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Scientists, Engineers and the Society of Free Choice:

Enrollment as Policy and Practice in Swedish Science and Technology Education 1960-1990.

Introduction

Since the 1950s reports of scientific manpower crises and engineer shortages have overlapped each other in most parts of the western world. Sometimes these reports have corresponded to reality, sometimes they have existed only on paper or in a chart, like a Fata Morgana of the cold war. Real or not, the repeated talk of crisis has left powerful imprints in political and educational discourse; materialized in words and numbers the problem of enrollment of scientists and engineers has been one of the most persistent fears in post-war educational policy.

As a consequence of the above, science education in most parts of the world has been challenged with a new mission. The example of Sweden 1960 to 1990 shows that besides teaching subject matter, methods of inquiry and the fostering of a scientific spirit, the need for recruitment has been inscribed into educational practices. Consequently the encounter with physics, chemistry, biology and technology has been designed to be interesting, fun and stimulating in order to attract students. If successfully done the presumption is that the threatening leak of science and technology students in the educational pipeline will be calked.

The aim of the article is to portray how science and technology education in Sweden 1960-1990 was influenced by this recruitment discourse, as policy and practice, through texts, images and charts. Put differently, the study deals with a politically established ambition to steer young people and children into science and technology as vocation, but also as identity and lifestyle. The first part of the text will outline the upcoming of enrollment of scientific manpower as a new problem area in post-war educational

policy. In a second and third part I will then go on and analyze the different forms of action taken and programs developed to increase the number of pupils in science and technology in different levels of the educational system. In what explicit ways were practices of science education influenced by the pressure of attractiveness and recruitment? In addition, how can they be understood with regards to the relationship between different forms of governing authorities and the population or the individual being?

Two Fields of Research – History of Science Education and Governmentality Studies

The text draws mainly upon two fields of research. The first of these consists of the cross-disciplinary field *history of science education* which has given multiple insights into the shifting purposes of teaching and training individuals, groups and nations in science (Olesko 2006; Rudolph 2008). More specifically, my source of inspiration has been studies that can be said to examine the politics of science education. For a number of years school science as a study object was often called for but rarely given full attention by sociologists and historians of science (Kaiser 2005). The last decade however has seen a host of scholars that in depth have emphasized the close relationship between science education and its social, cultural and political surroundings. This body of research has dealt with matters that concern both subject matter and forms of teaching as well as epistemological aspects and the “nature of science” (Kohlstedt 2010; Lynning 2007; Rudolph 2003, p. 65).

One of the more fundamental conclusions that can be drawn from this body of research is that school science has always has been a political project. To state this, however, is not the same thing as depicting a static relationship between society and science, or to deny the historically changeable conditions of how science education is perceived and executed. The need felt in post-war Europe and northern America to increase student enrollment in these subjects marks a significant shift in science education before and after 1945. The new role bears characteristics of an enterprise much more closely developed under the interest of politicians, organizations and industry. Again, this is not to say that science and science education was apolitical in the years before 1945 or during the 19th century. But the post-war era made them political in a new way and for different reasons. They became part of a solution to a

new problem area where economic growth and production rate intermingled with cold war policies and the shaping of a welfare society.

Another way of describing the new role of science education (and henceforth technology education) in Sweden is its location in the relationship between the individual citizen (the pupil) and authorities (state, industry and organizations). In a situation where specific forms of action are taken to remedy societally defined problems, analyzes that include relations of power become interesting. The second field of research that I employ in this study is less empirically attached to the practices of science education and more linked to political theory. By drawing upon the field of *governmentality studies* my ambition is to picture the process of creating more scientists and engineers as a special form of governing of individuals, populations and nations. As a research area the field is analytically oriented against societal initiatives in order to steer, conduct or organize action, but also to illustrate how resources for such initiatives are created and to identify historically specific ways and means to carry them out. The huge body of research being done originates in part from a desire to understand power not in traditionally and juridical terms or to see it as something prohibiting, counteracting and restraining. Instead – through the work of Michel Foucault and later on his interpreters – power is seen as something that enables or even presupposes action (Foucault 1980).

Closely connected with this notion of power is the illustration of a shift in “the art of governing” during the 18th century and onwards resulting in the successive replacement by other forms of exercise of power. Instead of the preserving of sovereignty as the most important functions of government, the managing of a population – its health, growth and wealth – became new priorities (Foucault 1991). Incorporated into the successive development of new rationalities for governing was also the self-interest and freedom of the individual. The concept of freedom was by many authorities portrayed as mechanisms that would help the self-government of a number of societal realms. Sociologist Nikolas Rose clarifies this notion and at the same time contrasts it to earlier forms of exercise of power (domination):

To dominate is to ignore or to attempt to crush the capacity for action of the dominated. But to govern is to recognize that capacity for action and to adjust oneself to it. To govern is to act upon action. This entails trying to understand what mobilizes the domains or entities to be

governed: to govern one must act upon these forces, instrumentalize them in order to shape actions, processes and outcomes in desired directions. Hence when it comes to governing human beings, to govern is to presuppose the freedom of the governed. To govern humans is not to crush their capacity to act, but to acknowledge it and to utilize it for one's own objectives. (2010, p. 4)

As one of the sub-fields where governing and self-governing through freedom has been in focus, history of education has produced a number of studies (Peters et al. 2009). Drawing upon these works it becomes clear that to govern through freedom in the earlier parts of the 19th century cannot automatically be compared to the situation after WW2. To comprehend the development of specific historical rationalities every study must outline its own points of departure and context. The advent of mass education and extended compulsory schooling in the second part of the 20th century made class rooms a space in which every child from 7 to 15 in Sweden was present. Thus, the possibilities of reaching large numbers through teaching increased immensely.

Hence it is necessary to distinguish between different modes of governing and “the ways in which they utilise the capacities of free acting subjects and, consequently, modes of government differ according to the value and definition accorded to the concept of freedom.” (Peters 2009, p. xxxi). It is also reasonable to assume that such modes of liberal governing are not only determined by time but also by nationally and culturally distinguishable contexts.

Historical studies of science education are still largely unbroken territory when it comes to governmentality studies, although there are a few exemptions (Lucena 2005). Therefore this article is also partly an attempt to open up such practices for questions on power and liberal government. In relation to the teaching of science and manpower discourse – what kinds of concepts of freedom were used in Swedish educational policy and how did they contribute to the forming of specific rationalities of liberal government?

Within the research field of science education attitudes towards STEM (Science, Technology, Engineering and Mathematics) are well-documented topics, however from a different perspective than used in this article. Many studies focus on attitudes as psychological phenomena, on measuring methods and on the close connection with similar concepts such as motivation and behavior (Osborne et al. 2003; Reid 2011). A

lot of this work can be described as having an instrumental character as they often discuss ways of improving attitudes (Osborne et al. 2003; Sjöberg & Schreiner 2007). This is also true for some recent work on specific national campaigns and projects designed to improve attitudes in STEM (Andrée & Hansson 2013; Andrée & Hansson 2014; Jensen & Sjaastad 2013). Even though such work highlights the agendas behind certain strategies, they rarely touch upon the historical roots of recruitment campaigns or the liberal rationalities of their performance. Instead they seek to evaluate the potential of these campaigns in expanding the range of students choosing STEM. To answer instrumental questions of that kind is not an aim of the present study.

The material used is made up two types of sources. Policy documents or texts closely connected to the forming of educational policies make up the first one – reports, government bills and ideological writings. The second type is oriented towards sources that tell us of practices of recruitment, for example teaching material, text books, career guidance brochures and documents containing activities from science clubs and science centers. The selection of material concerning the latter type have focused on practices with outspoken aims of affecting pupil's attitudes – practices that can be traced to the explicit need of increased enrollment in science and technology. This double focus on policy and practice has also shaped the analytical frames of the text. Consequently the study has prioritized the relationship between formation of educational policy, identification of objects of liberal government and different projects developed to acquire attitude changes and career choices favorable to science and technology.

Part 1. The Question of “Positive Propaganda”

Paris 1962, OECD Headquarters

Halfway into the meeting the American delegate Dr. Harold W. Stoke asked the Swedes to what extent they were practicing “positive propaganda” in order to entice more young people into scientific pursuits. The answer given to him was that although the unsatisfactory supply of scientists and engineers was a concern, the solution was not to put pressure on the single student. Instead the problem had to be tackled through a reconstruction of the educational system as a whole (OECD 1962).

In 1962, in the OECD headquarters at 2 rue André Pascal in Paris a “confrontation meeting” was held between high representatives of the Swedish educational system and the Office for Scientific and Technical Personnel (OSTP). The subject under discussion was Sweden’s capacity to increase the output of scientists and engineers in the near future. As such the meeting confirmed contours of a new problem area, but furthermore it was an attempt to discuss the need for action on a national as well an international level. A publication – *Country reviews: Sweden* – had served as a starting point for the session. It was written by an international examiner, Dr. Vogelnik, Dean of the University of Ljubljana, Yugoslavia. The report was the first of a series

in each of the member countries as a means of assessing the progress and problems of the individual Members of the Organisation in educating and effectively using a sufficient number of scientists, engineers and technicians to meet their present and future economic needs (OECD 1962, p. 4).

Dr. Vogelnik’s text was filled with charts of supply and demand of scientists and engineers from Swedish high schools, universities and technological institutes between 1960 and 1970. Although the report recognized that a much wider basis for recruitment of students had been established, its main concern was that a gap between supply and demand was not going to be bridged during the period. ”In any case” Dr. Vogelnik concluded “it is highly probable that throughout the 1960s Sweden will suffer from a shortage of engineers and scientists even if the intake capacities of the institutes of technology and the science faculties are expanded considerably.” (OECD 1962, p. 24).

The “confrontation meeting” with OECD was one of the earliest occasions where Sweden was faced with the problems of recruiting scientific manpower, although not the first (Pettersson 1985). Thus, what took place in Paris together with *Country Reviews: Sweden* forms an interesting point of departure for the study since it gives an early insight into the formation of a new societal sphere where technology, science and education were brought together into a national concern. To briefly sketch the main influences that shaped manpower politics in an international arena, I will first provide a backdrop into the early post-war period that preceded the Swedish example by a decade.

Cold War Science Policy and Economics of Education

Even though the cries for more scientists and engineers during the 1950s were multilayered phenomena, two main constituent parts seem to be more fundamental than others. Firstly a major change in U.S. science policy had been caused by the arms race and scientific competition of the cold war. The fear of Russian numbers in science and engineering made both the question of quantity and quality of the nation's own equivalents a pressing matter during the 1950s. As a rich collection of scholarly findings has pointed out, the notion of Soviet scientific achievements were already under way before October 1957 (Rudolph 2002). Yet at the same time it is also evident that after Sputnik, funding for projects was approved by the federal government in a way that had not been possible before (Lucena 2005).

The new financial resources were often canalized by National Science Foundation, which in the late 1950s evolved as the major actor trying to solve the manpower crisis (Lucena 2005). Throughout the 1960s the organization developed the so called Scientific Manpower Program. As Lucena (2005) has shown these programs can be described as technologies of government of the American science policy. They were made to gather knowledge on the country's existing technical and scientific population and to project the demands of the future. In helping to visualize the need for action the Program was a first step in a chain of population management procedures that sought to increase the inflow to the "science and engineering pipeline" (2005, p. 14).

Education in science and technology became – as a consequence of the above – portrayed as one of the more important solutions to the upcoming crisis. Both in graduate and lower levels as well as teacher in-service training, reform and reconstruction initiatives were being taken. Thus, the cold war that initially had taken place solely in military or political domains was now being fought in yet another arena involving curriculum development, summer camps for teachers and high school textbooks (Rudolph 2002).

Given the American origins of the manpower discourse, it was perhaps no coincidence that the question of "positive propaganda" in Paris came from U.S. delegate Harold Stokes. However, to understand the new status attained to science and technology education during these years – and especially in relation to OECD – it is not

enough to underline the threat of Soviet manpower. As a second part, and as science policy researcher Benoit Godin (2005) has pointed out, these fields of study were also brought into economic rational planning and models of productivity in the first decades of the post-war era. This development was largely attached to new theories of economic growth. As a third or “residual” factor besides capital and labor, education was identified as a way of increasing the quality of the labor force. Consequently the term *economics of education* was spread as an acknowledgement of the idea of an investment. If this was true regarding education in general, school science and technology in particular was understood as a way to increase industrial productivity and economic growth in the future (OECD 1964).

The two developments sketched above – cold war science policy and economics of education – were often interwoven in the international arena. In a European continent devastated by war, the need for industrial recovery was met by the Marshall plan and the starting of OECD (then OEEC). Here the fear of Russian technological superiority was intermingled with considerations of economic growth. One of the more concrete exponents of this blending was measurements of scientists and engineers in the OECD member countries. Initiated by the Americans, the organisation started to gather information on the numerical strength of qualified scientific manpower in 1958 (Papadopoulos 1994). An important effect of the measurements was, according to Godin, the way in which they produced certain “technological gaps” and “discourses of shortages” between different countries (Godin 2005, pp. 10 & 218-261) Although not always accurate, the statistics in this way enabled OECD to initiate certain forms of programs that confirmed the mixture of science, technology, economy and education.

One of the more ambitious programs was the OECD’s initiative to reform and homogenize school science. Targeted at governments of the member states and in particular Ministers of Education, the OSTP brought together a series of conferences and reports in the years 1960-1965 under the name *New thinking in school science*. Influenced by the “new curriculum movement” in the United States and with the ambition to form educational infrastructures that met scientific manpower needs, radical changes were proposed. The proposals entailed teaching materials, training of teachers, more active roles by industry and improved search for scientific talent (Papadopoulos

1994). In 1960 at a conference in school chemistry, welcome speaker T.S. Wheeler concluded:

This is an age of science [...] the prosperity of a country increasingly correlates with the number of scientists and technologists it employs and these can be produced only if there is adequate training in basic science in the schools. A growing shortage of such scientists and technologists has, over recent years, been a source of concern to those concerned with the governing of men, and much thought is now given to remedying to this defect (OECD 1961, p. 6).

These types of policy statements – together with forecasting procedures and statistical gaps – enabled the identification of new objects of liberal government, namely school children and their attitudes to science and technology. The process of changing minds, attitudes and habits was in this context inevitable. “In general”, Wheeler continued, “our aim must be to give those with the required talent *a desire* to make science – pure or applied – their life-work.” (OECD 1961, p. 6. *My italics.*)

Such was the situation in which Sweden was invited to the “confrontation meeting” with OSTP in 1962. When Stokes asked his question on the presence of positive propaganda the meeting had progressed into a stage where future actions were discussed. The Swedes had answered that a restructured, modern school system in itself would put the need for science and technology on display and thus create the attraction that was needed. In the encounter with that system, new students would understand and realize the prosperous futures that lie in the becoming of an engineer or a scientist. To conclude, Swedish youth would rationally use their freedom to choose.

This rather self-confident approach relied on a deep-rooted belief in educational planning and a typical tradition of social engineering that had become a trademark of the Swedish social democratic party since the 1930s (Ruin 1990). The reform that was so heavily entrusted encompassed all ages from 7 to 19 and had already been implemented to a large extent. In short it sought to abandon all other forms of parallel systems where middle class secondary schools (Läroverk) had existed alongside the less esteemed elementary schools (Folkskola). Instead one organization for all Swedish pupils was created. After nine years of compulsory and heavily uniformed education (Grundskolan), the high school system (Gymnasiet) gave five different alternatives for those who wanted to continue. Students could choose between programs in Science,

Technology, Economics, Humanities or Social Science. As Dr. Vogeltnik had concluded in *Country Reviews: Sweden*, the old system had left an insufficient proportionate division of these students to cover the needs of the labor market. One of the most outspoken goals of the new system therefore became to fix the percentage of individuals in the Science and Technology programs to more than half of the student population, 30 % and 22 % respectively (SOU 1963).

A Society of Free Choice and the Limits of the Sayable

Because of the strong demand and the high hopes, there was a disappointment when the first age group of students made their choices of programs in the new high school 1966-1968. Technology and science did not rise up to its desired levels of the students. The two programs were faced with different forms of problems. Students choosing technology started at 20,2 % in 1966, just below the benchmark. One year after the numbers was at 14.4 %. In 1968 they had dropped below 10 %. The Science program had different problems. The numbers of applicants was high, sometimes above the benchmark. A lot of high school students, however, dropped out between first and second year and switched to the supposedly easier program of Social science or Humanities. This made it hard to keep up with the desired percentage (Skolöverstyrelsen 1968/69).

In the following years the situation became even worse and called for immediate action to stop the negative trend. Even though the Ministry of Education was engaged in the process, the most persistent actor came to be the National Board of Education (NBE), a ministerial agency of government with a mandate to implement policy decisions. In a series of proposals sent to the government, they called for a harder steering of students into science and technology. In order to reach the needed percentage, the NBE argued it was necessary to – to some extent – disregard from the pupil's own choices (Skolöverstyrelsen 1968/69).

When considering these proposals the Swedish government became aware of an upcoming collision between two major ambitions in educational policy – on the one hand to solve the manpower shortage and on the other to respect the individual's right of free choice. The latter idea played an important part in Swedish post-war politics, and especially in the social democratic party that was in government 1932-1976. By the

1960s the party implemented the welfare society in more and more areas. Their ambition included a restructuring of the school system, something that relied heavily on the pursuit of making higher education available for all as well as the individual's right to a free choice. In 1962 Prime Minister Tage Erlander wrote the book *Valfrihetens samhälle*, ("The Society of Free Choice"), in his own words the most important book he ever wrote (Ruin 1990). In it Erlander sought to sum up political key visions of the social democratic party in the 1950s and 1960s:

When the [...] Party during the entire 1960s will put education in the center of societal development this means that we step by step will widen the liberty of the individual in an area that will be decisive for every person: in the choice of education and profession (Erlander 1962, pp. 67-68).

Following Erlander's ideas a new educational policy program was decided on in 1964. In it "the society of free choice" marked one of the cornerstones of the new school system (Government Bill No. 171 1964).

As a specific and historically constituted rationale for liberal government, the principle of the individual's right to choose education is fundamental to understand the handling of manpower issues in post-war Sweden. It is reasonable to say that the decision of 1964 to a large extent constituted the boundaries of manpower discourse. Lucena has described a similar state of affairs in an American context where the federal government was trying to increase scientist and engineer output without intervening in the free market. He uses the Foucaultian expression "the limits and forms of the sayable" to point to certain contextually formed discursive spaces in which enrollment action was allowed (Lucena 2005, p. 8). In the 1950s and 1960s to force people into studying certain subjects was to deny the very soul of American enterprise – the free acting citizen – and moreover would act as an imitation of the Soviet centralized system. Every step closer to what could be associated with the enemy's model was non-optional and therefore not a possible way forward for the federal government. Lucena concludes that such strong national images defined the limits of the sayable: "More than money and politics, images and discourse have shaped the actions of government to educate scientists and engineers in particular ways." (2005, p. 9).

The Swedish situation points to similarities with the U.S. example, however without the same pressure of cold war politics. Perhaps the most striking resemblance lies in the close presence of national self-images and their immutable character. The fear of imitating a Russian society was in the Swedish example replaced by domestic and historically rooted points of departure. Prior to his position as Prime Minister, Erlander was Minister of Education (1945-1946) and educational matters were a strong concern of his. "The society of free choice" was given its meaning in a certain historiography of Sweden and its road to becoming a modern society. In his book Erlander reminded the reader of a pre-war Swedish society where different social groups went to different forms of schools. Only upper and middle class secondary schools gave eligibility to higher education. By the reforms of the 1960s this system was to be brought to an end. "The new school implicates the breakthrough of a new principle: it should be parents and pupils that freely choose the orientation of study [...]. It is no longer society with its imprecise instruments that should differentiate pupils." (Erlander 1962, pp. 67-68). Thus, in the historiography of Erlander, free choice was given meaning against the abandonment of a pre-modern society, not a contemporary enemy.

As a result the Swedish social-democratic government could not solve the enrollment crisis by denying a pupil's right to choose freely. Consequently many of the proposals from the NBE were abandoned. Instead the agency was encouraged to "consider other actions to achieve a proper division of the students in high school and thus to find such methods that deals with factors that influences the choices of pupils." (Government Bill No. 1 1969/1970, p. 223). The decision marks an important turn of events in the forming of a rationality for liberal government in science education policy. By the turn of the decade then, Swedish authorities embarked on a slightly softer way of reaching their desired objectives. Looking back, the meeting in Paris became an ironic reminder of the road not taken in 1962. Now, almost ten years later the Swedish government was searching for ways in which to perform "positive propaganda".

Part 2. Recruitment Actions as Part of School Practice

If the 1950s and the major part of the 1960s had been dealing with the articulation of a new problem area, the following 10-15 years were dominated by the defining of exactly what was to be the object of governance within this area and by what methods a desired

outcome could be reached. When forcing individuals into science and technology was not an option, the key concept instead became to work on “persuasion and attitude change”. (Lindskoug 1977a). This entailed a search for pedagogical methods that would change the pupil’s approaches to science and technology. Different expert groups were put together to implement the new policy. These groups helped to institutionalize the ways in which such soft governance was to be achieved. Put differently, they formalized the relation between discourse (manpower needs), its speakers (government and NBE) and its audience (pupils) (Lucena 2005). Nowhere was this more obvious than in the so called “N-group” (“Arbetsgruppen för översyn av naturvetenskaplig undervisning m m i gymnasieskolan”), which was created by the NBE and operated in the years 1973-1982. The group functioned both as an actor that executed its own projects as well as compiling the work of others. In different constellations and sometimes engaging close to 30 experts it dominated the shaping of strategies to recruit engineers and scientists in Sweden. Its mandate was prolonged several times by the NBE, who in turn was told by the government to act upon the matter “with greatest strength.” (Government Bill No. 100 1976/1977, p. 217).

The way in which the N-group dealt with the recruitment problem can be described as a twofold technology of government. Firstly they produced knowledge on schoolchildren’s attitudes to science and engineering. This was being done through surveys and questionnaires where pupils were asked how they felt about studying science, what they thought about their science teachers, but also their relation to parents and after-school-activities (Dahlin & Thorén 1976; Mählck 1975; Richardson 1968). In this way the work of the N-group seemed to confirm an international trend; attitude research with reference to science education grew quickly in Europe and United States during the 1960s and 1970s (Reid 2011). One of the most comprehensive of these was the IEA study that was carried out between 1962 and 1973 and that engaged up till 258 000 students from 22 countries (Husén 1973).

The gathering of information was done in the same tradition as measurements of U.S. and OECD scientific manpower. Through this production of knowledge on young people’s attitudes, the objects of liberal government were rarified. Peter Miller and Nikolas Rose underscore the deliberate technologies at work during such a process, pointing to the involvement of specific

technical devices of writing, listing, numbering, and computing that render a realm into a knowable, calculable and administrable object. 'Knowing' an object in such a way that it can be governed is more than a purely speculative activity: it requires the invention of procedures of notation, ways of collecting and presenting statistics, the transportation of these to centers where calculations and judgments can be made and so forth. It is through such procedures of inscription that the diverse domains of 'governmentality' are made up [...] (Miller and Rose 1993, p 79).

As mentioned above, charts and figures formed discursive spaces – often in the shape of “gaps” – in which recruitment actions could be taken. Thus, the statistics cannot merely be apprehended as a reflection of policy, but rather as something that (re)constituted future action by providing legitimacy to certain programs.

Within these charts, the sheer number of individuals that needed to be converted to science and technology was illustrated with the type of immediate visibility that only statistics can provide. The figures and forecasts also clarified the new role of science education as part of population management; in order to amend the nationally defined manpower problem, every year a number of thousand young people had to change their way of reasoning about themselves and the future. In addition, the recurring use of terms as “attitudes”, “identities”, “carrier choices” and “life-work” enabled a development of actions directed at large groups of children. As will be elaborated on below this was also the case with the projects surrounding the N-group.

Even though the approval to gather information on pupils was formally given by the NBE and the government, other contemporary developments seemed to accentuate this mandate to compile knowledge. A strong presence of educational psychology in Sweden in the 1960s and 1970s increased the belief in measuring, calculating and comparing attitudes and achievements from different types of evaluations and surveys. Close links between NBE and university professors within educational psychology had resulted in a frequent use of the latter as experts in major curriculum reforms (Husén 1988; Härnqvist 1996; Marklund 1989). This intimate cooperation between academics

and politicians acknowledged the former as producers of relevant knowledge and at the same time it provided the legitimate base for governmental decisions.

In relation to science teaching, the belief in educational psychology led to the early formation of science education (Naturvetenskapernas didaktik) as an academic discipline in Sweden. Financially supported by the NBE and in contact with the N-group a number of didactic projects were run at university departments starting in the late 1960s. Theoretically they were largely inspired by the works of developmental psychologists Jean Piaget and Jerome Bruner. Piaget's idea of development stages provided the knowledge for a number of Swedish projects and led to the conclusion that lessons of a too abstract nature was a waste of time since they exceeded the child's intellectual level (Andersson 1989; Johnsson & Wallner 1974). As will be elaborated on further below, this led to the focus on more concrete and experimental teaching in early years.

The second feature of the N-group's activity was the different types of actions and programs through which "attitude change" was to be achieved. The group set to work accordingly to the policy of 1964 where the individual's free choice was sacred. In their work different types of knowledge of pupil's attitudes – grounded in psychological and pedagogical theories of the time – was used to try and foster interests and identities that were favorable to science and technology. Thus the exercise of power that was enacted was not meant to restrain but instead to enable action. Rather than to put individual's in a juridical coercive position, their strategies can be described as to generate a certain behavior or to foster pupil's free choices in certain directions.

To (Re)launch the Experimental Tradition – Curriculum, Syllabuses and Textbook Production

A good deal of historical studies of science has identified how different types of teaching materials could invoke hopes that exceeded the goals of curriculum. To replace outmoded didactic forms was sometimes associated with emancipatory effects that opened up the individual's perspective far beyond the class room walls. Research of this kind uncovers projections of a political nature – in the wider sense of the word – onto the teaching of school science. The example of instructing through object lessons in the

latter half of the 19th century meant that posters, stuffed animals and excursions were contrasted against books. To learn to observe was an ability that could be used in many ways. To immediately “view” something was not only apprehended as a better way to learn about nature but could also be the start of an inner and civilizing process – the possibility of seeing the world differently (Ekström 2000; Rantatalo 2002).

Another example of emancipatory features inscribed into science teaching can be found in the arguments for student conducted experiments in physics and chemistry at the turn of the 20th century. Besides teaching secondary school pupils the scientific method, these experiments were also portrayed as fostering self-independence, a will to take initiative and to love the truth (Lövheim 2006). As an educational tool the experimental tradition had its major intellectual breakthrough in the period around 1900 and was often celebrated as a turning point in the history of science education (Kaiserfeld 1999). However, the NBE referred to several surveys in the 1970s which concluded that laboratory work to a large extent was absent in Swedish schools. It was often de-emphasized due to practical matters and for safety reasons (Lindskoug 1977b; Skolöverstyrelsen 1975a). When the “N-group” set out to restructure science classes to meet the needs of a more interesting subject matter, the main solution was spelled to relaunch the experimental tradition. As a consequence, syllabuses in the Science and Technology high school programs were rewritten to place the laboratory in the center of teaching (Skolöverstyrelsen 1975b). The focus on more experiments was thought to make science more concrete and less complicated. Physics and chemistry courses were also arranged in such a way that “easier” concepts were placed earlier and more abstract ones – as *acceleration* – were saved for later grades. In this way the syllabuses was thought to provide a “softer entrance” from lower school stages (Skolöverstyrelsen 1977a, pp. 5-8).

The need for a more attractive experimental focus in science education also affected the use of teaching materials. The NBE – often through the “N-group” – sponsored the production of different forms of teacher instruction prototypes, locally produced by dedicated teachers or school advisors. Here the experimental tradition was arranged in new ways as it intermingled with a pressure of reaching out to more students. Locally produced projects could take the form of “The Chemistry of Photography” that was

tried at one school. In another one pupils worked with a project of assessing the water quality of local rivers. (Skolöverstyrelsen 1975c; Skolöverstyrelsen 1975d).

In targeting younger children (age 7-12) a more ambitious project – *3U – Upptäcka, undersöka, uppleva* (“Discover, examine, experience”) was being developed in collaboration with university departments, NBE and local authorities. Under close theoretical influence of Bruner and Piaget stage-developed teaching was recommended. In *3U* the activeness of the children was essential and the teacher was instructed to introduce terms and explain experiments only after the pupils had become acquainted to the different forms of teaching material (Johnsson & Wallner 1974).

Even though some instructors apparently were enthusiastic about developing experimental materials, the N-group described many of them as unsure of their own capacity to teach in that way. In order to overcome this obstacle the group arranged summer courses where teachers became re-trained in how to perform instructions that would foster independent self-guided pupils in the laboratory (Lindskoug 1977b). The courses confirmed an inclusion of teachers as technologies of government. Through their re-trained abilities they would insure an increased focus on experiments and – it was hoped – more interested students in the long run.

Besides the putting together of teaching materials in various forms, there was of course the production of regular textbooks. As a study object textbooks have attracted a growing interest from historians of science. This is evident with regards to change of content but also to the relation between different kinds of actors such as producers, state control and the educational institutions (García-Belmar et al. 2005; Shapiro 2012; Vicedo 2012). In the example of the American curriculum projects PSSC and BSCS, Adam Shapiro (2012) has pointed to the intricate blend between manpower policy and major scientific developments. As a consequence the identification of single grounds for changes in content becomes as a complex project. Indeed, such an analysis of textbook production is very difficult and sometimes unfeasible, following the lack of explicit grounds for selection. However, in a rare case of a Swedish textbook, the outspoken ways of reasoning by the author seem to make it possible. In 1977, as part of the “softer entrance” into the Science program mentioned above, a Swedish high school textbook in physics was produced. The author – who also was a member of the N-group – made it clear that the ambition was to write a book that wouldn’t scare off first-year pupils.

Accordingly, the presentation of physics was to be done in an “easy-to-read” manner and not “too mathematized”. Concepts that were deemed too abstract were saved for higher levels and the suggested apparatus was not to be too complicated but instead elementary (Adolfsson 1977, pp. 16-17).

Taken altogether these different examples above confirm the forming of a certain pedagogy that seemed to blur the borders between didactics and politics within science education. The need to produce many more individuals with a certain interest became part of a didactic thinking and of structuring subject matter in a way that deviated from earlier traditions.

Opening the Laboratory – Girls, Physics and Technology

If scientific manpower recruitment was a problem area that could be described as a post-war phenomenon in general it was particularly so with regards to women. Differences between the sexes’ choice of education was not problematized before 1945. The presumption that boys and girls had different abilities was deeply rooted and science and technology was heavily marked as male sectors. When it was realized that enrolling boys only would not satisfy the industrial and economic needs of the nation, attention was spurred elsewhere to the female “pool of reserve talent” (Berner 2003, pp. 120-121).

The nation’s need for more scientists and engineers was also strengthened by a mounting interest in female emancipation in the 1960s. As part of “The society of free choice”, to get rid of old stereotypes and obstacles fitted perfectly into the discourse on manpower shortage. In the steering of individuals to science and technology the discursive blend between industrial needs of the nation and female emancipation was unproblematic since they both pointed in the same direction. However, as historical investigations have pointed out, the argument that stressed needs of the nation seem to have preceded the abolishment of gender stereotypes. This renders a conclusion that the identification of girls as an object to act upon was less – at least in the 1960s – the result of a will to create greater gender equity than to solve national economic needs (Berner 2003; Hedlin 2011).

Part of the disappointment with the new high school in 1966/67 was that only 23 % of the girls chose the Science program and 3 % chose to go to Engineering (SCB 1967).

Thus girls in these disciplines crystalized as a problem within the problem. The situation implied an alternative object of government that was more specific and which required adjusted ways of collecting and administrating knowledge. In the workings of the N-group a lot of time was devoted to this specific question (Skolöverstyrelsen 1975e). In their compilations of different surveys certain patterns seemed to reoccur. One of the most noticeable was that physics and engineering studies seemed to be most alien to girls (Skolöverstyrelsen 1975e). The N-group concluded that the teaching of science was adjusted to boys and that the advantage that boys often demonstrated in class was the result of a gendered upbringing. Such differences could be noticed as early as the age of 10. Therefore the introduction of early laboratory based teaching was identified as a goal of specific importance to girls (Skolöverstyrelsen 1977b).

The physics lab, as a consequence, crystallized as the space that needed to be opened and made available. For more than a century the school laboratory had been the place where a gate opened to the real world of science. Here experimental abilities were trained but perhaps even more so the affinity for science as an intellectual endeavor was modeled and inscribed into one's personality. Hereby it marked the start of an identification process of oneself as a scientist (Bergwik 2005). For the greater part of modern educational history the invitation to embark on such a journey was with very few exceptions restricted to boys. When secondary schools in Sweden opened their doors to upper middle class girls in 1927 it formally meant the opening of school laboratories as well. However in the following decades girls did not use their access to this area in any large extent – only 15 % choose the Science program in the inter-war period (SCB 1946).

Girl's alienation to develop self-images as future scientists can partly be found in the deeply rooted male culture that had dominated science education for long. Examples can be found in the science clubs within secondary schools where girl's participation was often discouraged. When taking part in the activities of the club, girls were defined as a sex instead of becoming scientists. Indeed, such structural conditions were sure to bring limitations to a self-image as scientists and the possibilities of a free choice (Bergwik 2005; Johansson 2000). During the first decade of the post-war period, however, the percentage of girls choosing the Science program slowly increased. This

development can be understood in a way that more young women started to approach science studies and identities as future scientists (SCB 1946).

Girls in science were a troubling matter indeed. But it was in technology that the real failure of the new educational planning of the 1960s had been revealed. In the following decade specific strategies were developed, one of which included the arrangement of open days at a high school in Stockholm specialized in engineering studies. Every year 300-400 girls in ages 14 and 15 were invited to meet and listen to female students of the Technology program. Including information of the program and its career advantages, the event was thought to change perceptions on girls in engineering studies (Skolöverstyrelsen 1979).

Guidance to a Free Choice

Through the constant supply of updated statistics in the 1970s the situation of enrollment was evaluated and discussed in the Swedish government as well as the Parliament. This was done both with regards to trends in high school programs and at university levels. To a great disappointment the numbers showed no improvement but instead a decline in some areas (See figure 1). In media reports “the science crisis” was now a well-known point of reference (Elgström & Riis 1990, p. 146).

Figure 1. First grade students in Science and Technology programs in high school 1969-1974, compared with all programs.

The lingering image of a crisis meant that recruitment actions and programs were prolonged, although still under the policy of soft governance. Above I have given examples of technologies of government in the form of teaching practices and artifacts of syllabuses, textbooks, teacher instructions and experiments. As briefly mentioned above, another way of obtaining “attitude change” was to arrange study visits into higher levels of science. Some schools made elementary students visit high schools where members of science clubs advocated for choosing the Science Program and demonstrated spectacular experiments. This strategy of pupil-to-pupil recruitment was thought of as having a double effect – the younger ones were given an illustration that science in higher levels was fun, and the club members were strengthened in their capacity to present and propagate science. Another arrangement was to bring pupils in close encounters with “real” science. Different study visits were arranged to university institutions and industries where pupils could complete different kinds of school related projects and the same time interact with actual scientists (Skolöverstyrelsen 1975f).

In picking the most suited individuals to act upon, one important criterion was to focus on those age groups that were to make choices for the next level in the educational system. The so called TEK-NA project exemplifies this strategy. In 1975 two universities in the northern part of Sweden started a recruitment campaign to stop the leak from Science and Technology high school programs. In the form of posters, leaflets and brochures the dissemination of science and technology propaganda was supposed to reach every 15 year old pupil and every student counselor in northern Sweden. Deemed a success, the campaign was expanded the following year to the rest of the country (Government Bill No. 100, 1975/1976). In the dispatched material it is possible to identify central components of the specific mode and rationality of a liberal governmentality restricted by the limits of the sayable. Using a tone of voice that was partly persuasive and partly neutral the TEK-NA project sought to convince pupils to use their free choice in a way that corresponded to national educational policy. In its specific apostrophe to girls the brochures contained a diligent use of images to accompany the text. Girls in active postures appeared in all images, either in a lab coat, by the microscope or at the drawing desk. The caption made it clear that girls where

precisely as fit as engineers or scientists as boys and that there was no need for a background as an “amateur mechanics”. The caption ended with an appeal: “Don’t let old gender role thinking stop you from choosing Science or Technology” (TEK-NA projektet 1975).

The TEK-NA project also targeted student counselors in their strategy to achieve a change of attitudes. This confirmed the belief in career guidance as a way of creating positive propaganda; the Swedish government had stressed the need for such a development during the 1970s (Government Bill No. 1, 1974/75). Consequently student counselors were involved as a direct channel to pupils approaches to science. As a technology of government they were part of every-day school life without interfering with direct class room practice. In addressing counselors the TEK-NA material said:

As a student counselor you are probably aware of the decreasing numbers to the Science program. The numbers have dropped by 23 % from 1971 to 1974 [...] The government, NBE [...] has found it to be extremely urgent to turn this development around (TEK-NA projektet 1975, pp. 2-3).

The text also contained sections with advices on how to guide pupils – especially girls – into identities as engineers or scientists.

In spite of its rather careful approach, the TEK-NA project lead to protests from student counselors who claimed they were forced to persuade pupils into the high school Science program and that the material lacked a sense of objectivity (SYO-bulletinen 1975; SYO-bulletinen 1976). This kind of critique was sustained throughout the 1970s. Being such an elite program, it was argued, it was impossible to persuade more pupils into science since they would drop out anyway. The protests can be seen as a reminder of the limits of recruitment discourse as it collided with the conception of a free choice (Arbetsmarknadsstyrelsen 1978; Edholm 1977).

Part 3. Out-of-school Science Education and the Exercise of Political Power beyond the State

As been shown above, recruitment into science and technology in Sweden had become an apparatus that involved the government, the NBE, the N-group and several other

minor actors such as university departments, teachers and sometimes even other pupils. These actors all functioned through a common national image that explained the reason for their engagement. Nikolas Rose states that “to govern is to act under a certain description” (Rose 2010 p. 28). Formed in the early 1960s through texts, numbers and images such a description marked the contours of a new problem area in Swedish educational policy.

Besides economic and industrial needs of the nation, environmental problems had begun to enter the discussions of how to boost applicants to Science and Technology programs. The fear of nuclear wars, pollution and exploitation of natural resources was assumed to be a factor that made these subjects look dubious. Environmental concern was, however, quickly made into an asset in recruitment discourse during the 1970s. In order to prevent a rapidly growing misuse of nature, it was said, there was a need for increased education in science and technology (Skolöverstyrelsen 1975a; Skolöverstyrelsen 1975e).

The actors described above were all somehow related to the state or local municipalities. Governmentality scholars have drawn our attention to the exercise of “political power beyond the state”, thereby suggesting power as something not necessarily employed by central authorities but instead by “shifting alliances between diverse authorities in projects to govern a multitude of facets of economic activity, social life and individual conduct.” (Rose & Miller 1992, p. 174). Such authorities can also be found within civil society, industry or other contexts with an interest in regulating behavior and actions for their own objectives. The text will now turn to such non-state arenas to depict the width of recruitment discourse.

My shift in focus is also empirically motivated. The dissolving of the N-group in the beginning of the 1980s coincided in time with the growth of more varied and pluralistic approaches to improve attitudes towards science and technology. Organizations, industry and private persons had shared state authorities call for action and formed technologies of their own in order to stop the negative trend of student enrollment in these subjects. Sometimes this was done in cooperation with the state, sometimes as an enterprise of their own.

The examples below span from museums and exhibitions to summer camps and travelling science shows. As disparate as they may seem, and as distant as they may appear from textbooks and syllabuses, I argue that they were all parts of the phenomenon trying to come to terms with manpower shortage. Even though museums and science shows did not take place inside curricular frames, they were considered to be educational as well. The term *out-of-school science education* can be used to illustrate this. It appeared in 1969 when UNESCO wanted to highlight the importance of extra-curricular activities in science and technology, such as science clubs, science fairs, science camps, and museums among others. The expression sought to define

activities undertaken or done outside the formal teaching periods and the formal curriculum. An activity is ‘out-of school’ even if it takes place within the framework of the school; and even if it takes place in a free activity period in what is normally part of the school working day.” (Stevens 1969, p. 16).

By the late 1960s these kinds of extra-curricular enterprises had been going on for decades in other countries (Terzian 2013). In Sweden they grew steadily in scope and numbers from the late 1970s and on through the 1980s. Often initiated by industry, organizations or private persons but always tied to the recruitment of scientists and engineers, they complemented the activity of state authorities.

Another feature that links the out-of-school science projects strongly together with regular class room activities is their function as parts of population management processes. Taken together with textbooks, syllabuses and career guidance in the 1970s, the examples below make it possible to identify bio-political aspects of science education (in school as well as out-of-school) in Sweden during post-war era. They were attempts to regulate the customs and habits of young individuals and to foster their identities in a (re)directed manner of living. As such they exemplify education as forms of “governing ways of life”. (Simons, M. 2006, p. 526)

Compared to regular teaching though, participation in out-of-school activities was much less done under the guidance of teachers or other adults. As a consequence the phenomenon can be said to have fostered a notable degree of self-governance into science and technology as a study profile, identity and profession. It multiplied the time spent with these disciplines and presupposed an activity where the individual on its own

or together with others internalized a lifestyle where the commerce with science or technology became natural.

The concept of freedom, choice and liberal government was also – in somewhat different ways – inscribed into out-of-school activities. In its sourcebook from 1986 UNESCO underlined the respect of freedom of participation in these enterprises (UNESCO 1986). However – as will be shown below – the way that school children were introduced to them in several cases confirmed their role as technologies of positive propaganda where the individual were to be influenced to participate in them by their own choice.

Science Centers – Didactics or Politics of Participation?

The concept of Science Centers derived from the old Science Museum idea where objects, animals and technological inventions were put on display for both the amusement and educational needs of the citizen. As parts of the broad and fast-growing movement *Public understanding of science*, the founding of science centers grew rapidly in numbers in post-war Northern America. They sought to advance a tradition from the science museum that stressed the interaction between science/technology and the audience (Gregory & Miller 1998). Unlike museums, however, the science centers focused solely on modern objects. As a consequence exhibitions were designed to invite visitors to touch, smell, listen and in any other way experience science and technology. Frank Oppenheimer, founder of the trendsetting *The Exploratorium* in San Francisco stated in 1968 that its main purpose was to educate the public and serve as an extra resource for schools in their teaching of these subjects (Oppenheimer 1968).

Every science center that was built acknowledged the growing presence of science and technology in society. As part of the out-of-school education phenomenon they contributed to bring the question of enrollment to other public spaces in society (Quin 1993). Rooted in a tradition of fostering participating audiences their educational concept was often made up by different experiments or “stations” that needed the bodily involvement of an individual to function. The well-known example of visualizing static electricity using an influence machine or a Van de Graaf’s generator would make the individual’s hair to stand when placing its hand on a positively charged metal sphere. The didactics of participation here can be seen as twofold. Firstly, the displaying of

static electricity would not have been possible without the individual physically taking part in the experiment. He or she, however, could not see this (only feel it). Hence, and secondly, as a public attraction the experiment needed a greater audience that watched and marveled (Hanås & Hanås 1999; Tekniska museet 1999). In this way, drawing upon the technologies of multiple participation, interests and favorable attitudes were thought to occur.

Under the influence of institutions such as The Exploratorium and Ontario science center Swedish equivalents began to take form in the late 1970s. During the following decade a multitude of institutions were founded in all parts of the country. Sometimes linked to universities, sometimes to existing museums or as totally independent institutions they shared a will to increase the physical encounter with science and technology (Israelsson 2013; Riis 1995). Exhibitions were often visited by school classes and their teachers. The example of *Teknorama* which opened in 1985 at *The National Museum of Science and Technology* shows that school visits were not seen as mere reiteration of the regular teaching, but instead as attempts to broaden the possibilities of science lessons. After a short introduction by guides in white lab coats the children were free to explore the exhibition on their own. At the end of the visit there was a moment for questions answered by the guides (Belloni 1999; Lind 1986).

Not all science centers used the presence of guides at the exhibitions though. Most institutions seemed to have shifted between certain forms of guidance and modes of self-instruction to foster attitudes. The foundation of *Teknikens Hus* (“House of Technology”) in Northern Sweden in 1988 can be used to exemplify the explicit links to enrollment of future engineers even though most visitors were too young to choose a field of study. Besides stimulating the will to experiment, the institution was developed to plant an interest in technology before upcoming career choices (Norgren 1984). Following this – and as a parallel to was what said above in relation to teaching material – to distinguish between the didactics and the politics of participatory science education becomes almost impossible.

Clubs, Fairs, Shows and Summer Camps

In Sweden science clubs had existed in secondary schools since the latter half of the 19th century. From the time of their formation to the 1960s the clubs reproduced a tradition

of science as an elitist, male, and upper middle class endeavor. As a hobby they prolonged the time spent with science and thus – perhaps more than any other out-of-school activity – exemplified the fostering of science as an identity. Typical activities consisted of someone giving a lecture on a scientific topic, the organizing of a debate or of conducting experiments together. However, the seriousness and premature character of the activity was often intermingled with more playful attitudes and childish behavior (Bergwik 2005). The importance of having fun in science clubs was often deemed as a necessary ingredient – in the UNESCO handbook of out-of-school activities the organization stated that such an activity was dependent on joy and enthusiasm. The participation in a club demanded: “Rigid discipline, meticulous care, painstaking verification leading to the sense of achievement at the end of a piece of work – all these things are necessary. But they are all subordinate to the fact that the whole thing must be fun.” (Stevens 1969, p. 14). As a component of enticement, this vision of doing science grew steadily in the latter half of the century, both in science clubs and elsewhere.

At a time where the activity of clubs in Sweden seemed to decrease, the call for scientific manpower seemed to relaunch and, to some degree, redirect their purpose. If characterized by more civic aims before WW2 and offering science as an exciting choice of hobby, their subsequent commitment included actual recruitment into higher levels of education (Bergwik 2005). In the 1960s a national organisation – *Förbundet Unga Forskare* (National organisation of Young Scientists) – was established to work as a coordinator of the existing local clubs at different schools. At the same time, through the collaboration of the newspaper *Industria* and *The National Museum of Science and Technology*, a national science fair was started to stimulate the recruitment of scientists and engineers. The fair was modeled after existing ones in the U.S. – following regional fairs a final round was held in Stockholm where the winner was allowed to visit the National Science Fair – International (Bergwik 2004). The fair was held annually, and through the seventies and eighties it operated as yet another arena in which the socialization into science and technology was conducted through technologies of enjoyment and competition.

During the 1980s and the 1990's *Förbundet Unga Forskare* (FUF) widened their role as an actor for the enrollment of pupils to science and technology. In 1987 and 1988 they were touring the country putting together science shows in schools. More than 50

different schools in central and northern Sweden were visited by FUF members. In standardized performances of 40 minutes the following dramaturgy was displayed: “An astronomical slideshow. A figure drawing laser. A couple of chemistry experiments. Slide show on other areas within Science and Technology that one can pursue for instance in a club. Information on university programs in Science and Technology.” (Unga Forskare 1987). The most important moment came after the show when the audience had a possibility to linger and enlist for more information on how to start a science club or get information on science and technology programs at universities.

Science camps were also organized where younger pupils spent a couple of weeks in the summer doing elementary science under the supervision of FUF members. The camps were planned as an effort that would help planting an interest in science and technology. Experiments in chemistry, courses in “surface tension” and the building of rockets were mixed with regular camp activities as these projects fitted into the discourse of “having fun” at the same time as developing one’s knowledge on scientific matters (Jonsson & Ljungman 1995, pp. 26-27).

Conclusion

During the second half of the 20th century, science and technology education in Sweden became an object of politics in a way that differed from earlier periods in history. In a post-war society where economics of education and industrial production crystalized as high priorities of the western world, the identification of a new problem area – recruitment of scientific manpower – resulted in reformed policies for school science. During the 1950s and 1960s, one of the most important effects of such policy changes was an upcoming demand to increase the number of applicants in science and technology at high schools and university levels. This conviction was held by state and local authorities but also by actors representing civil society, such as organizations, industry and private persons.

Initial actions taken to remedy the problem soon prompted an upcoming conflict between the need of the nation and a respect of the individual’s right to a free choice. Instead a strategy developed in the late 1960s to work on “persuasion and attitude change”. Drawing upon the works in governmentality studies this text has portrayed such strategies as the formation of a rationality of liberal government which aimed at

the fostering and usage of pupil's free choices of science or technology. To obtain the goal of more children going into these fields of study, a combination of steering, persuasion, guidance, and propaganda were used, but also the shaping of a certain form of didactics, where experiments were more frequent and syllabuses and textbooks were made less abstract.

Through such projects science education were assimilated in a process of population management and the governing of ways of life in Sweden. Bio-political aspects of school science and technology can also be identified in other activities developed during the 1970s and 1980s, such as clubs, shows and science centers through which scientific attitudes were to be favored.

As stated in the introduction, shortages of scientific manpower have resulted in fears and crises in most parts of the western world during the last 60 years. Even if this case study solely deals with Swedish conditions, its findings could most definitely be related to similar developments in many other countries (EU 2004). To open up other national settings could – although not possible to pursue here – facilitate the portrayal of exactly how extensive the problem area of recruitment to science and technology really is on the global arena.

To evaluate the problem-solving effect of recruitment practices described above has not been an aim of this study. Therefore it is not possible to in depth discuss their impact in terms of attitude change. However, as governments all over the world continue to identify enrollment to science and technology as a major threat to many visions of the 21st century, it seems clear that the strategies used thus far have not been as successful as needed. It is therefore likely that talk of crisis in recruitment to science and technology will continue to be present in future discourses of educational policy.

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