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1 Executive Summary

In this report we present the results achieved in the framework of Pencil for what concerns identifying and dealing with gender difference in science learning. The gender difference issue has been appointed as transversal to all the Pencil Pilot Projects and all of them were asked to kept track of gender when performing their internal evaluation studies. This report provides an overview of their findings, presents the results of the subsequent general analysis we performed, presents the results of an additional evaluation study we carried out at *Fondazione IDIS - Città della Scienza* and gives some final recommendations aimed at informing future efforts in developing educational programmes which could succeed in facing gender differences more as a richness than as a barrier for science teaching and learning.

2 Background

Equity is one the founding principles in a modern vision of education in that it is desirable that all students have equal opportunities to learn, regardless of ethnic group, socioeconomic status, disability, gender. Giving equal opportunities implies taking differences into account and facing the challenge of identifying barriers, addressing different needs, meeting different interests, matching different learning styles.

As attested by several research studies and surveys (ROSE, Eurostat, Eurydice, etc.), in Europe, but the situation is similar in the rest of the world, women are largely underrepresented in science and technology careers. Graduate students in S&T are for approximately two thirds men. Already as school pupils, girls are less attracted to S&T than their male mates. Gender differences in competence beliefs concerning science are reported as early as kindergarten level. For example, boys hold higher competence beliefs than girls for mathematics, while girls have higher competence beliefs than boys for reading and language (Jacobs et al. 2002). Science learning is a typical gender role–stereotyped domain in which boys and girls tend to be strongly conditioned by the self-perception of their competences and skills resulting in resistances and lack of self-confidence (typical in girls) or in overestimation and excess of desire to be in the limelight (typical in boys). Girls also show evidence of doubtful beliefs concerning science careers because of the difficulties in combining professional and private life (i.e. being able to support themselves with their work, having children) and because of a lack for the needed aggressive and competitive attitudes. The few models of woman scientists in their entourage or in an academic environment can only reinforce these kind of beliefs (Koke 2005 and Taylor 2005).

Among many other factors, gender has therefore a crucial role in determining different attitudes and learning styles and consequently different impacts of educational activities on different individuals. Research claims that the problem is not a lack of interest in the

girls, suggesting that the way S&T is presented at school and portrayed by the media is somehow gender biased and continues to feed usual gender stereotypes.

The educational system should on the contrary profit from the diversity in experience and attitudes that ethnicity, language, culture, socioeconomic status and gender brings into the classrooms. This diversity is a richness and gives the opportunity to develop educational programmes capable of capitalizing this resource and, at the same time, meeting the needs of a larger number of students.

As they are able to foster different learning styles and bridge the gap among real science and the wider public, also informal learning institutions such as science centres and museums can play an important role in addressing the gender issue. Informal educators are taking commitment in trying to change a system that appears insufficiently female friendly. Science centres are implementing specific programmes to improve girls' and women's interest in science and technology. Among the Pencil partners, for example, *Teknikens Hus* (Lulea – Sweden) realized *Counting with patterns*, a temporary exhibition based on quilting as a "female" technology, the *Deutsches Museum* (Munich – Germany) launched *Frauen führen Frauen* (Women guide women), offering women an opportunity to discuss topics of science and technology in an easier and more open-minded way, *Technopolis* (Mechelen – Belgium) has a *Wednesday Technical Club*, a program for girls based on working with hands and building and other activities which are usually a prerogative of boys.

The Pencil project aimed at addressing gender issues both through a specific field programme (WP 13, "Social Dimension of Science, Diversity and Gender Issues") at *Fondazione IDIS - Città della Scienza* (Napoli – Italy) and desk research informed by the evaluation studies carried out by all the Pilot Projects for which the University of Napoli was responsible, the results of which constitute the content of the present deliverable. Working at the intersection between formal and informal learning environments Pencil Pilot Projects have explored a variety of educational approaches that can challenge girls

resistance and lack of self-confidence towards S&T. The gender issue has been appointed as transversal to this broad variety of pilot activities, which have focussed on relationship, communication and group interaction, have highlighted connections of S&T topics with social benefit and pupils' everyday life, have had pupils learn about or even meet female scientists. All Pilot Projects have been asked to evaluate their actions keeping track of pupils' gender and looking for differences in learning, motivation, perceptions. Some of them did succeed in identifying barriers, preconceptions, success factors. Some of them did succeed in changing girls' perceptions and motivation towards S&T.

3 Methodology, aims and structure of this report

This report presents the results of the analysis the University of Naples performed in order to identify elements of interpretation of gender differences emerging from the Pencil Pilot educational activities. This analysis is mainly based on the findings contained in the internal evaluation reports delivered by the Pilot Projects, but has been enriched and complemented by a specifically designed evaluation study carried out by the University of Naples at *Città della Scienza* science centre in Napoli, Italy.

As external evaluators of the Pilot Projects and being responsible the present deliverable, the evaluators from the University of Naples asked all Pilots to account for gender differences in evaluating and documenting their actions. For this reason, during the first of two evaluation visits they asked hosting institutions to adopt gender sensitive criteria in planning their evaluation and documentation strategies. This would have implied:

- making up hypothesises on gender related effects in the implemented action and its impact when planning the evaluation (for example, "exhibit A will meet girls' interest more than exhibit B because it implies more relationship and group interaction");
- keeping track of the gender of individuals when collecting evaluation data or producing project documentation (for example, include a Male/Female checkbox in the questionnaires or forms administered to the sample);
- accounting for known gender related effects when grouping for actions/data collection (for example in focus/discussion groups it could be useful to keep boys and girls separated because girls would feel more at ease and be more genuine when boys – who generally tend to dominate – aren't there);
- taking gender differences into account when analyzing and interpreting the data and reporting (for example, report Male/Female specific percentages or graphics).
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Some of the Pilot Projects followed this suggestions and kept track of gender during the carrying out of evaluation studies aimed at assessing different types of impacts (on learning, motivation, perception) on their target groups. On the contrary, many other Pilots did not succeed in performing suitable gender related analysis of their evaluation data. In most of these cases schedule and financial constraints did not allow Pilots to collect enough data. This deficit is surprising since it is well known that there is a gender factor with regards to engagement in science and more efforts should have been made in collecting gender related evaluation data in a project whose main aim was to identify criteria of innovation and quality for the European educational system. Nevertheless, the Pilots that did explore gender issues, including *Città della Scienza* and *NEMO* (Amsterdam – Netherlands), produced interesting results.

The internal evaluation of the Pilot Project at *Città* was specifically aimed at identifying gender differences in science learning at the intersection of formal and informal environments. For this reason the University of Napoli decided to design and implement a parallel evaluation study at *Città*, which was mainly aimed at investigating the science centre educators' perception of the gender issue.

This report provides an overview of the findings of all these evaluation studies, draws some general conclusions by comparing Pilot Projects' findings among them and with those that can reported in existing literature and gives some final recommendations aimed at informing future efforts in developing educational programmes which could succeed in facing gender differences more as a richness than as a barrier for science teaching and learning.

Section 4 is devoted to present the findings emerging from the Pilot Projects. Section 5 presents the findings emerging from the evaluation study performed at *Città*. In Section 6 some conclusions are drawn out.

3.1 Connection with other deliverables

The 14 Pencil Pilot Projects have been analysed through a series of case studies describing their development processes, activities and outcomes. One of the parameters against which Pilot Project have been analysed in the case studies is the "Emphasis on issues of gender equity and social justice". The 14 case studies are presented in D10 – "Assessment of Pilot Projects". We therefore refer to that deliverable for what concerns the definition of the general methodological framework on which the analysis developed by King's College London and the University of Naples has been based.

The specific analysis of gender issues in Pencil contained in this report has informed the development of the sections about gender differences in D28 – "Criteria of innovation and quality" and D31 – "Formal vs. informal education - Elements of evaluation".

4 Findings from the Pilot Projects

Although many Pilot Projects did not succeed in obtaining interesting results about gender differences, the ones that did explore gender issues found notable preconceptions of the part of girl students that "science was not for them", or that "I am no good a science" - views which constituted substantial barriers in their involvement in the activity. In some Pilot Projects (*Heureka* (Vantaa – Finland), *Universeum* (Gothenburg – Sweden), *Cité de l'espace* (Toulouse – France), *Technopolis*, *Teknikens Hus*), assessment of gender differences in learning or motivation was attempted by asking teachers to report about their direct observations of the pupils' behaviours during the educational activities. This approach has always revealed to be unsuccessful as teachers weren't able to notice or report any difference. In many cases, pilot project coordinators expressed their intention to plan some evaluation of gender differences in the future.

The Pilot Project carried out at *NEMO* (Amsterdam, NL) had participating pupils involved in developing their own "science centre at school" by building models of the real science centre exhibits (see Pencil - D10 for further details). During the first visit carried out by the evaluation team from the University of Naples, the Pencil staff at *NEMO* seemed quite sceptical about investigating gender biased impacts of their activity because they were quite confident in supposing that gender differences are to a good extent an out-of-date issue in the Netherlands. Nevertheless, upon suggestion of the evaluation team, they decided to look at gender differences by simply adding a gender check in the questionnaires for the pupils. Interesting findings emerged from the analysis of the evaluation data. Firstly, boys and girls had different preferences with regard to the exhibits they chose to build. For the boys, the most popular exhibits were those about batteries and electric circuitry, while girls liked exhibits involving human interaction such as the magic mirrors and the quiz game on the names of leaves. Secondly, interesting results were also found when looking at boys and girls perceptions of self with regard to science and technology. Project staff asked pupils "how technical" they would say they

were. They asked this same question both before and after the programme. Before the programme most of the girls (65%) said they were "not very technical", while most of the boys (52%) said they were "rather technical". Following the programme, only 30% of girls considered themselves to be "not really technical", and the vast majority considered themselves to be competent. In contrast, whilst a small percentage (6%) of boys subsequently decided that they were only "technical", as opposed to "rather technical", in general, estimation of skills remained high. Finally, it is interesting to note that at the end of the programme, there was a 43% increase in the number of girls electing to study nature and technical studies in the next stage of their education. However, any correlation between the effect of the programme and the subject choice on the part of girls was not confirmed, and other factors may have played a significant role in such choices.

The Pilot Project developed at *Explor@dome* (Paris – France) had the students involved in developing multimedia products (DVD, websites) in order to present scientific concepts to their peers (see Pencil - D10 for further details). Whilst the analysis of the evaluation data (knowledge tests, questionnaires, direct observations) did not indicate any evidence of a gender-biased impact of the educational programme, some interesting elements emerged from both the target and control group. In the target class there was an improvement of performances regardless of gender, although this improvement was more marked in boys, especially in geometry. Furthermore, starting from a generalized non enthusiastic attitude towards studying science, the programme produced a greater positive effect in girls' perceptions of science than it did in boys'. In the control group, the pre-test performances of boys and girls were equal, while in the post-test, boys' performances were very more lowered than those of girls. This may be related to a change in girls' perception of science and their own capabilities with regards to science, which both developed positively over the course of the school year, while boys' perceptions and initially overstated self-perceptions remained unchanged. A suggested interpretation of the good impact on girls' perceptions of science and self was the involvement of girls in participative and peer-to-peer educational activities in which, in contrast with the usual classroom activities, they

had enough room to express themselves without being overwhelmed by boys' excess of desire to be in the limelight.

The Pilot Project at the *Experimentarium* (Copenhagen – Denmark) was centred on a peer-to-peer teaching/learning approach and was designed to target girls but also intended to appeal to boys. The notion being that if the communicative aspect of science teaching was to be emphasised, this would appeal to girls, whilst the practical element (the hands-on demonstrations) involved in the activity would appeal more to boys. A gain in confidence (especially for girls) was a particular aim for the project. This aim seemed to be mainly achieved. The coordinator offered the following explanation of the differing approaches of boys and girls: "I think that a lack in confidence is one of the main reasons girls don't enter into science… We have girls saying time and time again saying 'oh, we can't be part of this. We are not so knowledgeable in science'. On the other hand, boys have confidence that even if they don't know the content, they can still explore the topic".

The Pilot Project at the *Bloomfield Science Museum* (Jerusalem – Israel) consisted of a teacher training course about biomedical technologies. Given the general objective of confronting teachers with real-world science, Pilot Project coordinators were committed to ensuring female scientists were among those selected to meet the teachers: "we wanted a woman to be one of the leading scientists to take lectures at the course. Also one of the labs we chose for the visits is actually run by a woman", one of them commented. Project staff felt that prejudices exist in the way teachers perceive males and females with regard to science and that these prejudices have an influence on the way science is portrayed at school.

4.1 The Pilot Project at *Città della Scienza*

The "*So... Science!*" Pilot Project carried out at *Città della Scienza* was designed in order to experiment educational activities mixing formal and informal methodologies, with the aim of identifying gender differences in science learning. After direct observation of the pupils during the programme and evaluation through focus groups, interviews, questionnaires and concept maps some differences emerged between boys and girls. Approaching what project coordinators defined as the "the two separate dimensions of the informal context", education and entertainment, girls and boys showed different propensities, the boys being more attracted to the entertaining aspects and the girls being more attentive to the educational goals.

While the proposed activities proved to be equally attractive and interesting for girls and boys, differences emerged in the following aspects:

- **expressive and modelling skills**: girls usually started from a lower level but in the end of the educational program they obtained better performances than boys;
- **long term**: girls much better preserved their expressive skills and acquired knowledge in the long term;
- **propensity to a creative approach in facing tasks**: boys were more inclined to try new ways of using tools and solving problems, while girls usually followed the prescribed steps to reach the final result;
- **capability to obtain the expected results**: girls were usually more willing and effective in reaching the expected results, while boys were usually more interested in exploring and having fun and little focused on results.

As a reason for the difference in behaviour, Pilot Project coordinators, *Città's* facilitators and partner teachers suggested the fact that society encourages boys to engage in science and technology – and, for example to play with meccano, or chemistry sets – whilst girls are encouraged to listen and not to assert themselves.

5 An evaluation study at *Città della Scienza*

Since the Pilot Project at *Città della Scienza* was specifically aimed at investigating differences in the impact of their actions on boys and girls' learning, motivation and perceptions, the researchers from the University of Naples decided to implement a parallel evaluation study which was mainly aimed at investigating explainers and teachers' perceptions about the relevance of the gender issue in their usual practice.

The study was structured in three different parts:

- visitor study (observations and questionnaires)
- open questionnaires and subsequent discussion group with explainers
- interviews with teachers involved in the Pencil project

The visitor study was mainly focused on the direct observation (and administering of questionnaires) of scheduled school group visits, but included also observations of free exploration visits during the weekends and observations of the activities comprised in a special summer programme dedicated to kindergarten pupils. The observations of school group visits were aimed at exploring visitors', teachers' and explainers' behaviours mainly for what concerns the aspect of human interaction when using hands-on exhibits.

The questionnaire administered to 30 explainers working at *Città* was based on the attempt to stimulate them to freely express their opinions about several aspects of gender differences in science learning that are well known in the existing literature. The questionnaire investigated explainers' perceptions of those aspects of gender differences, the self-perception of their ways of interacting with the same aspects in their practice and their general views, perspectives and ideas for innovation in practice with regard to the gender issue in science learning. After a preliminary analysis of the data, 15 explainers have been involved in an in-depth discussion group which lasted 4 hours. The discussion group allowed the researchers from the University of Naples to obtain more responses for

what concerns the self-perception of gender biased attitudes by the explainers that had not emerged from the questionnaires.

We also interviewed some of the teachers (from primary and secondary schools) who were involved in the Pencil Pilot Project at Città. Inspired by the negative conclusions of the evaluations of gender differences which were based on teachers' direct observations in other Pencil Pilot Projects, we decided to focus the interviews on teachers' perceptions and self-perceptions concerning the gender issue.

In the following subsections some of the findings emerging from the three different parts of the evaluation study are presented. Some conclusions are presented in Section 5.4.

5.1 Visits observations

The main indings emerging from direct observations of school group visits are:

1. Pupils

- Boys tend to be more confident in speaking, answering questions, touching the exhibits, showing their understanding. Girls are very shy in answering direct questions and in being the first to explore a new exhibit.
- Boys seem to be more intuitive but, at same time, attracted by the playful aspect of the exhibits and often wasteful. Girls are more polite, neat and focused on understanding the scientific content of the exhibits
- Boys are attracted by exhibits in which they have to use their body and force. Girls are attracted by the aesthetical dimension of the exhibits.
- Girls tend to work in groups (boys not allowed!) and to be attentive to what the explainer is showing and saying. Boys are more independent in exploration and tend to work alone.

2. Explainers

- Male explainers have in general a more friendly attitude towards the visitors, they are more indulgent with the restless boys, they interact verbally and physically, they use more non-technical language and examples. Female explainers tend to be more severe in keeping the visitors quiet, to be more technical and schematic in explanations, they are not used to interact physically with the visitors.
- Male explainers tend to involve girls more in the educational content of the exhibit and boys more in the playful dimension. Female tend to interact more with the boys often complying with their desire to be in the limelight.

3. Teachers

- Male teachers show almost all the time a completely non-participative attitude. Most of female teachers show the same attitude, but the ones who are interacting tend to be a little bit intrusive (i.e. answering questions before their pupils) and to keep the pupils unnecessarily quiet.

5.2 Explainer questionnaires

When asked if gender differences in the approach to science learning exist, 60% of the explainers answered in the positive. At the same time two thirds of them asserted that gender issues are out-of-date. This double-folded point of view was confirmed by the discussion group. Explainers were able to report for gender differences in pupils' behaviour, but at the same time they didn't see them as a problem, a barrier or even as a richness. They seem to consider gender differences simply as a fact they learn to deal with by simply increasing their experience in interacting with the visitors. Most of them expressed poor need for their practice to be informed by research about this issue. Female explainers in particular were (especially in the discussion group) quite annoyed in talking about differences. Their answers to the questionnaire were often centred on the "suspicion" that the objective of the research was to establish a sort of classification of skills between boys and girls. "We should talk about gender differences in the opportunities offered by society, not in science learning", one of the female explainers

commented. Nevertheless, both the answers to the questionnaire and the discussion group essentially confirmed the existence of the general gender-biased behaviours described in the previous section. It is worthwhile to note that most of the observed differences were mentioned by male explainers. Male explainers appeared in general more open to the discussion, while female explainers tended to minimize differences: "the group dynamics cancel the differences". The discussion group also facilitated the emergence of stereotypes in male explainers' point of view, such as: "clearly girls are less interested in science". When talking about the impact of gender differences on their practice, female explainers mentioned their difficulty to be accepted by boys as "leaders" of the visit. Some female explainers mentioned a need to comply with the boys' exuberance in order to keep the control on the whole group. This could partly account for the emergence in the debate between male and female explainers of differences in the definition of their role as educators: males tended to praise the value of visitors' enjoyment, while females were more oriented towards visitors' attention to the scientific content of their explanations (see observations in the previous section).

5.3 Teacher interviews

About the perception of gender related behaviours in their pupils, also the comments from teachers went more or less in the same direction of the direct observations. These comments were however enriched by their connections with the social and cultural context. For example, one teacher commented: "the 'explorative' and fearless attitude of the boys is certainly linked to the self-confidence in their body, their force, their cleverness which is determined by their family and by society; this attitude makes them naturally more disposed towards learning science". Another teacher commented: "boys and girls have different ways to communicate and they become more and more different as they grow up: education and mass-media are decisive factors in influencing their behaviours and attitudes; they transform diversities that could be a richness and a resource into rejection, resignation, inability, indifference".

Although the teachers we interviewed were quite attentive and interested in gender issues they all admitted that it is very difficult to take them into account in their usual practice: "You don't look at the class as composed by boys and girls; you look at the class as a whole; as you have to treat all the pupils in the same way so you end up considering them all equal and this makes you lose so much!". They also mentioned a difficulty to talk about this kind of issue among teachers and also talked of a lack of interest in many of their colleagues in discussing the origin of pupils' gender stereotyped attitudes. Moreover they reported a quite diffused attitude in their colleagues (both males and females) to comply with stereotypes such as "girls are not given for science".

6 Conclusion

Interviews with school teachers and museum operators from twelve different countries involved in Pencil show that gender issues are strongly underestimated in terms of both awareness and action. On the other hand, evaluation results such as from the project at *Città della Scienza* reflect research findings showing that gender difference does play a role in science learning. The *So... Science!* project together with other Pencil Pilot Projects showed that educational programmes can be designed which are attractive for both girls and boys, confirming that the way topics are presented is the key success factor in science learning. The results of the evaluation studies from *Nemo*, *Explor@dome*, *Experimentarium* also confirm that informal learning environments can have a fundamental role in addressing the gender issue: interaction and peer-to-peer teaching/learning methods are good tools to turn to better account for both boys' energy and self-confidence and girls' greater capability to stay focussed on the content of the activity. The impact on pupils', and in particular girls', motivation towards studying science in those programmes has been considerable.

Nevertheless, the main issue emerging from this evaluation study is the surprising lack of awareness and action about gender issues in science educators. Findings from both the Pilot Projects and the study at *Città* tell us that science teachers, even if they are often aware of the existence of gender differences, they are not able to report them and to take them into account in their practice, because they are used to work with the class as a whole. The group of explainers involved in the study at *Città* showed awareness of the existence of differences but, at the same time, showed some resistance in discussing how this awareness could inform their practice and how research findings could help them in becoming even more aware. This kind of resistance often emerged also in the discussions with the staff of the Pencil Pilot Projects. Many among those science educators from all over Europe expressed the belief that discussing about gender differences necessarily means talking about well known and out of date stereotypes about being "given" for

something. But even in countries such as the Netherlands, where those stereotypes are apparently really out of date, evidence for gender differences came out of the evaluation. On the other hand, the study at *Città* tells us that in Italy those stereotypes are at least still capable of influencing people's way of thinking. Addressing gender issues would actually mean renouncing those stereotypes by looking at gender differences as a richness to be exploited.

The overall experience made in the framework of Pencil shows that the collaboration between science educators and science education researchers could produce fruitful results, but also that this collaboration is useless unless cultural efforts are made to go beyond inattentive or disinclined attitudes towards gender issues. By taking gender into account when conducting evaluation, educators can gain a deeper understanding of existing issues and learn how to design new programmes that actively enable both boys and girls to engage with science and technology. A greater awareness of gender differences is needed in order to allow for educational programmes to be more flexible in taking the different learning styles into account and challenging boys' lack of effectiveness in attaining objectives and girls' inclination to lack of creativity in finding alternative ways to attain them.

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