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Startup orientated innovation for creating female STEMpreneurs: The PANDA approach

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Abstract: The industries of science, technology, engineering and mathematics (STEM) display a higher amount of male than female participants. When it comes to entrepreneurship in STEM industry the same picture is notable. The entrepreneur in STEM fields, the STEMpreneur, has been found gender biased. But the last years of gender research have shown that a female influence in business context is of high importance and improves business activities. But how to create more female STEMpreneurs? The German university of applied science Fresenius has developed a startup orientated cooperative innovation (SOCI) strategy, named PANDA, which connects established companies of the STEM industry and their business ideas with students of STEM study paths with the intension to inspire students of STEM study paths to become an STEMpreneur. This article analyzes the representation of female students in PANDA projects since 2017 until the first quarter of 2021 and discusses if PANDA can be seen as a helpful approach for creating more female STEMpreneurs.

Keywords: female entrepreneur, startup, STEM industry, cooperative innovation, PANDA

1. INTRODUCTION

The generation of ideas and their further development to innovation is one of the results of the growing competitiveness in a globalized world. Only organizations which are able to create innovations in a constant way can survive this increasing pressure of competition [1]. An increased competitiveness and high demand for innovations is also seen in industries of science, technology, engineering and mathematics (STEM) [2]. A further challenge for the STEM industry is the distribution of sexes. For example, the general distribution between the sexes of students entering STEM study paths which shows a share of female students of 40 %. In advanced academia levels like PhD this percentage further decreases [3]. According to the Startup Monitor 2019 one effect of mastering the need of new innovation is notable in the well represented number of startups in STEM industries [4]. But especially in startups of the STEM industry the representation of female entrepreneurs can be described as gender biased [5]. Like analyzed through research activities in the field of the influence of woman of business performance it is meanwhile commonsense that female influences are of high importance and represent an improvement for business activities [6]. For example, Xie and Lv have shown that social networks of female tech- entrepreneurs have a positive effect on new venture performance [7]. The German university of applied science, Fresenius, has developed a cooperative innovation strategy, called PANDA, which represents a strategy for companies is STEM industries to use the entrepreneurial mindset to develop ideas in startup-like conditions to enable established companies to innovate like a startup. Since 2017 this approach was implemented twelve times in different companies of the STEM industries in Germany and Poland. On the other hand, the idea behind PANDA is to give students of STEM study path the opportunity to experience the

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life of an entrepreneur and therefore to inspire STEM students to become an entrepreneur [8]. The aim of this article is to present the newest development of female students and their distribution in PANDA teams in comparison to male students and to discuss if a cooperative innovation approach like PANDA can be seen as a helpful method to creating more female STEMpreneurs.

To achieve this, aim this article starts with the definition of innovation, the term innovation strategy and the description of the different dimensions of innovation strategies. After this the categorization of the startup-orientated cooperative innovation (SOCI) strategies, the SOCI framework by Wolf et al. is presented and PANDAis localized in this framework. After this the PANDA is presented by describing the general process and its implementation since 2017 until the first quarter of 2021. In a next step the female role in PANDA projects is discussed through the analysis of the distribution of female students in comparison to male students through different perspectives.

2. WOMAN IN STEM INDUSTRIES AND AS STEMPRENEURS

Experts argue that the STEM industry can benefit from a higher diversity because a represented diversity results in higher creativity, groundbreaking solutions and therefore in innovations. People with different backgrounds and gender approach problems differently which caused constructive debates that in turn end in higher quality of the end result [9].

But the past has shown that men dominate the STEM fields for example from 1901 until 2016 only 5,5 % of all won Nobel prizes were given to women. In the near past the distribution of women and men in STEM has improved and the female share increased. For example, in the USA in the 1970s women received approx. 30 % of bachelor's degrees and 10 % of doctoral degrees in STEM until 2011 women represent 50 % of STEM bachelor's degrees, about the same as their proportion of high school graduates, and approx. 41 % of doctoral degrees [10].

Nevertheless, a gender gap is seeable and is transferable to the distribution of women and men in the context of entrepreneurship in STEM industries. Only 12% of all economies show an equal engagement in early-stage entrepreneurial activities between men and women [11]. But the Women's Entrepreneurship Report describes that women entrepreneurs have a 5 % greater chance of innovativeness than men [12]. Form this one can conclude that if there is no lack of female innovativeness, only structural barriers can hinder women in entrepreneurship.

A study by Swafford and Anderson 2020 identifies some possible reasons perceived barriers women face in the pursuit of STEM careers. Some of the major barriers are male domination of STEM careers, lack of awareness of educational and career opportunities, a lack of female mentors/role models and lack of encouragement from men [13].

To summarize the mention aspects woman are underrepresented in STEM industries apart from the improving situation and female STEMpreneurs are significantly less common than male. This gender-based gab can be categorized as problematic because the underrepresentation of female STEMpreneurs restricts the supply of human capital into important fields of innovation. Additionally, a higher amount of female STEMpreurs could contribute to higher success rates of startups caused by the proven higher growth expectations of startups which are influenced by women [14].

3. INNOVATION STARTEGIES

The term innovation is of Latin origin and means renovation or change. In general, innovation stands for the three-step process of an idea, invention and diffusion [15]. Therefore, in a business context, innovation can be conceptualized as an incidence (idea) for a product (invention) which has not been there before and which results in a high market acceptance (diffusion) [16]. The meanings of the term innovation are of high complexity and therefore result in a large number of existing definitions. Common and general characteristics of the term innovation exist and are defined as an implementation of change that introduces improvements [17]. Gault (2018) specifies the word implementation stating that innovation is an implementation of a new or significantly improved product. A product can be a good or a service [18]. In summary, the mentioned aspects and characteristics of the term innovation lead to the following definition applied in the context of this article: An innovation is an idea which is developed to an invention which creates change in the form of new products/services or product/service improvements, accompanied by high market diffusion.

There are two main types of innovation strategies called exploratory and exploitative innovation strategy [19]. Both approaches are described in more detail as follows.

A. Exploitative innovation strategy

The exploitative innovation strategy focuses on short-term successes by evolutionary or incremental improvements of existing technologies. Thus, the results are more proximate and predictable. Exploitative innovation activities are therefore making use of existing approaches, capabilities and available knowledge. In addition, exploitative innovations are more likely to look

familiar to the stakeholders of an organization, lowering pushback and speeding up the adaption of the innovation thus lowering their cost of implementation [19]. Exploitative strategies therefore focus on incremental changes and short-term returns. [20]

B. Exploratory innovation strategy

On the contrary, the exploratory innovation strategy focuses on a long-term success, by revolutionary or disruptive innovations. Along with this strategy comes an opportunity for potentially higher returns and at the same time an increased risk of failure [19]. Exploratory innovation has the intention to discover something that was unknown before as well as to create something new [21]. These so-called breakthrough innovations are usually generated through time-consuming research and development processes. Caused by the experimenting nature of exploratory innovation strategies, this strategy could impose higher risk of failure and potentially a knowledge and information gap between the organization and its stakeholders. For the success of an organization both innovation strategies, exploitative and exploratory, are of high importance, but resource-constrained organizations may not be able to implement both strategies at the same time. Often an organization has to decide for a singular strategic approach. If a company decides to implement an exploratory innovation strategy, this is often executed through cooperation with an external environment of an organization. This results in a utilization of the exploratory strategic approach through the use of a cooperative innovation strategy [19].

C. Cooperative innovation strategy

The general approach of cooperative innovation strategy is to open the organization to its environment in order to include external ideas, inspiration and expertise for its own innovation process. One motivation of this strategy is to overcome limitations in resources and/or a lack of know-how within the organizations [22]. There is a correlation between the application of a cooperative innovation strategy and the long-term success and value of an organization, resulting in a clear competitive advantage. Furthermore, this innovation strategy can pursue technological innovation and profit [23]. The cooperative approach puts the organization in the position to discover market developments or customer needs early in the process and therefore develop more custom-fit products. As a result, an organization gains a competitive advantage in the market [24]. Besides the advantages of cooperative strategies there are some risks which cooperative behavior also includes. Luo and Hu (2015) define three main risk paradigms: Cooperatives' internal factor, Technology factor and External environment factor. Each of the three risk paradigms have serval underlying risks which are displayed in Figure 1.

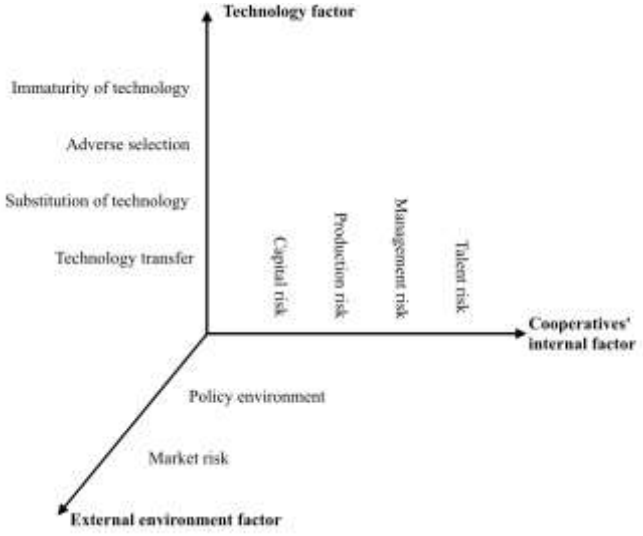

Figure 1: Main risk paradigms of cooperative innovation strategy [25]

The first paradigm, Cooperatives' internal factor, describes the risk factor arising from innovation project's activities within the cooperatives. Cooperatives' internal factor of risk includes capital risk, production risk, management risk and talents risk. Furthermore, technology innovation is difficult and advanced with high technical barriers. Therefore, cooperatives will take more risks and uncertainty when participating in a technology innovation. Technology factor of risk originates from the risk of technology immaturity, adverse selection, technology substitution and technology transform. In addition to this, External environment factors could have a negative influence on cooperative innovation caused by unpredictable changes in markets or political developments [25].

In spite of the potential risks of a cooperative innovation strategy, He and Tian (2018) state that cooperative innovation becomes more important and has attracted great attention from academic researchers in recent years, Cooperative innovation strategies are seen to be executed in many different types, for example research joint ventures, non-equity contractual collaborations, joint projects and formal or informal arrangements and cooperation with startups [26, 27]. One popular approach is the so-called Open Innovation approach described first by H. W. Chesbrough. [28] A cooperation between an organization and external startups is nothing unusual. 262 companies out of the 500 world's biggest public companies cooperate with startups. The way this coworking is happening is of high diversity however, it has not been tried to thoroughly analyze and classify those cooperation types yet [29].

The transfer of the general Open Innovation approach to a cooperation between established companies with startups is included in the SOCI framework which is described in detail in the next section.

4. SOCI FRAMEWORK

Through the relating of the three archetypes of Open Innovation to a cooperation between an organization and a startup as the external input, three possible ways of cooperation are possible: (1) Buy/rent a startup, (2) spin-off, and a startup in a (3) coupled process as a mixed method [8]. Figure 2 illustrates the three archetypes of SOCI-framework.

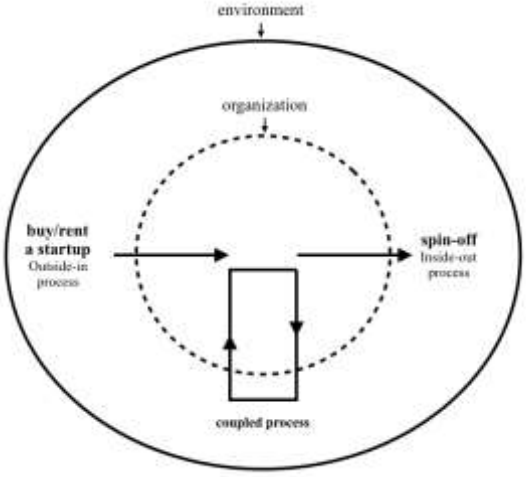

Figure 2: The archetypes of SOCI framework by Wolf et al.

A. Buy/rent a startup

Most organizations have realized that the innovation potential of startups per definition is much higher than the internal innovation potential. Thus, organizations are trying to boost their own innovation potential acquisition of a startup. For startups this is one of the so-called exit strategies where the owners of a small company sell their shares to an established organization [30]. One emasculated way for this cooperation for an established organization is not to buy, but to buy or rent a startup for a defined period of time. The worldwide increase of the acquisition of startups (1.217 (2011) to 4.217 (2017)) shows the relevance of the method of the outside-in process of an Open Innovation approach through a cooperation with a startup

B. Spin-off

A spin-off is when a company is formed through the transfer of technology from an R&D company (inside-out), which is independent of the parent company and involves the transfer of human and technological capital to a new formed market entity [31]. The innovation potential of, for example, the R&D unit of an established organization is used to find a new company which continues the innovation process as a quasi-autonomous entity. The smaller, more flexible and more agile structure of the new founded company aims to contribute to the innovation potential of the parent company. For example, the strategy of a spin-off is often used, when an innovation has great future potential but doesn't fit in the general approach of the parent company.

C. Coupled process

A clearly definable type of a coupled process through a cooperation with a startup is not existing in the reviewed literature. There is no academically defined coupled process approach of a cooperation between a startup and an established company. Nevertheless, it is theoretically imaginable that such a startup-orientated cooperative innovation strategy approach, which includes the general characteristics of the third archetype in which information flows inside and outside an organization and a startup-like partner [8].

5. THE PANDA APPROACH

The PANDA approach is a project of the Hochschule Fresenius in Germany. The PANDA approach has been implemented for the first time in the year 2017. During the last three years the PANDA approach was implemented twelve times with different organizations of the European industry with a focus on chemical and pharmaceutical companies. The target behind the PANDA approach is to enable established companies to develop a general idea to an innovation without any company-based limitation. For this motivation the statement "innovation like a startup" was established at Fresenius and with the participants of the PANDA projects. [8] Furthermore, the idea behind this initiative is to give students the opportunity to experience the life of an entrepreneur with a high amount of independence and responsibility to inspire STEM students to become an entrepreneur in their future life. The general procedure of a PANDA project is described in the next section.

A. General description

The general structure of the PANDA approach is displayed in Figure 3.

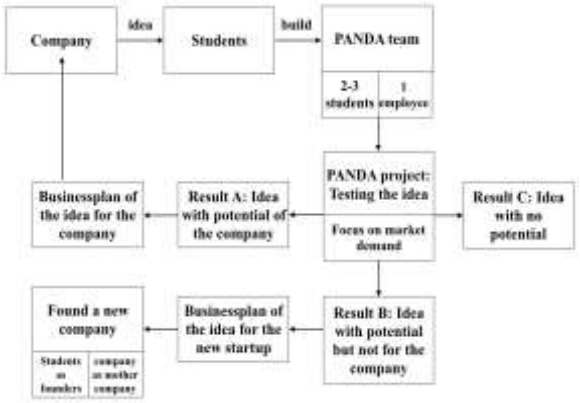

Figure 3: Process of PANDA by Wolf et al. (2020)

The PANDA process begins with an idea of a company for a potential new technology or new application for an existing technology. But often the companies have no time or resources to explore the idea respectively to a possible market demand and develop the idea to an innovation with high market acceptance, the company gives the idea to students. With two or three students and one company employee one PANDA team is built by Fresenius. This team has to test the idea concerning a possible market demand and develop the idea to a promising business model. The PANDA team has the freedom to analyze the idea completely without any company-based limitations and develop the idea detached from the business model of the original company. After expiration of the project three results are possible [8].

The first result (Result A) is if the PANDA team has identified that the idea of the company has a solid market demand and based on the findings of the project the team has developed a business model. If the business model fits the general structure and offerings of the company the PANDA team transmits a business plan with the business model to the original company. Now the company can start immediately to implement the business plan. Another result (Result B) is if the PANDA team has identified that the idea of the company has a solid market demand and based on the findings of the project the team has developed a business model. If the business model fits the general structure and offerings of the company the PANDA team transmits a business plan with the business model to the original company. Now the company can start immediately to implement the business plan. The third possible result (Result C) and the most desired result is if during the PANDA project the team has identified no market demand for the idea. If this is the case, the PANDA team recommends the original company not to further advance the idea in the future and not to invest more time and effort to develop the idea.

Important to mention is that the participating companies pay for a PANDA project. The amount of payment depends on the time scope of a PANDA project. With a part of this payment the participating students get a payment for their work [8].

B. PANDA as a coupled process

By opening established companies to new influences from external factors, PANDA therefore represents one possible implementation of a SOCI strategy. The process shows that the PANDA approach represents a coupled process of the SOCI framework because it combines aspects of an outside-in and inside-out process between an established company and a startup. The startup part is represented by the PANDA team. Because during the PANDA project the team can act and think like entrepreneurs enabled by the freedom of developing the idea without the consideration of sensitivities of the original company. Furthermore, a PANDA team has a similarity to a startup team caused by their small size, higher agility and flexibility. Through the similarities between a PANDA team and a startup team the students get an impression how it is to be an entrepreneur in the STEM industry [32].

To summarize the intention of this project of the Fresenius University of applied Sciences, PANDA represents in the perspective of companies a coupled process cooperative innovation strategy and through the perspective of students, PANDA stands for a method to get in contact with the topic of entrepreneurship and to inspire students to become an entrepreneur.

Figure 4: Idea of PANDA

The implementation of PANDA of the last three years is described in the following section.

C. Comparision to similare initiatives

Initiates concerning the importance of female entrepreneurs for society and economy are nothing unusual. There exists a variation of different initiatives which focus on the topic woman in startups. The most relevant initiatives are displayed in Table 1 [33].

TABLE I. GLOBAL INITIATIVES FOR FEMALE ENTREPRENEURS

Initiative name	*Description and focus*
International Women's Day	Initiative for gender gap-closing around the world, in the year 2020 with focus on entrepreneurs
The Alison Rose Review of Female Entrepreneurship	This initiative is a review about female entrepreneur and issues of woman in startups
Goldman Sachs 10,000 Women	It is a global initiative, built to foster economic growth amongst female entrepreneurs

Initiative name	*Description and focus*
Women Entrepreneurship Fund	This fund has an overall $30 million funding package for female entrepreneurs
Enterprise Ireland	The initiative released a 2020 action plan for women in business, aiming for a 100% increase number of women-led companies especially in Ireland
The Association of Women's Business Centers	It is a national non-profit organisation
SBE Australia	It is an accelerator, focused on women-led businesses and the particular challenges they face

The initiatives in Table 1 make clear that there already exist several high level initiatives for supporting woman as entrepreneurs. This was summarized by the name fempreneur [33]. The difference to the approach by Fresenius University is that PANDA includes female students while not excluding male students and aims to achieve an early integration of female students into male dominated industries. This is additionally highlighted by the fact that PANDA shows a strong focus on the STEM industry, which further differentiates the approach. Table 1 furthermore shows a primary focus of many mentioned initiatives on the financial aspects of supporting female entrepreneurs through organization of funds and other financial support systems, an aspect which is not the primary aim of the PANDA approach even through PANDA participants are financially supported during the project.

An international comparable approach can be found in the U.S.-Middle East Partnership Initiative (MEPI). The MEPI launched the US–Saudi Forum (ICF) on social entrepreneurship at Jeddah, Saudi Arabia. This forum has the goal to introduce the concept of social entrepreneurship among 100 students from three different colleges with the focus on professional development while empowering women. The ICF has educated 100 young Saudi women concerning the power of social entrepreneurship, shaping their communities and laying a conceptual foundation of social entrepreneurship for the future. As a result, 30 promising female students were selected to attend more in-depth training and were enabled to found their own company [34]. In comparison to the global initiatives in Table 1 the ICF has the same focus as PANDA, empowering young students. One core difference is that the ICF focuses its work only on female students while PANDA is gender inclusive, and therefore open for male students, too. In summary there are different initiatives which have some similarities but also differentiate from PANDA. The implementation of the PANDA approach of Fresenius University of applied science concerning number of participants and cases, industries etc. are described in the flowing section.

D. Implementation of PANDA

Since 2017 twelve PANDA projects were implemented in companies of the STEM industry in Germany and Poland. The next figure shows the distribution of PANDA projects which were implemented in Germany and Poland.

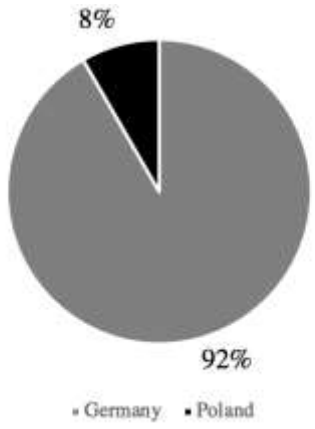

Figure 5: Distribution of German and Polish PANDA projects

The specific distribution of the industries of the twelve PANDA projects is displayed in the Figure 5.

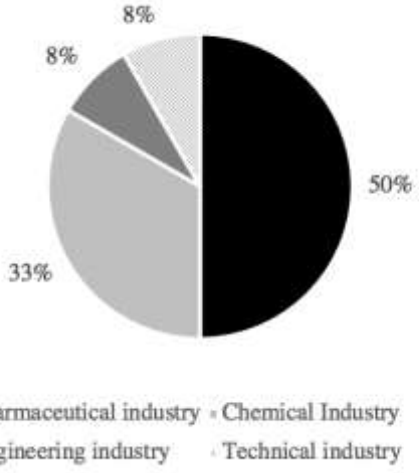

Figure 5: Distribution of industries of PANDA projects

Figure 5 shows that the pharmaceutical industry is represented with the highest number of projects with 50% (6 projects), followed by the chemical industry with 33% (4 projects) and the technical as well as the engineering industry with 8% (1 project). It can therefore be shown, that the PANDA projects were implemented over a wide variety of STEM industries. Table 1 now gives detailed information about the different projects and the number students which participated in the PANDA projects (anonymized and named Alpha-My). The PANDA

projects were anonymized to ensure the confidentiality of company internal information of the participating companies and to protect personal student information.

TABLE II. NUMBER OF PRTICIPATING STUNDETNS OF PANDA PROKECTS

Project	*Number of participation students*
Alpha	2
Beta	2
Gamma	2
Delta	2
Epsilon	2
Zeta	2
Eta	2
Theta	3
Iota	2
Kappa	3
Lambda	3
My	4
Total	**29**

Table 2 shows that in total 29 students have participated in the 12 PANDA projects. As mentioned, a PANDA team consists out of a minimum 2 students (8 of 12 projects) with 3 projects consisting out 3 students and 1 project with 4 students. Based on the described PANDA projects it is now possible to further elaborate on the role and participation of female students.

6. FEMALE STUDENTS IN PANDA PROJECTS

The following section analyses the share of female students of all 12 PANDA projects in comparison to the share of males and discusses the question if PANDA can contribute to generate more female STEMpreneurs.

A. General distribution of sexes in PANDA projects

The next figure shows that the distribution of sexes for all PANDA projects in general.

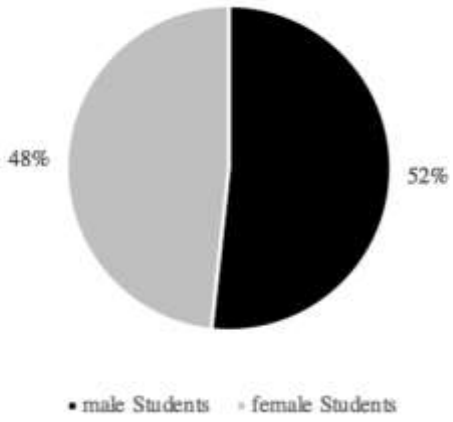

Figure 7: Distribution of sexes in PANDA teams

Figure 7 shows that the distribution of sexes in PANDA projects are nearly evenly distributed with a share of female students of 48% and a male student share of 52%. Figure 7 shows the distribution of sexes of in the 12 PANDA projects.

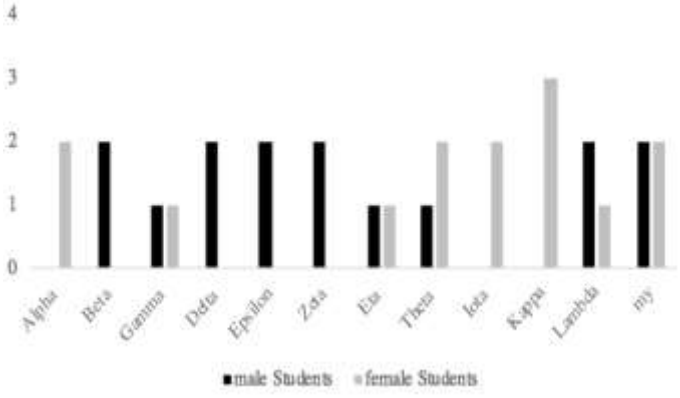

Figure 8: Distribution of sexes in PANDA projects

Figure 8 shows that the female share of participating students tends to increase in later PANDA projects. In the projects Alpha – Zeta 4 out 6 teams were male, 1 team was mixed and only 1 team was female. In the projects Eta – My 2 projects were female only and 4 projects were mixed. Based on this information, the distribution of sexes over time is now analyzed in further detail.

B. Distribution of sexes over time

Figure 8 shows the distribution of sexes in PANDA projects in time-period 2017- first quarter (Q1) 2021.

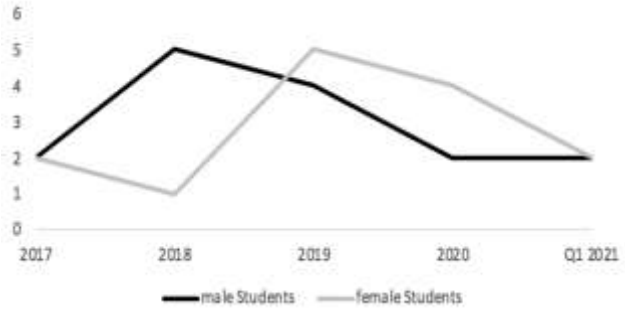

Figure 8: Distribution of the sexes in PANDA projects 2017 – 2021

Through Figure 8 it is recognizable that since 2019 the share of female participating students exceeds the male share. For the first quarter of 2021 the distribution is balanced. The next section now further discusses the composition of sexes in PANDA teams.

C. Group composition of PANDA teams

The three different possibilities of group composition (only male / only female / mixed team) is shown in Figure 9.

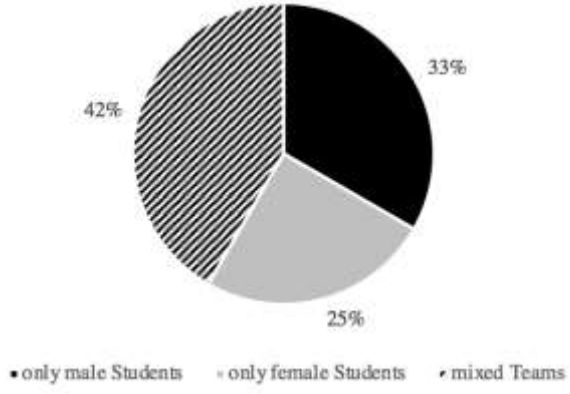

Figure 9: Group composition of PANDA teams

Figure 9 shows that the share of only male teams is with 33 % higher than the share of only female teams with 25 %. The highest percentage of team compositions is the mixed team with 42%. In addition to this it is also recognizable that the compositions (only female / mixed teams) accumulate to 67 % of all PANDA team where a minimum of at least one female student was included.

D. Creation of new STEMpreneurs through PANDA

In Q1 2021 a PANDA project lead to the creation of a real-world business for the first time in the history of the project. The founder of the startup is a male student of the study path Business Chemistry and the newly founded company develops a solution for independent private sector carbon dioxide certification for German companies. This means for PANDA concerning the creation of new startups in the STEM field and therefore the creation of STEMpreneurs a success rate of 1:12.

E. Contribution of PANDA for creating female STEMpreneurs

The analysis of the female share of participating students through different perspectives makes clear that PANDA shows no over-proportional focus on female STEM students and that the male share is in general higher than the female share. But on the other hand, it becomes visible that the female share of students participating in PANDA projects becomes higher than the male share since 2019. In an addition to this fact the amount of PANDA teams with a minimum of one female student represents the most common group composition. Nevertheless, up until today no female STEM startup has been founded through PANDA.

F. Discussion

In comparison to similar initiatives for creating more female entrepreneurs PANDA can be regarded as a gender inclusive approach. Furthermore, the financial supporting aspects included in PANDA are not as substantial like in other global important fempreneur initiatives. This fact might be seen as one possible reason why PANDA has not created a female STEMpreneur until now. Additionally, PANDA has its focus on students of STEM fields, an industry which already shows a higher representation of male students. These two described aspects can be seen as possible assumptions to explain the currently limited success of the PANDA approach concerning the idea of creating female STEMpreneurs. But in comparison to other initiatives PANDA also only includes a small number of participants, in overall 29 students which necessarily leads up to a lower statistical probability of success. In general, it can be stated that the overall aim of PANDA, namely to connect male and female students of STEM study paths with the topic of startups and entrpreneurship while enabling first real world contact points to this topic is achieved by the illustrated results in this study.

7. CONCLUSION

The startup scene shows that female entrepreneurs are less represented than male entrepreneurs. In fields of STEM industry this trend increases. One possible explanation for this is the general gender biased distribution of female participants in STEM industries or STEM study paths. But the analysis of the role of women in business context in the past years has shown that a female influence has a positive impact on business and organization in general. A higher amount of female entrepreneurs in STEM industries, so-called STEMpreneurs, is consequently needed. The German university of applied science Fresenius has developed and implemented an approach, the PANDA initiative, which allows students of STEM study paths to experience the life of an entrepreneurs, connects them to

business ideas of the industry and enable them to develop a future orientated real-world business model. The idea behind PANDA is to inspire more students to become a STEMpreneur. After 12 projects the first success is visible, the first startup created through PANDA experience. But can PANDA create more female STEMpreneurs?

This article shows that the general distribution of male and female student is in balance and since 2019 the female share is higher than the male share. In addition to that, more PANDA teams were built with a minimum of one female participants in comparison to only male teams.

To summarize the overall role of female students in PANDA and to provide an answer to the question described above, PANDA stands for one possible approach in the context of the SOCI framework which can contribute to create more STEMpreneurs but the role of female students in the PANDA approach has shown that the female share is developable and until now no female STEMpreneur was created. It is also notable that the PANDA approach is a method to transmit the idea of founding a startup as a female STEM student and enable a possible founding by reducing the barriers through connecting with the STEM industry and entrepreneurial development of a STEM business idea.

8. OUTLOOK

Next steps concerning the question if PANDA can be a helpful method to inspire students of STEM study paths, especially female students, are to continue the observation of the female share in PANDA projects and to observe and analyze the long- term effect of PANDA on female students. In addition to this, future research activities considering the PANDA approach are being implemented. One cooperative research venture with the Hochschule Fresenius and the University of Economics and Business in Poznań, Poland analyses the effectiveness of the PANDA approach as an innovation strategy for established companies. Research considering the effect of PANDA on the entrepreneurial behavior of STEM students is additionally conducted at Hochschule Fresenius.

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