences were better than those of their colleagues with parents in non-technical jobs.

3.1.5 Job market

Students in STEM-disciplines who also had at least one parent working in this field, perceived their chances on the job market significantly higher than their colleagues with no such specifications.

3.2 Limitations of the study

These findings are to be interpreted in light of several limitation. The sample is limited in size and a generalization to a larger population may not be feasible. Secondly, the study may not capture all relevant aspects, as to a certain extent it demonstrates a snapshot. There is always the possibility that the interviewed students of the sample change to a different major over time. Therefore future research which is longitudinal in nature would better explain definite career and study choices. Moreover, further research on the connection between academic self-efficacy and support and feedback by teachers would be of major interest [55].

Moreover, this study focused exclusively on girls and did not include male students. Their study choice pattern, however, would be of interest as well.

4 Conclusion

According to the results of this study that implemented a qualitative [56] and a quantitative [57] approach it is of major importance that teachers understand their enormous influence on the choice of the career path of their students especially when it comes to STEM-subjects. They should support their female students in all their professional ambitions and aspirations especially in non-traditional areas.

Interest on technical subjects alone is not sufficient for choosing a technical study discipline and profession, as also girls in traditional study disciplines show interest in STEM-subjects during their school years [58]. Therefore it takes motivated and committed teachers to actively inspire their female students to pursue a technical career. They have to discover and encourage technical interest, abilities and potentials in their female students and support and empower them during their whole school career. When girls are in the phase of the search for identity, it is necessary to help prevent a possible acquisition of gender specific role patterns. Traditional role models and patterns should be questioned and reflected.

Increasing self-confidence and self-efficacy in mastering technical areas can also motivate girls to continue with and expand their interests in STEM-disciplines. Teachers have to be aware that they exert a high degree of relevant

influence in this matter. Discriminatory remarks by male or female teachers have never been experienced by any of the interviewed students. On the other hand, however, neither did teachers function as professional role models for any of their students.

Good job opportunities and job security are key factors that strongly influence the choice of a study discipline and respective profession. Therefore benefits and opportunities of technical and scientific professions have to be identified and connected with the individual goals and aspirations of girls. Female students often need more detailed information on technical study disciplines and professions. This kind of knowledge and specific ideas of professions are a key prerequisite for an appropriate career choice. Access to this kind of information should also be offered by schools on a regular basis and in addition to the already existing counseling centers in other institutions.

Practical elements should more often become an integral part of schooling. If teaching takes place in a practice-oriented way, it is much easier to motivate girls for a certain content. This is especially true for technical subjects. The observed applicability of what has been learned can definitely function as a key motivator for the choice of a study major in a technical field. Lots of experimenting, projects and workshop offers organized by professional experts in school, as well as professional orientation days, job fairs, and internships in the "real world" can also enhance the knowledge of and as a consequence the interest in technical subjects. Specific extra-curricular initiatives for the recruitment of girls into technical fields of study (e. g. like fForte-Women in Research and Technology) should also be increased.

According to the majority of the interviewed students of both groups the teaching material especially in mathematics but also in physics should be up-dated and take into account the latest research findings on didactics and methodology. Books in sciences and especially in mathematics should be improved and include more practical and vivid learning material.

To help decrease the huge gender-specific segregation on the Austrian labor market empowerment and support by teachers are key components for motivating and convincing girls to decide in favor of a technical study discipline. This could help to prevent the loss of many talented females for technical professions which is of major concern in many industrialized societies [59].

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