“Leaky pipeline” – to be or not to be a useful metaphor in understanding why women to a disproportional degree exit from scientific careers

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The metaphor[1] a “leaky pipeline” is used in the literature on women in science to describe the circumstance that women scientists leave science academia at a greater rate than their male colleagues. The image of a pipeline is used to illustrate a set of educational and employment stages that comprise a science career. The implication of the metaphor is that, to increase women’s representation in science, policies must be devised to “patch” the leakage at those points where the pipeline loses more women than men. Pointing at the many weaknesses of this quite popular metaphor, the paper will question the usefulness of the metaphor when it comes to understanding why women at a disproportional rate leave science academia. The paper argues that the metaphor oversimplifies the highly complex issue of retention and exit from science careers and thus does more damage than good. To ensure a more thorough understanding of how the representation of women in science academia develops and accordingly proper political actions, it is time to give up the notion that the “leaky pipeline” metaphor communicates the problem.

Introduction

It is increasingly accepted that scientific endeavours are improved by having a great diversity of perspectives in the search for knowledge (Blickenstaff 2005). As long as women – and other minorities for that matter – are highly under-represented in physics, and other fields of science, a significant number of intelligent and talented women are using there abilities elsewhere, leaving the talent pool in physics relatively small. The She Figures 2006 suggest that it will be difficult to sustain and impossible to increase the EU’s research capacity according to the ambitious plans that

[1] Not everybody consider the ”leaky pipeline” to be a metaphor. Phrases like a ”conceptual framework”, ”model” or “phenomenon” are often applied in the literature.

have been set, if intellectual resources are not drawn from those with appropriate abilities and attainment on a more equitable basis than they are at the present. The fact that women are – and always have been – under-represented in physics academia in most countries has caused an increased focus and concern among both scholars and politicians (e.g. Preston 2004; ETAN 2000, She Figures 2006). A situation where women also disproportionably exit from scientific careers adds to the problem of the under-representation[2].

This phenomenon of women exiting a career in science[3] is often referred to as the "leaky pipeline". It is a key point that the further along the pipeline one looks the fewer women you find – they are leaking out of the pipeline to use the terms of the metaphor[4]. Hence, the implication of the metaphor is that, to increase women's representation in science, policies must be devised to "block" the leakage at those points where the pipeline loses more women than men.

"Leaky pipeline" – origin and widespread use

Sue Berryman (1983) used a pipeline as the conceptual metaphor to help outline the representation of women among B.A, M.A and PhD degrees in quantitatively based disciplines. She provided a model, which has been seen as a major innovation, in the empirical analysis of gender difference emerging in the process of becoming a scientist (Xie and Shauman 2003). Joe Alper brought additional life to the metaphor with his article in Science (1993) where he summarized studies on why the pipeline is leaking women, and it is not unusual to see Alper referred to as the father of the metaphor (Højgaard and Søndergaard 2002).

The educational "pipeline" is often referred to as beginning at the level of elementary school where boys and girls chose math and science courses. The pipeline continues through high school to bachelor and master level ending with a PhD degree in science (Berryman 1983; Anders 2004; Atkin and Green and McLaughlin 2002; McDonnell 2005; Kidd and Cohoon and Liuti). Another set of studies focus on the career pipeline which runs though the different levels at faculty starting at

[2] The lack of advancement is a third problem closely related to this issue. The European Commission's report "She Figures 2006" reveals a substantial glass ceiling effect in all Member States for women scientists.

[3] As pointed out by Preston (2004) exit from science is a slippery concept since "in science" and "out of science" are not easily defined terms. Science encompasses a large number of fields, and scientific skills are used in countless jobs. In this paper I will primarily focus on physics which traditionally is one of the fields with the fewest women pursuing a career in academia. In 2004 26% of the PhDs in physics in the US were awarded to women (http://www.nsf.gov/statistics/nsf06308/pdf/tab3.pdf). According to the European Commission's report "SHE figures 2006" the EU countries have an average proportion of 33% female PhDs in physical science in 2003.

[4] Only 11% women working in natural science in the EU countries were in 2004 full professors (She figures 2006).

post-doctorate level, where career tracks begin and ending at the very top with a full professorship (Langberg 2005; Preston 2004; Sonnert and Holton 1995; ETAN 2000; Mählck 2003). Some studies combine the educational pipeline and the career pipeline (Blickenstaff 2005; Ivie and Ray 2005; Pell 1996). Only a few studies include scientific research in the industry and governments.

Even though the pipeline metaphor from time to time has been criticized, the metaphor has become so widespread that it is commonly accepted as the dominant, if not the standard, conceptual framework within which to organize studies of the science educational and career trajectory (Xie and Shauman 2003). The notion that "The pipeline metaphor communicates the 'problem' to many" (Hartline 2004) has been used to defend the metaphor. This paper questions this and similar notions and the rest of the paper will address the many limitations of the metaphor.

Implying that PhD degrees and careers in science academia are the goals of education

Firstly, the point of departure for understanding the metaphor is problematic. The metaphor is based on a framework where PhD degrees and careers in science academia are the means to the end of education (for men and women), hence the use of the word "pipeline". David Goodstein (1993) considers it a serious mistake to think of the educational system as a pipeline leading to PhDs e.g. in science. As he said, if the educational pipeline was repaired, we would soon have a flood of PhDs that we would not would not know what to do with. Since the production of PhDs leading to careers in science academia is not the primary purpose of the educational system, it is reasonable to question the very use of the word "pipeline".

The metaphor considers only the "push" effect not the "pull" effect

Secondly, the metaphor is one sided and considers only the "push" effect – women falling out due to leaks in the pipeline, while it more or less ignores that physicist can be "pulled" out of science in pursuit of a career in other more or less related fields. It would be to oversimplify matters to ignore the fact that far from all of those who leave science do so because they are discontent or because they were forced to leave (e.g. due to lack of funding or because they were discriminated).

An American female physicist, Alison Chaiken (2004), working in the industry has the following comment on the metaphor and the lack of focus on the "pull" effect and physicists in the industry:

> "Have women who like me work in industrial research positions leaked into the ground and disappeared? Are our career successes somehow less important than those of our academic colleagues even if we are widely recognized and feel fulfilled? Are we simply harder to count? Perhaps I'm being overly sensitive but I find the pipeline image rather insulting in its implications".

Chaiken's frustration is supported in one of the few empirical studies on occupational exit from scientific careers. Economics professor Anne E. Preston has conducted an extensive study on the reasons why scientists leave science (see table 1). Among women, the primary reason was: "Preferred other positions" (pull-effect) closely followed by "Career opportunities lacking" (push-effect). Men primary left science due to "Pay better in non-science and engineering positions" (pull-effect) and second "Career opportunities lacking" (push-effect) (Preston 2004).

Table 1. Reasons why men and women left science (n=1,688)

Percentage who cited[5]:	**Men**	**Women**
	%	
Pay better in non-science and engineering positions	68	33
Career opportunities lacking	64	34
Other fields more interesting	36	30
Science and engineering positions not available	34	21
Preferred other positions	23	35
Promoted out of science	18	3
Impossible to have a family and work in science and engineering	5	21
Demands of the career are too severe	5	3
Hours required are too long	0	20
Science and engineering unfriendly to women	0	19

Source: Preston (2004).

The experience of leaving science can be rather frustrating to the individual physicist – man or woman – who has made it through a doctoral program (Sonnert and Holton 1995; Preston 2004), and the risk of forced exit from science is part of the picture for scientists. However, it does not

[5] The respondents were asked to indicate a maximum of three reasons to have left science.

encompass the whole picture, which is the point I want to make here in my criticism of the leaky pipeline metaphor. As it was also found in the study by Sonnert and Holton (1995) the causes for leaving science are often multiple and complex, and there are not necessarily any clear boundary between the push and pull effects.

Life course events such as family formation that coincide and interact with the science career trajectory are also absent from the pipeline conceptualization. By not situating the science career in a context of other life course events, pipeline researchers implicitly assume an independency of the timing of especially women's science careers (Xie and Shauman 2003); a clearly implausible assumption.

The metaphor is unidirectional

Thirdly, the metaphor implies that physicists enter a career in academia at one – lower – level and then move through the pipeline to a higher level – at a slower or faster pace – or leave somewhere along the line. The metaphor does not capture the complexity of the educational and career processes of becoming a scientist. In Denmark, for instance, science careers do not always follow a straight line. Among the persons who started as associate professors in Denmark in 2002 only 1/3 came from positions as assistant professors at Danish universities – the rest came from positions outside the Danish university sector (research institutes, industry, universities in other countries etc.). In Denmark, the pipeline in science is not only leaking, it is also absorbing (Langberg 2005). The metaphor does not really take into consideration that the traffic goes both ways and by no means is unidirectional. Because the pipeline has only one entry point, the metaphor does not lead to policies that encourage women to enter science at different stages of their lives.

The metaphor is value-laden

The previously mentioned quotation on the metaphor by the female physicist Alison Chaiken also indicates an implicated and rather old fashioned standard that an academic career is the best choice and anything else can be considered second best or even a failure. With a vocabulary like; women are *lost* from the pipeline (Berryman 1983) or women are *missed* from the pipeline (Tower 2006) etc., the "leaky pipeline" conveys negative connotations and is strongly value-laden. Moreover, the metaphor implies that a career in science is the most prestigious career choice and that prestige is the most important element in deciding what career path to pursue. Several studies have shown that this is not the case. Preston found men and women to have different priorities concerning income,

opportunity and non-pecuniary conditions of work (Preston 2004). Again the issue seems to be far more complex than implied in the metaphor. To some researchers, the leaky pipeline problematic also has strong believes attached. Tower (2006) finds, in her resent pipeline study based on head counts from faculty homepages, that one out of six women are missing from physics academia when she compares the observed fractions of women in faculty with the predicted fractions based on the PhD pool. Tower concludes that these women "in an equitable society, would have been physics faculty members". Quite a strong conclusion from a study based on a simple headcount from the homepages of physics faculties[6].

The metaphor does not consider the entry problem

Last but not least, the heavy attention on the "leaky pipeline" removes focus from the very important question; how do we get girls/women **into** the pipeline. The dispute in the US whether a leaky pipeline exists in physics or not (Ivie and Ray 2005; Towers 2006) is partly based on the fact that there are only relatively few women pursuing a career in science academia to begin with, thus missing out on a single one of them is considered a problem (Tower 2006). Policymakers and educators have two choices when it comes to increasing the representation of women in science academia. They can try to increase the representation of women in the initial scientific talent pool or they can try to increase the rate of retention of women already in science. For more than two decades both approaches have been applied with various effort and results. Both approaches are useful and are of course connected in a "hen and the egg" problematic where the benefit of a certain "critical mass" of women already in science is beneficial. However, the potential for significant changes in this field is greater if we succeed in getting more women to *enter* into science than if we succeed in retaining all of those already in the field. According to Xie and Shauman's findings, institutional efforts to facilitate the flow of high school students into science majors during the first year of college may significantly reduce the gender gap in the attainment of science bachelor's degrees (Xie and Shauman 2003). At faculty entry problems most certainly exist. Wennerås and Wold (1997) showed, e.g., extensive gender bias in the peer review of research grant applications to Sweden's Medical Research Council.

[6] I am not questioning the existence of discrimination in science. As Preston's (2004) study showed, 19% of the women pointed at the statement: "Science and engineering unfriendly to women" as a reason why they have left science.

Conclusion and perspectives

It is easy to understand the fascination with a catchy metaphor like the “leaky pipeline”. I do think it is an illusion though, to believe that this metaphor, or any metaphor for that matter, can adequately describe a highly complex cultural issue as the one in focus here. To fully understand how the representation of women in science academia develops, we need a much closer look at career patterns of both men and women. Since the processes and outcomes that comprise a career are multifaceted, it is a gross oversimplification to focus on just one or two aspects of a science career. The lack of high quality statistical data on a disaggregated level, longitudinal and comparative studies including also industrial and governmental scientific research are some of the issues I think should be addressed. We need a much stronger focus on those who have already left science academia (both men and women), in order to understand the diversity and the development of career paths. A strengthened validity of the empirical studies in the field is a necessary starting point. I therefore welcome the methodological guidelines and questionnaire prepared by OECD, Eurostat and Unesco (2006) regarding statistics on the careers of doctorate holders, where some of the issues addressed here are included. Yet, a stronger focus on gender related issues is necessary, if the initiative shall serve the research on women in science. It would also be highly relevant to see an increased blend of quantitative and qualitative methods as a means to better understand why women tend to exit physics academia at a disproportional rate. Simple headcounts provide little insight, and statistics should be mixed with interviews and detailed questionnaires. Last but not least, we also need a language which is less value-laden where we do not maintain an overall distinction between first and second class careers and where we do not automatically consider a woman leaving science a victim of inequality.

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