STEM Gender Bias in Austria: – the result of a segregated Educational Schooling System and an exclusive masculine STEM Culture?

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Introduction

"Equal pay for equal work and work of equal value" is one of the five priority areas identified by the European Commission in the "Women's Charta" (Commission, 2010). It has been introduced as a key area to even the gender pay gap which has amounted in Austria to 23,4% in 2012 (Statistik Austria[1]) which is significantly above the European average of 16,4% (Eurostat[2]), hence Austria ranks at the last but one position in Europe. This data illustrates the persisting gender pay gap between men and women on the European labour market which is considered to stem from disproportional representation of men and women in certain sectors of the labour market and different value paid to jobs done by women within the same sector. The horizontal segregation of the labour market is certainly true for Austria as local data provides evidence that decisions for education and training still follow traditional gender-paths: a low percentage of young women engages in the field of STEM, on the other hand few young men opt for the care and education sector. This can be considered one of the causes why young women in Austria though achieving better at school and earning higher degrees in secondary and tertiary education are rarely able to convert their educational attainment into an equivalent job status. International student assessment studies underpin this data and provide, moreover, evidence that the inequity in engagement correlates with inequity in attainment (OECD, 2007, 2010, 2012). Austrian scores in PISA reveal an outstanding gender gap in the field of physics to the advantage of boys (PISA 2006) as well as a large gender gap in literacy to the advantage of girls (PISA 2009). Although questions of gender inequality have been on the political agenda for years and although a lot of initiatives to change the situation have been conducted by the Austrian federal ministry of education and women affairs (for an overview see Paseka & Wroblewski, 2009) it seems that there has been little change in the participation of women in the STEM field and also the development of attainment points rather in the opposite direction: The recent PISA data in mathematics (2012) expose "the largest increase in the gender gap observed among all countries with data for both 2003 and 2012" (OECD, 2012, p. 2).

A considerable body of literature suggests that gender inequities in engagement in the field of STEM are rooted in the widely spread societal assumption that science – especially physics and engineering – is a male field. In addition, Angelika Paseka and Angela Wroblewski, the authors of the Austrian EURYDICE report (2009, p. 1) describe "the acceptance of gender issues in policy making especially in the education system […] as ambivalent. […] Questions of gender equality are not realised as a question of main concern". Although the reasons for the persisting STEM gender bias are complex, the aforementioned statements draw attention to the interdependency between the structural level of policy measures on the one hand and individual values and beliefs rooted in the societal construction of gender on the other hand. In this paper I will shade light on the interference between the prevalent science discourses that align science with masculinity, the structure of the educational system and the subjective theories of teachers on physics teaching and gender which have impact on teaching designs and classroom interactions.

[1] http://www.statistik.at/web_de/statistiken/soziales/gender-statistik/index.html
[2] http://epp.eurostat.ec.europa.eu/tgm/table.do?tab=table&init=1&plugin=1&language=en&pcode=tsdsc340

Firstly, this paper will provide a brief overview of the organisation of the Austrian education system first. Secondly, a literature review on physics as a culture seen from a feminist point of view and its influence on STEM aspirations of women will be laid out. Thirdly, the methodology and the results of an interview-study with four Austrian teachers will be presented. Particularly the relation between the embodiment of beliefs and habits during the physics teachers' education at the University of Vienna and the physics classrooms culture will be investigated. Finally, an outlook is provided discussing which measures could be taken to help to change the situation.

Organisation of the Austrian education system

Madeleine Arnot (2000, p. 293) ascribes the value attributed to "gendering of separate spheres in society" by Western Nations as one of the most powerful global forces in the nineteenth and twentieth century. Following a historical perspective Kathryn Scantlebury and Dale Baker (2007) offer an insight how the segregated labour market emerged in the United States and Canada in the first half of the twentieth century. They draw attention to the fact that "by the end of the nineteenth century more girls than boys were studying science in high schools in the United States and Canada, and girls were receiving better grades than boys" (p. 260). However, the vocational education movement which was initiated in the USA after World War I, "led to a decrease of 80% of girls enrolling physics from 1920-1928 in the US" by creating different tracks for boys (mechanical and university) and girls (business or home economy) (p. 260). The correspondent societal concept of men as breadwinners representing a masculinised public sphere and women as caretakers who are responsible for the family and the private life sphere shaped the organisational structures and content of national educational systems not only in the US (Arnot 2000,p. 293).

Likewise in Austria a similar development which set apart the sphere of science and engineering and the sphere of humanities and social studies can be traced even though modulated in some way or another. In Austria the philosophical faculty of the University of Vienna was the first Austrian university, which was opened for women in 1897. In this time – from 1897 until 1938 –the rate of women, who studied and graduated in physics, was high. Between the two world wars 20-50 % of the students, who acquired a doctoral degree in physics were women, which amounts to half of all doctoral degrees in physics earned by women until 1998 (Durstberger, 2005). A closer glance at the organisation of secondary vocational education in Austria suggests that the gender bias is encapsulated and pre-formed in the organisational structure: The vocational education movement, which started at the beginning of the twentieth century, and evolved a story of success in the 80s of the last century, might be one of the causes for the large gender pay gap in Austria as well as an explanation for the OECD's largest inequity in physics scores (PISA 2006). Nowadays more than 50 % of young people in Austria attain their final certificate at Higher Colleges for Vocational Education, which qualifies them for the labour market and at the same time graduates them for an academic track: While young men outnumber young women at Higher Technical Colleges girls outnumber boys at Higher Colleges of Management and the Service Industries, whereas the gender ratio is balanced at Higher Colleges of Agriculture and the female-male-ratio~~n~~ amounts to 60% (female)-40%(male) at Higher Colleges of Business Administration. Having a closer look at the curricula, colleges preferred by male students offer more than ten lessons of science teaching per week (grade 9-13) whereas colleges, preferred by female students offer fewer than eight lessons of science teaching , whereupon physics lessons make up only a small portion (two lesson in whole upper secondary).

The organization of the academic secondary educational track in Austria reflects also the segregation between the scientific – male – hemisphere of knowledge and the linguistic and humanities and therefore female hemisphere of knowledge in the respective school types. This segregation is reflected in the proportion of girls and boys composing classes in academic secondary schools (AHS – Allgemeinbildende Höhere Schulen) Comparable to the vocational track female students outnumber male students in the language track whereas male students outnumber female students in the science track. However, there are more science lessons on the upper secondary level at academic secondary schools with a strong language focus (6 lessons of biology, 4 lessons of chemistry, 5-7 lessons of physics) than at the female dominated higher vocational colleges but less than in academic secondary schools with a focus on mathematics and science (7-9 lessons of biology, 5-6 lessons of chemistry, 7-10 lessons of physics teaching), whereas the difference lies in the so called hard sciences – physics and mathematics. As decisions have to be taken early in educational carriers – at the age of 12 for the specific academic careers and at the age of fourteen for vocational careers – interests and possible ambitions are pipelined early.

Although governmental measures promoting Gender Mainstreaming have been taken since 2000, e.g. the establishment of inter-ministerial committees (Interministerielle Arbeitsgruppe, IMAG) (cf. Paseka & Wroblewski, 2009) improvement takes place very slowly and changes in career choices can hardly be detected. Anyhow, success is reported when the focus of vocational tracks is transformed (e.g. combining engineering and design or combining technology and media competences). This strategy for creating innovative job-profiles is also recommended by the European Commission which suggest to “encourage women to enter non-traditional professions, for example in "green" and innovative sectors” as a key action to combat the gender pay gap (Comission, 2010).

Physics as a culture

A recent systematic science education literature review on girls’ engagement in science (Brotman & Moore, 2008) has figured out that the focus of research has changed since about 2000. Feminist researchers focus less on girls but rather work out how the marginalisation of girls and women in the field of physics, engineering and technology is intertwined with the culture of physics.

Since the work of Thomas Kuhn on “The Structure of Scientific Revolutions” (1970) it is shared knowledge that there is a tension between the logicoempiristic description of science and ‘science in its making’ (Osborne & Collins, 2003). The discourse on history, philosophy and sociology portrays science rather as knowledge situated in a scientific community where scientific progress is negotiated in discourse amongst its members. Science/physics is a specific perspective on nature which is developed by the inspiration and creativity of the members of a specific community of practice (Wenger, 1998b). Therefore science cannot be reduced to an epistemological body and a set of scientific methods as often done in textbooks which characterize science according to the Baconian epistemological myth, that the theories and concepts of physics are absolute and unaffected by values and beliefs (cf. Brickhouse, 2001). Physics is as any science a “human enterprise”, which is practiced in the context of a larger culture and its practitioners (scientists) are products of that culture. [Furthermore science] … affects and is affected by the various elements and intellectual spheres of the culture in which it is embedded” (Lederman, 2006, p. 1). However “that official ideologies about objectivity and scientific methods are particularly bad guides to how scientific knowledge is actually *made*” (Haraway, 1988, p. 576, original italics).

In their everyday routines the members of the scientific community have developed certain patterns of perceptions and behaviours, specific ways of reasoning and values. These implicit rules and values are border markers and safeguard the community. Novices who want to become acknowledged members of the community of physicists have not only to indulge deeply in the episteme of physics and its scientific methods, they also have to embody the implicit habits and beliefs of the professional community. Therefore Wenger draws attention to the fact that learning cannot be considered merely as a matter of acquiring knowledge. It requires engagement of body, mind, and emotions, it affects the whole person. Therefore novices who want to become physicists must “find a liveable identity” in the respective community of practice (Wenger, 1998b, p. 41). Learning should therefore rather be understood as a transformation of “identity-in-practice” (Brickhouse, 2001, p. 289 following Lave, 1996) or as Etienne Wenger (Wenger, 1998a, p. 263) describes it eloquently, “education must strive to open new dimensions for the negotiation of self”.

However, the crucial question is, how young women can “find a liveable identity” in the scientific community of physicists. According to Judith Butler (1990, p. 24) “the cultural matrix through which gender identity has become intelligible[3] requires that certain kinds of ‘identities’ cannot ‘exist’.” As some gender performances are rendered “unintelligible” within the so called “heterosexual matrix” for women who want to develop a “physics identity” (Carlone & Johnson, 2007) only a limited range of “intelligible” identities are available. To summarize the arguments of Judith Butler and the previous short literature review on physics as a culture one can conclude that women who want to engage in physics have to face two constraints: 1) There is a limited range of intelligible identities for girls who want to engage in physics as the popular discourses which associate physics with “cleverness” and “masculinity” sets constraints to the balance of ‘appropriate gendered’ identities and science aspirations. Furthermore, there is a cross-cut with class and to a certain degree also with ethnicity (Archer et al., 2012). 2) Due to the fact – as argued before – that physics as any other knowledge is culturally situated, and due to the fact that the societal dichotomic gender discourse associates physics with masculinity the dominance of men in the field of physics is sustained and girls and young women are subtly hindered in their aspirations. Therefore Donna Haraway proposed to deconstruct the “claims of hostile science by showing the radical historical specificity, and so contestability, of *every* layer of the onion of scientific and technological constructions” (1988, p. 578). From this it follows that the societal dichotomic gender discourse ascribing physics cultural values such as objectivity, reason, mind, … is challenged. As these stereotyped ascriptions are in turn closely associated with masculinity and opposite to femininity, they establish~~ing~~ the exclusive and male culture many students prototypically attribute to physics lessons, which causes the ‘othering’ of girls and hinders subtly their progression.

Yet the feasibility of an academic career in physics differs throughout Europe as researchers from Denmark, Estonia, Finland, Italy and Poland could figure out: To shade light into the puzzle of the gendered European brain-drain-map in physics they collaborated in a research project which was conducted to identify specific cultural patterns at university workplaces (Hasse & Trentemøller, 2008). They could provide evidence that access to academic career paths (the height of the so called glass ceiling) depends on the workplace culture, which they categorized as Hercules, Caretaker or Worker Bees cultures. Whereas in Herculean culture gender overshadows women’s skills in physics, in Caretaker cultures as well as in Worker Bees cultures, women are very well respected for their

[3] „Intelligible“ genders are those which in some sense institute and maintain relations of coherence and continuity among sex, gender, sexual practice and desire” (Butler 1990, p.23) vi

skills in physics and therefore can persist in the science pipeline. Although all types of workplace cultures could be found in all participating countries, there is a strong tendency to the Herculean culture in Denmark whereas the Caretaker culture was dominant in Italy and the Worker Bee Culture in Eastern Europe. However, there were local cultural trends intervening with workplace cultures and moreover, making a career in research was not equivalent with having power and position to direct research. Additionally, participation in research does neither allow predictions on the percentage of women in physics courses nor on engagement in physics at school level. Both predictions differ considerably between European countries.

Physics classroom cultures

Although career choices are complex and parents play a substantial role, physics classroom cultures and the recognition of the ambitions and the performance of students by their teachers is an important factor for future individual vocational development. Despite of the fact that physics lessons at school are not directly related to the correspondent scientific discipline, teachers are recognized by their students as role models, they are assessed against the students' prototypes of people who are engaged in physics. Teachers facilitate learning, they find ways (or do not find ways) to address the interest of their students. However, the selection, legitimacy and didactic foundation of content, the transformation of disciplinary approaches, the specific forms of classroom communication, the architecture of physics classrooms and the equipment used there, correspond to lecture rooms and lab equipment commonly used in the respective scientific discipline. Physics classrooms at school are a mix of classroom and laboratory space. The seating rows there are oriented to the blackboard in front of the room. There is a huge desk anchored in the floor which marks a clear separation between the space for the students and an exclusive space for the teacher. This arrangement together with the mismatch of issues being taught and time abundant for learning favors a hierarchical model of teaching by clearly separating the area of expertise and science-based instruction from the space of the learners and the amateur view of nature. The frontal orientation of classroom furniture, the high stakes demands aligned to a small group of interested and talented students, the attribution of difficulty to physics as a school subject, favours teacher centred-instructional designs as well as a teaching culture which supports rather students' assimilation than integration into the culture of physics (cf. Willems, 2007).

The culture of physics lessons is also the institutionalized result of societal negotiations materialized in curricula and textbooks, and in regulations on teacher education. Furthermore, it is visible in the budget for teaching facilities and equipment and this is further developed in classroom processes amalgamated with the students' expectations, attitudes and learning strategies in respect to physics as a school subject. To sum up the culture of physics classroom is institutionally established by the scientific culture of physics as well as by the societally negotiated structures of the educational system mantled by local and contextually bound parameters.

However, when planning lessons and enacting them in the physics-classroom the embodied patterns of behavioral dispositions and thoughts as well as the embodied values acquired during teacher training at the university influence teaching decisions (selection and schedule of issues taught, arrangement of teaching and learning designs; illustrations, artefacts, and methods used; evaluation procedures selected,….) as well as classroom interactions. Therefore the culture of physics classrooms can be considered isomorphic to the culture of physics as a discipline – although not being absolutely the same. The teachers' habits and beliefs as well as certain arrangement in the physics classroom are the agents mediating the transformation of an academic culture which is gendered in multiple ways as aforementioned. However, teachers are working in particular societal, school and classroom contexts and communities. Their experiences reframe their knowledge, beliefs and practice and amalgamate in the highly idiosyncratic pedagogical content knowledge of teachers' "content base for teaching" as Shulman (1987) called it.

Research Design

The study discussed in this paper has explored the following questions: Which subjective theories do shape the focus of the case study's teachers' learning environments and their classroom interactions? How are these subjective theories related to the process of physics learning, and how are they related to gender? The study tried to examine the assumptions, attitudes, norms and values upon which teaching decisions are made. It reconstructs the narratives teachers build about their motivation of becoming a teacher, the influence their own experiences at school and university had when being a student there. It tries to analyze how these narratives are connected to the aforementioned culture of physics and the societal discourses on gender and science.

The study is based on in-depth interviews with four Austrian physics teachers and a close observation of their physics classrooms' micro-processes of interaction (observation reports of ten lessons of fifty minutes in lower secondary classes).: Two of them (Erika and Johanna[4]) were female; two of them (Franz and Thomas) were male. They differ in their school experience: two teachers (Erika and Franz) have already taught more than twenty years, two (Johanna and Thomas) have only a few years of teaching experience. Three of them (Erika, Johanna, Franz) hold also a teaching degree in mathematics, the younger male teacher (Thomas) holds his second degree in philosophy. All of them achieved their physics teaching degree at the University of Vienna.

The interviews were videotaped, transcribed and analyzed through hermeneutical in-depth methods and interpreted from a social constructivist theory of high school physics as well as gender studies. The reification of gender has been omitted by focussing on the diversity of the learning processes in the classroom observations had escaped.

Results

Before discussing the results of the interviews I will give a brief description of the four teachers' learning design: Teaching for understanding by elaborating the core concepts of physics together with the students is an important focus of all four teachers. However, the content structure of the lessons is based more or less on the textbooks available to the students and therefore driven by the systematics of 'textbook physics'. Yet the teachers choose different real world contexts for imbedding physical content. For example, Franz and Theresa follow the traditional technical contextualization of physics; nevertheless the ecological aspect of technology is also important for Franz. Johanna, who is also focusing on ecology, favors in contrast to Franz competences for ecological behavior. Physics as a powerful scientific explanation of the world around us is the focus of Thomas' learning designs. Methodologically the male teachers prefer classroom talks, while 50 % of the female teachers' lessons are dedicated to small-group hands-on-activities. With the exception of Johanna all three teachers demonstrate experiments in front of the class frequently. However, only the female teachers provide opportunities of peer-instruction for their students. Moreover, both of

[4] all names are pseudonyms

them monitor the learning-process regularly by formative assessment. However, the specific assessment technique of Theresa causes suspense as some students are anxious to succeed.[5]

Although all four teachers are aware of the pitfalls of the male connotation of physics, the image of the technical potent man arises frequently during the physics lessons – partially explicitly exposed in the teaching design by dramatizing physics as a success story driven forward by 'exceptionally gifted lonesome male heroes' and regularly happening as boys apply technical vocabulary more frequently in everyday language (most of all in early adolescence) to underline their masculinity. Besides the use of male symbolism male students also dramatize masculinity by demonstrating their experimental competences which frequently leads either to social conflicts or to the discrimination of girls when small-group hands-on activities are conducted in gender-heterogeneous-groups. In additon, gender is explicitly dramatized by Theresa and Thomas when speaking about everyday technical experiences (domestic appliances, do-it-yourself experiences), and implicitly by using abstract artefacts for illustrating physical phenomena which emanate the entanglement of physics and male annotated technology.

When asking the teachers to explain their considerations for the elaboration of learning environments, an interesting difference arises: As the male teachers think that school is not the predominant place for learning physics, they align their lesson design to the (assumed) interest of their students, while the female teachers focus on safeguarding successful learning and thoroughly developing experimental skills of all their students. Furthermore the male teachers express their preferences for teaching upper-secondary students: They assume that only there they have the opportunity for realizing their specific physics teaching ideals, which Thomas, who is also teaching philosophy, explicitly describes as a *"heuristically-hermeneutic"* teaching style [Int/Th/L489-490]: *"physics is understanding how things work"* [Int/Th/L435]. For the other three teachers, who attained their second teaching diploma in mathematics, experiments, hands-on-activities, the direct contact with the questioned phenomena is of utmost importance for good teaching practice. For Theresa, experiments are even the focal point of good practice (Int/Th/L44-45). Although she targets her lessons at 'physics for all', courses for the gifted and talented (e.g. physics olympiade) are for her the most important and motivating element of her work at school (Int/Th/L252), as only these courses give her the possibility for performing all her experimental expertise she has acquired. Although experiments are of importance for Thomas, especially when they provide the opportunity for aesthetic sensations, he is convinced that the affective tension arisen by a discrepancy between everyday concepts and phenomena thoroughly watched is the utmost chance for learning.

While for the female teachers, empowerment of students by giving them a variety of occasions for experiencing competence and understanding, are important teaching objectives, the two male teachers and to some extent also Theresa are attracted by the aristocratic grandiosity ascribed to physics. Thomas specifies this in the interview:

"*I think that I primarily address the gifted students … because, because only with them such a dialogue is possible, which is satisfying for me. Because those cognitive processes are happening there, which I like to have. Ahmm. However I think that the others also like listening, … That means that also witnessing a cognitive process is really good"* (Int/Th/L109-121 shortened)

[5] for more details see (Bartosch, 2013).

However, the difference in goals between female and male teachers can be understood out of their own gendered experiences: As both male teachers remembered a lot of out-of-school informal activities motivated by presents they got from their parents, they project these experiences unconsciously onto their class not reflecting that there might be students, who do not have the same chances they had – especially the majority of girls probably have not had equal opportunities for informal physics learning. On the contrary Johanna's teaching designs remembers her missing experimental experiences when she attended her first laboratory-course at the university:

"*The cliché – not being gifted in handicrafts not being gifted in engineering – has been an issue through out all my university time. …. As I had few previous experiences // this was // during my academic studies // insanely difficult and it was deeply intrenched in myself ….. I//I can't manage it"* (Int/Jo/L326-336 shortened)

However, this was not the only coincidence of teaching practice and biographic experience. All four teachers reported a traditional family environment: the father is the bread winner, the mother abandons her job at the birth of her first child (except for Johanna, whose mother returned to a low-paid job in the social sector.) The two male teachers but also Johanna remember a typical sex-role-socialization during child hood and adolescence. However, as it is often reported of women in the field of physics and engineering, Theresa's and Johanna's father were engaged in the field of engineering. Theresa as the only daughter had the privilege of developing her interest in physics by doing experiments with her father regularly since the time of her childhood and still yet. Johanna, however, could not profit from her father's expertise, as there was her elder sister, closely interwoven in her fathers' world of engineering. However, it was Theresa's father who also persuaded her to become a physics teacher and abandon her dream of becoming a physicist. He was reasoning that the teaching profession will allow her to balance family work and job more easily. Johanna on the contrary took her chance, when her sister decided to follow the female vocational track and started an education in elementary pedagogy: She disclosed to her rather astonished parents that she aspired becoming a physics teacher. In contrast to the two women's fathers who supported their daughters' aspirations, Thomas' father did not agree with his son's desired professional future as a physics teacher as he considered such a career not appropriate for a *proper* man and also Franz' father would have preferred his son to become a lawyer.

Though the experiences with physics lessons at school differed to a great deal, all four teachers integrated in some way or another the way they were taught at school in their lesson designs. For Theresa her physics teacher was *"an exceptionally gifted experimenter"* whom she admired as a role model for good physics teaching. Similar positive experiences were reported by Thomas. For Franz the performance of his teacher was not outstanding, however, it suited his interests and for Johanna after some good experiences in lower secondary she had to 'bear' a female physics teacher in upper secondary who stereotyped her as a diligent girl who could never ever succeed in physics as physics this was a male field and not for girls. Nevertheless, Johanna took over the stereotype of *"the diligent girl"* when she was speaking about the girls in her class who were interested in the issues she taught, who succeeded and partially identified with the subject and were 'keen" on doing physics and could work out even complicated issues thoroughly.

All four teachers report experiences of being discriminated or even humiliated during their studies at university. They were educated by teachers and laboratory tutors whom they hardly experienced as supportive teachers. They perceived them rather as gate-keepers who refused entrance to novices, who were incongruous to the image of a proper physicist who was of course male and not female, who wears his hair neatly cut and not long like a woman (as Franz did). All of them vividly remembered their first laboratory course experiences where they felt confronted – either in reality or phantasy – with their experimental incompetence. All of them remembered tutors who refused to provide support which they would urgently have needed then. Having overcome those early obstacles Theresa and Franz, however failed to do their doctoral degree in physics. Theresa felt not able to balance laboratory work and family obligations, Franz could not imagine spending the rest of his life in the sophisticated and aristocratic intellectual world of physics. He also dedicated himself to family life and becoming a teacher. When asked for the traits of a woman who can succeed in physics, Theresa answered that she had to be *"handfest"* which means that she has to harden herself against potential mental stress and injuries. However, she reported that some of her female students started to study physics – the majority in order to become physics teachers. Yet she was wondering: *"I now have an 8th class // there is a girl who wants to study physics, another one in my 7th class … wants to study physics as well.// That's of course a rarity".* (Int/TH/L50-52, shortened).

Discussion and Conclusions

To summarize, all four teachers were socialized in a traditional heteronormously organized family, all four teachers had experienced humiliations during their physics education either at school or at university, all of them had embodied an image of physics as an aristocratic, difficult, hard and male field. As they never reflected their embodied experiences, they in turn enact them again (unconsciously) in their everyday teaching-routines when they feel that 'girlish' students are rather diligent than gifted (Johanna), when they think that only robust ("handfest") girls can succeed in physics (Theresa) or when they align their teaching design with the gifted students (Thomas, Franz, Theresa). This leads to the conclusion that during their academic studies at physics institutes in university, the physics teachers have embodied the aristocratic social structure of the field which they now enact (unconsciously) when teaching physics at school.

As none of the teachers had the chance for research in physics, it can be assumed that they were trained in what Kuhn (1970) called "normal science". However, Kuhn drew attention to the fact that "normal science" is not about discovering the unknown, but rather "a strenuous and devoted attempt to force nature into the conceptual boxes supplied by professional education" (Kuhn, 1970, p.5). Therefore, though doing inquiry regularly with their students, these teachers see themselves rather as foundation layers (Franz, Johanna and Theresa), role models (explicitely Thomas) and also as gate-keepers who only give those access to the scientific career pipeline who are talented and gifted – and normally male, as girls, who succeed in physics are either recognized as diligent (Johanna) or an exception to the rule (Theresa).

Realizing a career in physics is highly dependent on two factors as was explicated earlier: 1) Are aspirants recognized as members of the scientific community? 2) Is a physics identity intelligible for a man or woman? Johanna and Thomas never thought of becoming a scientist in physics. They wanted to become a physics teacher which can be understood as a reconciliation of intelligible male and female identities in a heteronormative society. However, a physics teacher was not considered a proper identity for a man by Thomas' father. Theresa and Franz could not realize their doctoral aspirations in physics. Yet the reasons they narrated were interesting: For Thomas the "brainy" physics culture did not offer him a liveable identity. For Theresa the workplace culture of the physics lab was incompatible with being a mother and having a family life which is aligned to the Herculean workplace-culture described by Cathrine Hasse and Stine Trentemøller (2008). Having a family life was not regarded as congruent with pursuing a scientific career for Franz either – also for financial reasons as Franz explained in the interview. This is aligned with the results published by Louise Archer (Archer, DeWitt, & Willis, 2014), who worked out that there is not only a tension between a desirable female identity (intelligible in a heteronormative society!) and sustaining aspirations in physics. She also focuses our attention to the aspect that despite of the alignment of masculinity with the orthodoxy of science, male students who are imagining "a future for themselves within science … need to self-identify as 'brainy' — an identity which is structurally more difficult for working-class and ethnic minority pupils to occupy due to the sociodicy of dominant societal groups which aligns privilege with academic achievement achieved through 'natural intelligence'" (p. 22).

Overcoming gender inequalities in the STEM-field is highly dependent on the compliance of key actors in the field of politics and in the field of science to bridge the gap collaboratively. This means facilitating a structured debate which unmasks the 'choices' young women make as a consequence of the exclusive and masculine image of STEM and societal gender stereotypes . Following Louise Archer (2012, p. 984) I thus propose a bottom up – top down strategy for raising STEM participation: "interventions need to integrate ways for young people (and staff) to engage with and challenge dominant gender discourses". This includes organisational development of the educational system as well as of physics institutes at university. A starting point could be a critical analysis of the chances and challenges arising from the gendered structure of vocational education and the traditional long lasting exclusion of teacher students from the research field. It requires a tailored curriculum for teacher students where awareness and metacognitive competences with respect to the connection between the elitist construction of the scientific culture of physics and inequities (due to gender in intersection with other dimensions of inequity) can be developed. This is of utmost importance as metacognitive competences are constitutive for the development of PCK (pedagogical content knowledge).

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