Project no. 217728

Project acronym: YOSCIWEB

Project title: Young people and the images of science on websites

Funding scheme: FP7

Thematic Priority: Science in Society

Deliverable reference number and title

1. Bibliography of similar study

Due date of deliverable: May 2008
Actual submission date: 2008-06-05

Start date of project:2008-01-01 Duration: 2 years

Organisation name of lead contractor for this deliverable:
Glasgow Caledonian University (United Kingdom)

* This report is compiled from the collective submissions of the EU FP7 YOSCIWEB project partners 'Young people and the images of science on websites'.

Children's perception of science and scientists - developing better websites

Andrew Quinn, Anna McGee and Birgit Schroeter, Glasgow Caledonian University .

The following review will argue for the need to examine images of science presented on children's websites. After commenting on the reduction of students choosing science subjects in tertiary education (1), young people's negative and stereotypical perception of scientists and science will be analysed (2). It will then be proposed that media representations of science and scientists may be important influences on young people's attitude to science (3). As Internet consumption among young people is rising rapidly, the review will then focus on examining research pertaining to children's use of websites (4). Factors that make websites attractive to young people will be highlighted (5). After briefly describing some suggestions that may help to analyse websites (6) the state of current science websites is reviewed, demonstrating that many websites do not live up to young people's expectations (7). The conclusion of the review (8), will then serve as guideline for the current proposed project (9).

Table of contents

1. Concerns about science uptake at school

The High Level Group on Human Resources for Science and Technology in Europe (2004) has alerted the European member states that there are not enough scientists in each country and that there is much need to increase numbers. There has also been a growing concern about student uptake of science at higher levels. A closer look at the UK statistics, drawn from HESA, the British Higher Education Statistics agency, highlights that while student numbers have continuously increased, undergraduate study in Physics or Chemistry has declined markedly from the late 1990's until now. There has been a lesser decline in Biology, while Mathematics seems to have been relatively unaffected by the drop (see table 1).

Table 1: Full time undergraduate students per subject at UK universities

Year	Total no. of students	Physics	Chemistry	Biology	Mathematics
06/07	1208645	9560	12055	18090	19665
05/06	1198820	9430	11180	17980	18730
04/05	1165445	9350	11070	17380	17925
03/04	1141850	9400	11280	17580	17015
02/03	1111310	9045	11625	17390	16855
01/02	1069210	8605	11645	15705	18085
00/01	1037880	9025	12030	16625	14280
99/00	1027400	9480	13110	17130	13940
98/99	1032897	9706	13728	17536	13772
97/98	1022606	9731	13714	17542	14190
96/97	997661	9990	13923	18081	13188

This table already highlights some main caveats for the proposed project, primarily the notion that the decline in student numbers seems to be somewhat subject-dependent, and that therefore any conclusions drawn about science in general need to be viewed with caution. Secondarily, the table highlights that the heading "science" in itself is underspecified; the data presented here cover some of the more "typical", "pure" subjects, while applied sciences, such as computer sciences, pharmacology, neurosciences and even engineering subjects are disregarded.

The table presented above accounts only for the British Higher Education system, which already boasts a higher percentage of tertiary science graduates than other European countries. Table 2 shows the UNESCO statistics for tertiary science graduates in the countries participating in this study.

Table 2: Percentage of tertiary education science graduates across countries.

Year	1999	2000	2001	2002	2003	2004	2005
Bulgaria	3	4	4	5	5	5	5
Estonia	4	6	6	6	8	9	11
France	13	15	...	13	13	...	12
Iceland	11	14	14	14	11	11	9
Netherlands	5	5	5	5	6	7	7
Spain	9	10	11	11	11	11	...
UK	14	15	17	17	17	15	14

The table demonstrates that the issues with regards to science education are not solely focussed on recent declines in science-uptake, but are also concerned with general low levels of science education. These data raise the question as to what can be done to encourage students to choose science subjects, and how to prevent science uptake rates from dropping.

Furthermore, the participation of girls and of children from lower socio-economic status is of special concern. Science is generally a largely male-dominated domain, with the exception of Biology and Medicine-related subjects which tend to appeal more to girls, presumably because their out-of-school science interests tend to focus on these topics (Jones, Howe and Rua, 2000; Miller, Slawinski Blessing and Schwartz, 2006). Consequently, women are under-represented in many areas of science research across Europe (The High Level Group on Human Resources for Science and Technology in Europe, 2004).

In addition, children from lower socio-economic background not only achieve less in science (Ma and Wilkins, 2002) – possibly due to the competing priorities of education and part-time work (Singh and Ozturk 2000) – but also hold more stereotypical perceptions of academic achievement (Régner, Huguet and Monteil, 2002), two factors which may contribute to the more negative attitudes to science in the lower status adult population in many European nations (Pardo and Calvo, 2006).

One important factor to consider is the importance of the perception of science, as students are unlikely to choose a scientific career unless they are convinced of its merits. The following sections will elaborate on the perception of science and scientists held by young people. The influence of the electronic media in general and web-sites in particular will then become the focus of this review.

2. The perception of science and scientists held by young people

One important determinant of behaviour is the attitude that is held towards the behaviour in question. The link between these two constructs has been extensively reviewed in psychological literature, in particular in Fishbein and Ajzen's Theory of Planned Behaviour (see for example Ajzen, 1991), and need not be elaborated here. Suffice to say that in order to understand the low uptake of science, it is necessary to investigate children's attitude towards science.

As already alluded to above, it is pertinent in this introduction to make a distinction between science in general and school science in particular, as attitudes to everyday aspects of science, such as popular computer programs (Physics), antidepressant medication (Chemistry), or stem cell research (Biology) may be distinct from attitudes towards school Physics, school Chemistry or school Biology. In fact, Baram-Tsabari, Sethi, Bry and Yarden's (2006) study on children's questions on a science web-site, shows that the topics of spontaneous and personal interest questions differ markedly from the content of school related questions. While it is the perception of science in general, that is investigated by Public Understanding of Science (PUS) research, it is the perception of school science that is more directly linked to science uptake at school and University.

Further support for the non-equivalence of these two attitude constructs comes from the Commission of the European Communities (2005), Osborne, Simon and Collins (2003), and Trumper (2006). The Commission of the European Communities noted that contrary to their perceptions of school science, children are, on the whole, optimistic and confident about the value of science in general, while Trumper found that the attitudes towards Physics in their Israeli sample were neutral, but this neutrality was linked to a negative opinion about science classes. In addition, although attitude neutrality was found for both genders, boys' attitudes towards science were more positive than girl's attitudes. Using a young adult sample, Brandi, Cerbara and Valente (2005) note that in Italy scientific content in mass media is perceived to be satisfactory, but scientific education is considered poor. This observation thus presents a third caveat to the current project, and care must be taken not to generalise the results obtained by the studies below beyond their validity.

Another note of caution needs to be added for making the equally important distinction between *science* and *scientist*. While both these topics are undoubtedly related, children's perception of science and scientists will not completely overlap.

2.1. Perceptions of Scientists

One popular way to assess the perception of scientists held by children is the Draw-a-Scientist Test (DAST), a pictorial assessment that has the advantage of avoiding difficult verbal questions, in particular for younger children. As children move through their teenage years, verbal and written reports may become more appropriate.

Chambers' (1983) original work introducing the DAST was conducted with a sample of 4,807 5-11 year old school children. Results showed the stereotype of the scientist to be male with facial hair, wearing a lab coat and glasses, surrounded by symbols of research, knowledge and technology, mythical figures and signs of secrecy or danger. Finson's (2002) more recent review on the DAST, commenting on studies drawing on primary and secondary school children as well as adults, concludes that since then, the stereotype of the scientist has hardly changed, with the exception of the mythical element of the mad scientist which seems to have declined over the past 25 years. Particularly worrying is that even in the 21st century, most pre-intervention images drawn by children are men, highlighting the preconception of science as an exclusively male pursuit (see also Picker and Berry, 2000).

A cross-European study by Rodari (2007) concurred with Finson's somewhat discouraging findings, reporting the predominance of the white coat, glasses and lab equipment, as well as the occurrence of the mad and dangerous "Einstein" stereotype in samples of 9 and 14 year-olds. The European children also frequently included scientists working with or experimenting on animals. It is interesting to note that representations also depended on local knowledge, drawings by children from the Polish town of Kopernik depicting disproportionally more astronomers as scientists.

Although critics of the DAST maintain that asking young people to draw a scientist will invariably elicit a stereotype, studies using alternative methodologies, such as questionnaires (Miller and Hayward, 2006) or interviews (Brandes, 1994) have shown that the scientist/science stereotype is indeed alive and well. Miller and Hayward, analysing occupational gender stereotyping in a sample of 14 to 18 year old students, found that girls consistently preferred occupations that had previously been identified as female-stereotyped, such as nurse, secretary, occupational therapist, hairdresser or physiotherapist, while Brandes, using clinical interviews with primary school children also reports stereotypical perceptions.

Scherz and Oren (2006, p.797) quote the (pre-intervention) statement of a 14 year old boy, describing a scientist as "*sort of absent minded, like Einstein, bald with grey hair on the sides of his head, with glasses and moustache*."

2.2. Perception of School Science

The perception of school science is no more positive, studies reporting a steady age-related decrease in excitement about science (Brandes, 1994; Osborne et al., 2003). In fact, students tend to describe science as a boring subject that has to be learned by heart (Lyons, 2006), that is irrelevant (Osborne et al., 2003) and difficult to learn, particularly for girls (Jones, Howe and Rua, 1999). It is in the aspect of relevance that the non-equivalence of the sciences is usefully demonstrated, Biology being seen as having much more relevance to the everyday human experience (understanding the body, understanding illness) than Physics, Mathematics or Chemistry, where the periodic table is perceived to be particularly irrelevant (Osborne and Collins, 2000). According to Otero, Leon and Graesser (2002), this negative perception comes as no surprise, considering that most students take up lessons with little background knowledge, and are confronted with complex and poorly written texts.

The perception of school science as difficult (Eurobarometer 2001) may make a particular contribution to the uptake of science in higher education, as considerations of achievement lead students to choose subjects in which they are likely to excel (Barmby and Defty, 2006, see also Waering, 1990). While girls' maths performance at young ages is similar to boys' performance (Lachance and Mazzocco, 2006), girls at secondary school age tend to achieve less (Mullis, Martin, Fierros, Goldberg, and Stemler, 2000). In addition, children from lower socio-economic background do not expect to excel at science, (Régner, Huguet and Monteil, 2002; Sirin, 2005), it is hardly chosen. A report by the High Level Group on Increasing Human Resources for Science and Technology in Europe (2004) poignantly sums up the current situation of school science, stating:

> *"Science education suffers badly in this respect. Not only is it trying to cope with this image of 'becoming a scientist', but it is also fighting to relate to society. And yet it is being bound by an old-fashioned view that it must develop the 'fundamentals' of science which, all too often, are abstract, even microscopic, and far from the science ideas underpinning the technological advances within society which form the focus of debate and divide public opinion. It can be argued that science education in schools lives in a world of its own. It seems unsophisticated because it is unable to compete with advances within the scientific fields. It is abstract because it is trying to put forward fundamental ideas, most of which were developed in the 19th century, without sufficient experimental, observational and interpretational background, without showing sufficient understanding of their implications, and without giving students the opportunity of a cumulative development of understanding and interest. It is heavily in danger of being excessively factual because of the explosion in scientific knowledge and the 'adding-on' of topics to an already excessive content base. And, to add to all this, the measures of assessment of student achievement have been largely confined to the regurgitation of information, and the ability to manipulate equations algebraically"*

2.3. Perception of Science outside the school context

In contrast, the perception of science outside the school context is much more positive; science being frequently described as useful, relevant, good for employment and important in everyday life (Adnamuti – Trache, 2006; FECYT, 2006; Institute of Electrical Engineers - see Osborne, 2003), although students also perceive threats and danger (Rodari, 2007) as a consequence of their knowledge of previous scientific accidents. This mirrors the Office of Science and Technology and the Wellcome Trust's (2001) findings that adults generally tend to see science as positive, but that the control of science is a concern. Many respondents, in this questionnaire-based study, thought that rules will not stop researchers doing what they want to do. It should be noted that this concern may be linked with the stereotype of the mad/dangerous scientist who stops at nothing to reach his or her goal. Interestingly, many adults also seem to endorse the "brainy" stereotype, arguing that decisions on science and technology are best left with the experts (Luján and Todt, 2007).

In addition, it is "being a scientist", rather than "science", that is perceived unfavourably. Looking at the adult population, the High Level Group on Increasing Human Resources for Science and Technology in Europe (2004), notes that scientific careers seem unappealing in terms of remuneration, career structure, work environment and status.

Once more, the perception of science is dependent on the topic analysed, with medicine, health and environment being particularly popular, re-emphasising the importance of relevance (FECYT, 2006). In addition, science perception varies with the individual characteristics of the participant respondents. The 2005 Eurobarometer study shows that apart from topics such as environment, genetics and humanities, science appreciation is largely male dominated, with higher interest shown by the young adult population, by participants with high educational background and high socioeconomic status (see also Luján and Todt, 2007).

Some interesting intercultural differences show that a number of previous Soviet states, such as Romania and Bulgaria, report a lesser appreciation of science than established European states such as Greece or Sweden, while also being more reserved in encouraging women to study science. Latvia and the Czech Republic in particular show low agreement with this question, while other countries such as Portugal, Sweden or Cyprus are highly in favour of encouraging women to study science.

3. Influences on the perception of science

The observation that adults' attitudes towards science are related to their amount of knowledge about science (Allum, Sturgis Tabourazi and Brunton-Smith, 2008), makes it imperative to analyse factors influencing young people's perception of science as this is, as demonstrated above, closely linked to their science uptake at school and therefore to their degree of knowledge and attitudes in adulthood.

Scholars in the field of media and communication studies (for example Reeves Timmins and Lombard, 2005) make the distinction between two types of experiences that impact on modern life: the non-mediated face-to-face experiences found in direct interactions with others, be it teachers, parents or peers and the mediated experiences provided by newspapers, television or websites.

3.1. Non-mediated influences on children's perceptions of science

The impact of non-mediated experiences on the perception of science has been well-documented by research showing the importance of teacher support, parental encouragement, and peer group support. Stake (2006) attests to the importance of all of these factors, her research with senior high school students showing that encouragement from family, encouragement from teachers, and encouragement from peers were each independent predictors of science attitudes.

It is once more noteworthy that these social interactions are not gender neutral and that peers, parents and teachers treat boys and girls differently. Teachers may think that boys are better at science (Li, 1999) and therefore may focus more on boys' achievement, parents may not encourage their female offspring as much as their sons (Bleeker and Jacobs, 2004; Tenenbaum and Leaper, 2003), and the (usually all-girl) peer group may put girls off science (Stake and Nickens, 2005), even if only not to violate the perceived norm (stereotype threat: Spencer, Steele and Quinn, 1999).

The power of non-mediated interaction is also revealed in intervention studies which show that children's stereotypes of scientists can be transformed through personal encounters with scientists (Bodzin and Gehringer, 2001; Steinke (2004).

3.2. Mediated portrayals of scientists and science

In the realm of mediated experiences, the electronic media have made a major contribution to children's worlds. While the use of electronic media is obviously influenced by non-mediated experiences - Fluckiger (2007), for example, notes that parental attitudes and parental use of computers predict teenager's computer ownership and use – the influence of the media is an important topic in its own right, particularly as children themselves rate the media as an important influence on their perception of science (Steinke, Lapinski, Crocker, Zietsman-Thomas, Williams, Evergreen and Kuchibhotla, 2007).

Research on the portrayal of science in film and television shows that scientists are portrayed both negatively - as mythical/magical, dangerous, omniscient, eccentric, antisocial, dangerous or evil, and positively - as people who look for the truth and try to find solutions to problems (see for example Long and Steinke, 1996, Weingart, Muhl and Pansegrau, 2003).

Vílchez-González and Perales Palacios (2006) have investigated the portrayal of science (as opposed to scientists) in cartoons, utilising Gallego's (2000) categorisation of distorted images of science in comics. The authors found that in 70% of the episodes analysed, science was portrayed as either rigid, Aproblematic, Ahistorical, individualist or elitist.

In addition, the media also propagate the picture of the male scientist, providing fewer role models for girls (Long, Boiarsky and Thayer, 2001), and depicting women scientists as assistants to male scientists (Elena, 1997). Based on Bem's Gender Schema Theory, Steinke (see Steinke, 1998), argues that this discrepancy is important in shaping girls' attitudes towards science and scientists. Her research shows that more men are depicted as scientists in children's TV series (Steinke and Long, 1996) and that stereotyping is also found in other more subtle aspects of representation. For instance, Steinke argues that research teams in films usually contain one woman only and that for a woman a scientific career comes at the expense of a private life (Steinke, 1999, 2005). However, she also comments on one US television series – Discovering Women – which actively challenges the male dominated stereotype (Steinke, 1997).

While television remains the most popular medium for younger children as it can be viewed without prior learning (Koolstra, Bos and Vermeulen, 2006), older children and teens are also avid users of the Internet. In fact, adolescents use the Internet more than any other age-group (Kalmus, 2007), with The British Office of Communication, Ofcom, (2008) noting that for 12 -15 year-olds the average amount of time spent on the Internet has nearly doubled from 7.1 hours /week in 2005 to 13.8 hours/week in 2007.

3.3. Website portrayals of scientists

Broadly speaking, websites' portrayal of science and scientists (or being a scientist), can be analysed on two levels. The first level is concerned with the representation of professional scientists and their work, and resembles by definition the reporter's point of view found in television programmes. The second level is concerned with the overall attractiveness of the page, asking whether the site through layout, design and interactive features gives the impression that science is interesting or boring, achievable or difficult etc.

Investigation at the first level of analysis leads to very few results, with no studies explicitly surveying the portrayal of science and scientists in general, even though Massoli (2007) shows that the Finish MIT website offers life stories, narrating the experience of young researchers and describing both professional and personal aspects of their life. In terms of gendered representation on the Internet, Terrón Bañuelos (2002), having analysed educational websites, reports that men are more frequently represented on websites than women. Men are also more frequently referred to by name, rather than forming part of a generic category and are more frequently linked to specific occupations rather than to family roles, such as brothers, fathers, or uncles. Countering this, work by Steinke (2004) shows how science and engineering websites for girls combat the male-only stereotype by describing female scientist and their careers.

In contrast, more research has been conducted with regard to the second level of analysis. The following sections will comment on young people's use of the web, on the expectations young people hold of a "good" website and on whether or not current scientific websites meet these criteria.

4. Young people and the World Wide Web

Much like television, young people use the Internet at home as diversion: for entertainment - often in the form of games (Bevort and Breda, 2001) - for passing time, for relaxation and for obtaining social and general information (Ferguson and Perse, 2000). Unlike television however, the big focus for young people is on social interaction (Mediappro, 2006), recent research on the use of blogs (for example by Delaunay - Téterel, 2008) attesting to this preference. Interestingly, this communicative use is particularly marked for girls, results of an Icelandic study reported by Jakobsdóttir, Gautadóttir and Jóhannesdóttir (2005) showing that the older girls in their sample (13-19 years old) used the web more frequently for social interaction, while boys favoured entertainment or information (see also Guðmundsson, 2004).

The Internet is also the medium of choice when it comes to getting information quickly, particularly when information on a very specific topic is needed (National Science Board, 2004). Scholastic endeavours are rarely mentioned, although older youths in the Danish sample participating in the Mediappro study acknowledged the role of the Internet for homework. This age difference in the use of the internet has also been confirmed for an Icelandic sample by Jakobsdóttir, Gautadóttir and Jóhannesdóttir, who found that in the most recent (2003) sample of their 3- year study, the younger age group (6-12 years old) tended to use the internet for games, while the older age group (13-19 years old) used the web primarily to acquire information. Cole (2002) also states that 14% of his sample used the Internet for school. However, it should be noted that young people's perceptions of Internet use are not always accurate. Ebersol (2000) for example reports that students visited commercial sites more frequently than other sites and that even though participants claimed that they used the web for research and learning 52% of time, only 27% of sampled sites were suitable to this pursuit.

In the school setting, where websites are used more explicitly for educational purposes, such as thorough study of particular topics, students rate the importance of the Internet for their work highly. Lelièvre (2003) for example states that 92% of her respondents claim that they have used the Internet for school work.

This school/home distinction leads to differing ways of using the Internet. While Bevort, Breda, Smedt and Romain (2003) note two patterns of Internet use in their Italian sample, utilising the web either as television-like diversion or as book-like information medium, where pages are printed out before they are read, Fluckiger (2007) describes three main patterns of usage, namely generational use, which is ludic and pragmatic, familial use, which is inter-individual, and scholastic appropriation, which is based on structured manipulation. The non equivalence of the way the Internet is employed at home and at school (see also Hamon, 2006) leads to different requirements in website design. As Internet use at home is more self-directed, it is important that websites are attractive to adolescents, in order to reach their audience and create desire for self discovery. Therefore websites used at home tend to be more playful than websites used at school (Lelièvre, 2003).

While Internet use is very distinct for school and home purposes, it also varies according to individual characteristics and user preferences. Messin (2007), for example, analysed different patterns of web use and concluded that young people may use the web as followers, as pragmatists or as experts.

4.1. Websites, science and individual differences

Looking at science communication, the unique potential of using the World Wide Web should again be highlighted. By using interactive elements and by including links for further reading, scientific websites provide the opportunity to become a researcher and can demonstrate that doing science is neither boring nor difficult and that in order to be a scientist, one does not have to be a white male in a lab coat, but can be a 15 year old ethnic minority girl in jeans.

Although learning on the Internet may be less “relaxing” than learning through television, as the latter provides opportunities to learn unintentionally and offers both audio and visual means of encoding (dual processing hypothesis, see Koolstra, Bos and Vermeulen, 2006), the Internet benefits from larger storage, faster access to information from allowing the individual to control reception and dissemination of information and communication (Havick, 2000).

The popularity of the Internet in the communication of scientific information is demonstrated by Horrigan (2006) who notes that for 20% of US adults, the Internet is the prime source of science information, with much higher numbers having been engaged in some science related activity on the web.

However, the aforementioned variables of socioeconomic status and gender also impact on the use of the internet. In terms of socio-economic status it should be noted that while most families have television, Koolstra, Bos and Vermeulen’s (2006) Dutch review demonstrates that Internet access is still reserved for the better-off population. Stempel III, Hargrove and Bernt (2000) report a positive relationship between Internet use, news awareness, education, and income, and Sturgis and Allum (2004) state that participants with higher political awareness and higher scientific knowledge hold the most positive attitudes towards the Internet. When one pairs these observations with the fact that good quality scientific information is not necessarily free on the web and that articles and online journal subscriptions are not cheap (House of Lords, 2000), Roth’s (2002) hope that the Internet might assist science to be communicated to a broader public should be echoed with caution.

In addition, males tend to make more use of the Internet and of Internet science information than females (Bevort and Breda, 2001; Eurobarometer, 2005) with the exception of online health information, which is more frequently read by women (Dutta-Begman, 2004), leading the National Science Board

(2004) to conclude that Internet science information is used by a mostly male, mostly well educated and mostly attentive public.

5. What makes a website attractive to young people?

Using a series of multiple regression analyses with his Dutch sample, Van der Heijden (2003) has shown that perceived attractiveness, perceived usefulness, perceived ease of use and perceived enjoyment significantly predict the attitudes, intention to use and the actual use of websites of adult participants.

The relative weighting of these factors depends largely on the purpose for the utilisation of the site. De Angeli, Sutcliffe and Hartman (2006), for example, conducted a comparative investigation into two history sites with the same content, but with different interface styles. The authors report that usability is a prime concern for educational purposes and mature audiences, while attractiveness and interactivity is seen to be more important for younger target groups and leisure pursuits.

While science websites for young people differ from websites for adult audiences in that they tend to be jargon-free and more interactive (see for example Johnson, 1996), teenagers have similar requirements with regards to site attractiveness and usability. Corroborating Van der Heijden's (2003) model with focus groups of 16-17 year old US high school students and with explicit reference to science websites, Weigold and Treise (2004) state that in their participants' eyes, "good" websites

- were geared specifically towards them
- had appealing visual presentation ('cool ' graphics)
- were easy to navigate (clear layout),
- were interactive (opportunity to ask questions, message boards, games, surveys, downloads, polls, jokes, member profiles, links).
- addressed school homework demands.

5.1. Specific target audience

The specification of target audiences has been an important topic in website globalisation research. Website globalisation research is concerned with adapting websites to the cultural and linguistic needs of their target audiences by creating different "localised" versions of their "global" websites - see for example Clough, Marlow and Sanderson's (2006) project for the Tate Modern Gallery. Failure to create such localised versions can lead to poor appreciation of the site. Dmitriyev and Sarapuu (2003), for example, asked school teachers to compare Estonian websites on Physics education and found that the least popular site was used infrequently because of the foreign language of the user interface and educational materials.

The notion that the target audience needs to be defined as specific and as explicit as possible is underlined by Frank and Noble (2007). The authors, reviewing users' opinions on a British Health website for children and teens (http://www.childrenfirst.nhs.uk/), found that children requested more gender and age specific sections. The site is now well structured into separate age groups (juniors, kids and teens), the teen section containing "girls only" and "boys only" section.

Steinke's (2004) review comments on 27 US science websites that are explicitly directed at girls, while Aschbacher (2003), investigating the Whyville.net site, hypothesises that this website is popular with girls as it offers chat and social interaction, using cartoon avatars, thus giving the girls a "safe" social platform for interaction.

If the target audience is underspecified or the site does not supply sufficient recognisable features for their target group - Johnson (1996), for instance, notes how the use of jargon can distinguish between children's pages, pages for a general audience and expert pages as websites may fail to attract the intended recipients. Dunwoody (2001), for example, reviewing the visitors of the Whyfiles page, found that rather than the expected young audience, the most frequent Whyfiles visitors were white educated adult males.

Another important consideration with regard to target audiences is the accessibility of web pages to users with physical limitations. Accessibility can be increased, by varying background, text colour, or font (for dyslexia) and by giving alternative texts to objects displayed (for computer reading programs). Accessibility of websites has been a concern for European governments, the UK Cabinet Office highlighting the need for more accessibility and the Icelandic Ministry of Education (2005) supporting projects that use ICT for the benefit of people with disabilities.

5.2. Appealing visual presentation

Tractinsky's work on aesthetics in IT highlights the growing concern for appealing visual presentation of websites (for example Tractinsky, 2004; Tractinsky, Avivit Cokhavi, Kirschenbaum, and Tal Sharfi, 2006). With regard to websites for young people, research indicates that visual appeal is very important for children and teenagers, and that the visual presentation needs to be carefully adapted to the intended age group. Indeed, like adults, teenagers make a fast decision on whether a website appeals to them, and are put off by sites that do not correspond to their age or gender preferences. Livingstone (2007), for example, investigates teenagers' opinions of a British Government website and states that the specified target group (13-19 year -olds), was too broad, content and illustrations being either perceived as too adult and boring or too child-like and patronising. Neither was the presentation perceived as 'funky' and 'cool' as intended, but as 'cheesy' and 'dull', highlighting that what adults think is 'cool', may not be what kids think is 'cool'. In terms of gender, Livingstone's study clearly shows differential preferences for boys and girls, two girl participants in her study advocating "more girly colours and more wiggly lines" (p.127)

5.3. Usability – easy and fast navigation

Online material produces a higher cognitive load than print material. It is harder and slower to read and more error prone (Macedo-Rouet, Rouet, Epstein and Fayard, 2003). As a consequence the ease of navigation, based on concise grouping of the content materials and informative labelling, is a third important factor in website design for young people.

In fact, according to Doss (2002), poor navigation is, next to slow page loading speed, a prime cause of usability problems. Easy navigation relies on giving a clear overview of the available information on the site, as well as giving clear position indicators, showing the users where on the site they are and how to proceed from this position. These considerations have to be applied to the global navigation, that is the roadmap of the entire site, to the local navigation for major sections of the site, as well as to site maps, search engines, and breadcrumb trails.

As these tools are used to gain a good oversight, Doss warns web designers to think carefully about what needs to be dynamic and interactive, and what aspects are better kept static, stating that it might be difficult to manipulate several levels of dynamic sitemaps in order to reach the desired content.

Macedo-Rouet et al. (2003) looked specifically at the role of the usability for content comprehension, comparing hypertext format to print format. The authors note that data presented in the hypertext condition - a flash animation accompanied by small text, which had to be manipulated in order to be fully visible, was hard to understand and was perceived to be the main source of cognitive load. These results may partly explain the fact that a higher percentage of 15-28 year-olds in Europe actually prefer using more traditional as opposed to interactive websites (Commission of the European Communities, 2005).

The navigation system of a site needs to be calibrated to suit the target audience. Designing for young people poses the challenge of making navigation easy and clear as well as entertaining. Research has shown that while children clearly appreciate interactive and "fun" features, funky designs do not necessarily make site navigation any easier (Sullivan, Norris, Soloway and Peet, 2000). In fact, because of their shorter attention span, children can get easily distracted by detail, affecting their performance in educational tasks, such as mathematics (see for example Huang, 2004).

Therefore, navigation for children needs to be made as unambiguous as possible by using easily comprehensible and highly visible logos (Hanna, Risden, Czerwinski and Alexander, 1998). In addition, when Doss (2002) attests to the importance of speed of page loading for adults, it is evident that this is an even more important factor for young users, in order to prevent the child from losing attention.

5.4. Interactivity

The concept of interactivity in IT has been a debated issue due to the multitude of meanings the concept can carry (McMillan and Downes, 2000). The most frequent notions of website interactivity refer to the possibility of social exchange (message boards, member profiles, chat rooms), to active participation of the users (surveys, polls, games) or presentation of information in alternative, entertaining formats (downloads, jokes). User control, for example by presenting a variety of links to follow, is another benchmark of interactivity.

As children in general, and girls in particular, primarily visit websites for social interaction, websites featuring social interaction opportunities are justifiably popular. In fact, Aschbacher (2003), observes that girls using the Whyville.net website arranged to login at the same time as their friends, thus creating a web-based extension to their social circle.

The importance of interactivity has also been shown by Hwang and McMillan (2002) who compared two websites that were equal in content, but varied in the degree of interactivity, in that one of the sites provided chat rooms, bulletin boards, a site map, and enhanced navigation bars, whereas the other page did not. They found that interactivity was significantly more important than engagement with the topic in predicting positive attitudes towards the site. Likewise, Tremayne and Dunwoody (2001) compared a highly interactive (nonlinear hypertext, navigation tools, hyperlinks, click-through modules, animations, interactive quizzes) and a low interactive (hierarchical linear hypertext structure with minimal navigation) health website. The authors found that that not only did the interactive features aid comprehension of the site; they were also related to a more positive attitude towards the site.

However, as already alluded to in the section on usability, the function of interactive tools needs to be clear in order for the interactive use to be effective. Pata, Pedaste and Sarapuu (2007) for example, found that their 12 - 13 year old Estonian students did not make full use of interactive tools because they failed to understand their function correctly.

5.5. School homework demands

School homework and the need to study for examinations is an important reality in every teenager's life, and may be the prime reason for visiting certain scientific websites. Baram-Tsabari, Sethi' Bry and Yarden (2006), demonstrated that the school-related questions asked on the ask-a-scientist website increase as children grow older, reaching 57% of all questions by the time teenagers reach senior high school. Likewise, Falchetti, Caravita and Sperduti (2007), looking at questions submitted on the website of the Museum of Zoology in Rome, note that the majority of questions focus on accomplishments and assignments, while Livingstone and Bober (2004) report that 90% of their sample of 9–19 year-olds who used the Internet daily or weekly, used it to do work for school or college. Therefore, science websites that provide some space for the solution, discussion or revision of homework, are highly relevant to teenagers.

6. Analysing websites

In order to investigate whether science websites meet the criteria specified by Weigold and Treise's (2004) respondents, it is pertinent to draw on studies that have evaluated websites.

Companies and museums have been known to review the performance of their websites (PortalTechnoCienciaTeam, 2003; Monsistrol, Rovira and Codina, 2006) in order to improve the site according to demand. While site analysis will always depend on the analysts' aim and the resulting formulated questions, Petch (2004) makes some general propositions. She suggests that when analysing web pages, important questions need to be which portion of the web page should be analysed (the home page only or the entire site), how the web pages will be sampled and which time frame should be chosen for analysis, as websites may be updated at short intervals.

In her work, Petch (2004) chose to analyse four dimensions of web pages, namely the purpose of the site, the intended audience, the accessibility and the quality of the site. Similarily, Lelièvre (2003) chose to investigate audience, content, structure, navigation, functionality and the graphic elements, while Sarapuu and Adojan (1998), who evaluated educational websites, looked at the composition of the site, pedagogical aspects and curriculum-related aspects. Another useful coding scheme is proposed by Tweddle, Avis, Wright and Waller (1998), who look at purpose, authority, purpose, design, readability, implementation and evaluation of the site.

In order to look at the accessibility and usability of health websites, Petch (2004) analysed the reading level, font size and background on a page and noted whether there is a toolbar, a link to homepage, a title on each page, a search engine and/or an online glossary. She also took into account whether the site is mono or multilingual and whether other means to access the information presented are provided (for example telephone numbers).

The cited research highlights that analysis must be well coordinated in order to yield reliable results across the participating countries, that it should take into account several applicable *dimensions*, such as audience, science topic addressed, interactivity, usability and others) and that each dimension may need to be assessed by using finer grained tools, such as noting the presence of different interactive tools and of different aids to navigation.

7. What are the characteristics of current science websites?

Teenagers express a preference for sites addressing a specific target audience that have high visual appeal, easy navigation, interactivity, and provide homework assistance (Weigold and Treise, 2004). These preferences expressed by young people could serve as a guide as to how to dispel the commonly held stereotypes of science and scientists, a “good” website could potentially counteracting the prejudice of boredom with interactivity, and the male stereotype by including sections specifically appealing to girls. However, it still stands to question whether scientific web-pages match young people’s expectations.

When looking at scientific websites with an adult audience, interactivity and usability have been reported to be somewhat limited. Lederbogen and Trebbe (2003) for example compared the websites of German Universities and non-University based research institutions. The authors found that the websites of Universities make better use of keywords, but poorer use of illustrations than other sites and that sites were very text-based. In addition only the websites, but not the documents posted on the websites were explained in clear, non-scientific terms. Further, 82 of the 100 web pages hosted by the non-University based research institutions were available in English only, despite being German sites, therefore obviously targeting an expert audience.

Massoli (2007), who analysed websites of European Research institutions, found that the prevailing communication tools were very basic and that only the Norwegian and Belgian pages reviewed showed advanced techniques, such as user customisation. Likewise, Pinto Molina, Alonso Berrocal, Cordón García, Fernández Marcial, García Figuerola, García Marco, Gómez Camarero, Zazo and Doucet (2004) note that some Spanish Universities do not provide sufficient links to their research projects, and that information is scattered across several pages rather than clearly organised.

Developments are perhaps more interesting with regards to educational websites, where some pan-European efforts - for example the Globe project (Lichtenegger, Brøgger Sørensen, Loret, and Strømsholm, 2003; Kikas, 2003) - stand as exemplars for websites fostering international collaboration and interaction. Many educational websites however, lack a clear educational purpose and use few multimedia components (De Pablos Pons, García Pérez, Barragán Sánchez and Buzón García, 2002). Furthermore, research by Tuvi and Nachmias (2001) indicates that the majority of Chemistry websites analysed by the authors were conceived solely as an education base, with few tools or structured activities and were low on interactivity. They relied heavily on the memory skills of the students rather than fostering skills in analysis or problem solving, thus reinforcing the stereotype of science as boring.

It is accessibility however, that seems to be the overall bête-noir, The EU e-accessibility and e-inclusion directives by the UK Cabinet Office stating that website accessibility rather than usability is generally very poor.

8. Conclusion

The above review demonstrates that young people hold negative stereotypical perceptions of science and scientists. These negative stereotypical views discourage science uptake at school and therefore contribute to a greater ignorance of science, which in turn is linked to more negative adult perceptions. The stereotypical perceptions are particularly detrimental for girls and for young people from lower socio-economic background who do not perform well – and do not expect to perform well - at science subjects.

Mediated portrayals of science on television contribute to the maintenance of these perceptions, television frequently propagating stereotypical and male orientated characters, the perceived omnipotence of scientists being of particular concern for both adults and child respondents.

Although websites have great potential to combat stereotypes by presenting science and scientists in a more realistic light and by enhancing interest in science through high-quality web-pages, similar concerns of equality have to be acknowledged. For example, only the economically more advantaged have easy access to the internet as a learning resource, while males and educated people hold more positive attitudes towards the internet than women or less educated participants.

Little research has been conducted into explicitly analysing the representation of science and scientists on web pages as well as evaluating the quality of science websites for young people. The current project specifically aims to address these issues, investigating how website portrayals of science and scientists may combat or uphold the negative stereotypes.

9. The current project

Initially focussing on the first level of mediated representation, which is, as stated above, concerned with representation of professional scientists and their work, the project will use 5 point- Likert-scales to assess a selection of web-sites from the UK, France, Spain, Estonia, Iceland, Bulgaria and the Netherlands. The Scales will address the commonly-held stereotypes, for example asking whether scientists are portrayed as brilliant, intelligent, normal, of less than normal intelligence, or not intelligent (to assess the "brainy" stereotype, or as having no dress sense, dressing oddly, dressing normally, mostly dressing well or always dressing well (to address the "unfashionable" stereotype. In addition, occurrences of female and male scientists and scientists' ethnic group (Caucasian, African, Asian) will be counted. The project will then involve empirical studies with young people, letting the target group evaluate a selection of science web-pages.

10. References

Adnamuti – Trache, M. (2006). Who likes Science and why? Individual, family and teacher effects. Retrieved 22/05/2008 from www.ccl-cca.ca/NR/rdonlyres/9458A577-2A56-486F-9F80-49DCCD8E05F3/0/WhoLikesScienceJan2007.pdf

Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes, 50,* 179-211.

Allum, N., Sturgis, P., Tabourazi, D., & Brunton-Smith, I. (2008) Science knowledge and attitudes across cultures: a meta-analysis. *Public Understanding of Science. 17*(1), 35-54.

Aschbacher, P. (2003). *Gender Differences in the Perception and Use of an Informal Science Learning Website*. Grant funded by National Science Foundation, PGE 0086338. Arlington, VA

Baram-Tsabari, A., Sethi, R.J., Bry, L. & Yarden, A. (2006) Science Learning in Everyday Life. Using questions sent to an Ask-A-Scientist site to identify children's interests in science. *Science Education, 90* (6), 1050 – 1072.

Barmby, P. & Defty, N. (2006). Secondary school pupils' perceptions of physics. *Research in Science and Technological Education, 24* (2), 199–215.

Bleeker, M. M., & Jacobs, J. E. (2004). Achievement in math and science: Do mothers' beliefs matter 12 years later? *Journal of Educational Psychology*, *96*, 97–109.

Bévort, E. & Bréda, I. (2001) : *Les jeunes et internet. Représentations, usages et appropriations*. Rapport du CLEMI (Centre de Liaison de l'Enseignement et des Moyens d'Information)

Bevort, E, Bréda, I., De Smedt., T. & Romain, L. (2003) *Les jeunes et Internet : représentations, usages et appropriations (international synthesis)*. Rapport du CLEMI (Centre de Liaison de l'Enseignement et des Moyens d'Information)

Bodzin, A., & Gehringer, M. (2001). Breaking Science Stereotypes. *Science and Children, 38* (4), 36-41.

Brandes, A. A. (1994). Elementary school children's images of science. in Y. Kafai and M. Resnick (eds). *Constructionism in Practice: Rethinking Learning and Its Contexts.* The MIT Media Laboratory, Cambridge, MA.

Lichtenegger, J., Brøgger Sørensen, P., Loret, E. & Strømsholm, B (2003). Eduspace, the European Earth Observation Website for secondary schools. Retrieved 22/05/2008 from http://www.isprs.org/commission6/proceedings02/papers/018.pdf

Chambers, D. W. (1983). Stereotypic images of the scientist: The Draw-A-Scientist Test. *Science Education, 67* (2), 255-265.

Clough, P., Marlow, J. & Sanderson, M. (2006). .Designing Multilingual Information Access to Tate Online. *Proceedings of the Workshop on New Directions in Multilingual Information Access*, 69–72. ACM-SIGIR 2006, Seattle, Washington, USA,. Retrieved 22/05/2008 from http://research.microsoft.com/users/cyl/download/papers/MLIA2006/book.pdf

Cole, J. (2002). *Surveying the digital future: The impact of the internet year three: The emergence of trends*. Presentation to the National Science foundation, Arlington, VA, Dec 11.

Commission of the European Communities (2005). *Questions of Science – Echoes from the Science in society Forum*, Brussels, March 9-11.
Delaunay- Téterel, H. (2008). *La communication juvénile à travers les blogs de lycéens* in Agora Débat Jeunesse – Dossier TIC : construction de soi et autonomie.

De Angeli, A., Sutcliffe, A. & Hartman, J. (2006). Interaction, usability and aesthetics: what influences users' preferences? *Proceedings of the 6th conference on Designing Interactive systems, June 26-28, 2006, University Park, PA, USA*

De Pablos Pons, J., García Pérez, R., Barragán Sánchez, R. & Buzón García, O. (2002). *Análisis de páginas web elaboradas por docentes de tecnología educativa: Una aproximación descriptiva desde conceptos socioculturales*. Retrieved 22/05/2008 from http://dewey.uab.es/pmarques/evte2/varios/link_externo_marco.htm?http://web.udg.es/tiec/orals/c71.pdf

Dmitriyev, V. & Sarapuu, T. (2003). *Usage of educational multimedia by Estonian Mathematics and Science teachers*. e-Learning in Science and Environmental Education Proceedings of the International Conference. October 1- 4, 2003, Tartu, Estonia

Doss, G. (2002). Designing effective web navigation. Towson University, Centre for applied Information Technology. Retrieved 22/05/2008 from http://www.gdoss.com/web_info/web_navigation.pdf

Dunwoody, S. (2001). Studying Users of the Why Files. *Science Communication* 22, 274-282.

Dutta-Begman, M. J. (2004). Complementarity in Consumption of News Types Across Traditional and New Media. *Journal of Broadcasting* & *Electronic Media 48(7)*, *pp. 47-60*

Ebersol, S. (2000). Uses and Gratifications of the Web among Students
Journal of Computer-Mediated Communication 6 (1) retrieved 22/05/2008 from http://jcmc.indiana.edu/vol6/issue1/ebersole.html

Elena, A. (1993). Exemplary lives: biographies of scientists on the screen. *Public Understanding of Science*, 2 (3), 205–223.

European commission, Eurobarometer Unit (2001). *Europeans, Science and Technology. Eurobarometer 55.2*. Retrieved 22/05/2008 from ec.europa.eu/research/press/2001/pr0612en-report.pdf

European commission, Eurobarometer Unit (2005). *Special Eurobarometer 224. Europeans, Science and Technology*. Retrieved 22/05/2008 from ec.europa.eu/public_opinion/archives/ebs/ebs_224_report_en.pdf

Falchetti, E., Caravita,S. & and Sperduti, A. (2007). What do laypersons want to know from scientists? An analysis of a dialogue between scientists and laypersons on the web site Scienzaonline. *Public Understanding of Science, 16*(4), 489 - 506.

FECYT- Fundación Española para la Ciencia y la Tecnología (2006). *Percepción social de la Ciencia y Tecnología en España*. Retrieved 22/05/2008 from http://www.fecyt.es/fecyt/docs/tmp/345032001.pdf

Ferguson, D. & Perse, E. (2000). The World Wide Web as a Functional Alternative to Television. *Journal of Broadcasting & Electronic Media 44*,155–74

Finson, K.D. (2002). Drawing a Scientist: What We Do and Do Not Know After Fifty Years of Drawings. *School Science and Mathematics, 102*(7), 335-345.

Frank, L.S. & Noble, G. (2007). Here's an idea: ask the users! Young people's views on navigation, design and content of a health information website.
Journal of Child Health Care 11 (4), 287-297

Fluckiger, C. (2007) *L'appropriation des TIC par les collégiens dans les sphères familières et scolaires*. S/dir. Éric Bruillard ENS Cachan/UMR STEF.
Gallego, A. P. (2002). *Contribución del cómic a la imagen de la ciencia*. Doctoral Thesis University of Valencia, Spain

Guðmundsson, G. P. (2004). *Internetið og íslensk ungmenni* (The internet and Icelandic youth). Unpublished B.A. thesis. Retrieved 04/06/2008 from http://www.btvi.hi.is/docs/btvi_2004_internet_ba.pdf

Hamon, D. (2006). *L'appropriation d'Internet par les élèves de collège*. S/dir. Jacques Crinon Escol/ESSI, Université Paris 8.

Hanna, L., Risden, K., Czerwinski, M., & Alexander, K. J. (1998). The role of usability research in designing children's computer products. Retrieved 27/05/2008 from http://research.microsoft.com/users/marycz/druin98.htm

Havick, J. (2000). The impact of the Internet on a television-based society *Technology in Society, 22*, 273–287.

HESA (British Higher Education Statistics agency), retrieved 27/05/2008 from www.hesa.ac.uk/

The High Level Group on Human Resources for Science and Technology in Europe (2004). *Europe needs more scientists*. Retrieved 27/05/2008 from http://ec.europa.eu/research/conferences/2004/sciprof/pdf/final_en.pdf

Horrigan, J. (2006). *The Internet as a resource for news and information about science*. Pew internet, Washington DC. Retrieved 27/05/2008 from http://www.pewinternet.org/pdfs/pip_exploratorium_science.pdf

House of Lords (2000) *Science and Technology - Third Report*. retrieved 27/05/2008 from http://www.parliament.the-stationery-office.co.uk/pa/ld199900/ldselect/ldsctech/38/3801.htm

Huang, H. E. (2004) The impact of context on children's performance in solving everyday mathematical problems with real-world settings *Journal of Research in Childhood Education 18* (4), 278-292

Hwang, J.-S. & McMillan, S. (2002). *The role of interactivity and involvement in attitude towards the web site*. Proceedings of the 2002 Conference of the American Academy. Retrieved 27/05/2008 from http://web.utk.edu/~sjmcmill/Research/AST%20for%20proceedings.doc

The Icelandic Ministry if Education (2005). Risk with responsibility: Policy for ICT in education, Science and Culture 2005-2008. *Science and Culture 26*. Retrieved 04/06/2008 from http://bella.stjr.is/utgafur/risk.pdf

Jakobsdóttir, S., Gautadóttir, H., & Jóhannesdóttir, S. (2005). Life was bacalao – life is Internet? Should we develop a „fishing culture“ mentality in schools? *Recent Research Developments in Learning Technologies*. Retrieved 04/06/2008 from http://www.formatex.org/micte2005/235.pdf

Jakobsdóttir, S., Gautadóttir, H., & Jóhannesdóttir, S. (Date unknown). *Internet use of Icelandic children 2001-2003: A qualitative glimpse.* Retrieved 04/06/2008 from http://soljak.khi.is/netnot/nidurstodur/netnotreport/Default.doc

Johnson, C.C.(1996). World-Wide Web Sites for the Dissemination of Science to the Public: A Classification into Three Types. *Science Communication 18*, 80–87.

Jones, M. G., Howe, A., & Rua, M. J. (2000): Gender Differences in Students' Experiences, Interests, and Attitudes toward Science and Scientists. *Science Education, 84,* (2), 180-192
Kalmus, V. (2007). Estonian Adolescents' Expertise in the Internet in Comparative Perspective. *Cyberpsychology: Journal of Psychosocial Research on Cyberspace*. Retrieved 28/05/2008 from http://www.cyberpsychology.eu/view.php?cisloclanku=2007070702

Kikas, Ü (2003). *Learning in Internet – A challenge for school education*. e-Learning in Science and Environmental Education. Proceedings of the International Conference. October 1- 4, 2003, Tartu, Estonia

Koolstra, C.M., Bos, M. J. W., & Vermeulen, I. E. (2006). Through which medium should science information professionals communicate with the public: television or the internet? *Journal of Science Communication 5* (3)

Lachance, J.A. & Mazzocco, M.M. M. (2006) A longitudinal analysis of sex differences in math and spatial skills in primary school age children. *Learning and Individual Differences 16* (3), 195-216

Lederbogen, U. & Trebbe, J. (2003). Promoting Science on the Web: Public Relations for Scientific Organizations—results of a Content Analysis. *Science Communication, 24* (3), 333-352.

Lelièvre, V. (2003) Connaître et utiliser les outils pédagogiques en ligne. *La Lettre de l'OCIM, 83,* 20-26**.**

Li, Q. (1999). Teachers' beliefs and gender differences in mathematics: a review. *Educational Research 41*(1), 63 - 76

Livingstone, S. & Bober, M. (2004) UK Children Go Online: *Surveying the Experiences of Young people and their Parents.* Retrieved 27/05/2008 from http://www.children-go-online.net

Long, M., Boiarsky, G., & G. Thayer, G. (2001). Gender and racial counter-stereotypes in science education television: A content analysis. *Public Understanding of Science 10* (3): 255-69

Long, M. & Steinke, S. (1996). The thrill of everyday science: Images of science and scientists on children's educational science programmes in the United States
Public Understanding of Science, 5, 101-119

Luján, J. L. & Todt, O. (2007). Precaution in public: the social perception of the roleof science and values in policy making. *Public Understanding of Science, 16*, 97–109

Lyons, T. (2006). Different Countries, Same Science Classes:
Students' experiences of school science in their own words. *International Journal of Science Education, 28* (6), 591 – 613.

Ma, X. & Wilkins, J.L.M. (2002). The Development of Science Achievement in Middle and High School: Individual Differences and School Effects. *Evaluation Review 26* (4), 395-41.

Macedo-Rouet, M., Rouet, J.-F., Epstein, I. & Fayard, P. (2003) Effects of Online Reading on Popular Science Comprehension. *Science Communication ,25* (2), 99-128.

Massoli, L. (2007). Science on the net: an analysis of the websites of the European public research institutions. *Journal of Science Communication 6* (3)

Mediappro (2006), The appropriation of new media by youth. Official publications office of the European Communities, Luxembourg.

Messin, A. (2007). La *culture ordinaire de l'écran: L'usage social d'Internet par les jeunes adultes*. S/dir. Josiane Jouët. University Paris 2 - IFP

McMillan, S. J. & Downes, E.J. (2000). Defining Interactivity: A Qualitative Identification of Key Dimensions. *New Media and Society*, *2* (2), 157-179

Miller, L. & Hayward, R. (2006). New jobs, old occupational stereotypes: gender and jobs in the new economy. *Journal of Education and Work, 19* (1), 67 - 93

Miller, P., Slawinski Blessing, J. & Schwartz, S. (2006). Gender Differences in Highschool Students' Views about Science*. International Journal of Science Education, 28* (4), 363-381.

Monsistrol, R., Rovira, C. & Codina, L. (2006). Catalonia's museums websites: Analysis and evaluation proposals. *Hipertext net* 4. Retrieved 47/04/2008 from http://www.hipertext.net

Mullis, I. V.S., Martin, M.O., Fierros, E.G., Goldberg, A. L. & Stemler, S. E. (2000) *Gender Differences in Achievement.* IEA's Third International Mathematics and Science Study (TIMSS).International Study Center, Lynch School of Education. Retrieved 27/05/2008 from http://timss.bc.edu/timss1995i/TIMSSPDF/t95_gender_all.pdf

National Science Board (2004). *Science and Engineering Indicators 2004*. Arlington, National Science Foundation. Retrieved 28/05/2008 from http://www.nsf.gov/statistics/seind04/pdfstart.htm

Ofcom's response to the Byron Report (2008) retrieved 27/05/2008 from http://www.ofcom.org.uk/research/telecoms/reports/byron/

Office of Science and Technology and the Wellcome Trust (2001). Science and the public: A review of science communication and public attitudes toward science in Britain*. Public Understanding of Science, 10* (3), 315-330

Osborne, J., Simon, S. and Collins, S. (2003). Attitudes towards science. A review of the literature and its implications. *International journal of science education 25* (9), 1049 – 1079

Osborne, J. & and Collins, S. (2000). *Pupils' and parents' views of the school science curriculum.* London: King's College London.

Otero, J., Leon, J.A. & Graesser, A. C. (2002). *The Psychology of Science Text Comprehension*. Lawrence Erlbaum Associates.

Pardo, R. & Calvo, F. (2006). Mapping the perception of Science in End-of-century Europe. *Science Communication 28* (1), 3-46

Pata, K., Pedaste, M. & Sarapuu, T. (2007). The formation of learners' semiosphere by authentic inquiry with an integrated learning object "Young Scientist". *Computers & Education 49* (4), 1357-1377

Petch, T. (2004). *Content analysis of selected health information websites*. Final report. Action for health in association with Simon Fraser University & the Vancouver coastal health Research Institute. Retrieved 28/05/2008 from www.sfu.ca/act4hlth/pub/working/Content%20Analysis.pdf

Picker, S. H. and Berry, J. S. (2000). Investigating pupils' images of mathematicians *Educational Studies in Mathematics 43*, 65–94

Pinto Molina, M., Alonso Berrocal, J.L., Cordón García, J.A., Fernández Marcial, V., García Figuerola, C., García Marco, F.J., Gómez Camarero, C., Zazo, Á.F., & Doucet, A.-V. (2004). Análisis cualitativo de la visibilidad de la investigación de las universidades españolas a través de sus páginas web*, Revista Española de Documentación Científica, 27* (3), 245.370.

PortalTechnoCienciaTeam (2003). Metodología para la creación de un sistema de información científico-técnica en Internet: el caso de PortalTecnoCiencia. In *Los sistemas de información en las organizaciones : eficacia y transparencia* [Fesabid 2003 : 8ª Jornadas Españolas de Documentación, Barcelona, 6, 7 y 8 de febrero de 2003], pp. 343-355

Reeves Timmins, L. & Lombard , M. (2005). When "Real" Seems Mediated: Inverse Presence. *Presence, 14,* (4), 492-500.

Régner, I., Huguet, P. & Monteil, J. (2002): Effects of Socioeconomic Status (SES) Information on Cognitive Ability Inferences: When Low-SES Students Make Use of a Self-Threatening Stereotype. *Social Psychology of Education*, *5* (3), 253-269

Rodari, P. (2007). Science and scientists in the drawings of European children *Journal of Science Communication 6* (3)

Roth, W.-M. (2002). Aprender ciencias en y para la comunidad*. Enseñanza de las Ciencias, 20* (2), 195-208

Sarapuu, T. & Adojaan, K. (1998). Evaluation Scale of Educational Web Sites. *World Conference on the WWW and Internet & Intranet (WebNet), 07.11.-12.11.1998, Orlando, Florida, USA*. Maurer, M & Olson, R. G. (Eds.) Norjolk, VA, USA: Association for the Advancement of Computing in Education (AACE), 798 - 804.

Scherz, Z., & Oren, M. (2006). How to change students' images of science and technology. *ScienceEducation, 90*(6), 965–985.

Singh, K., & Ozturk, M. (2000). Effect of part-time work on high school mathematics and science course taking. *Journal of Educational Research, 91*(2), 67–74.

Spencer, S. J., Steele, C. M., & Quinn, D. M. (1999). Stereotype threat and women's math performance. *Journal of Experimental Social Psychology, 35,* 4–28.

Sirin, S (2005): Socioeconomic Status and Academic Achievement: A Meta-Analytic Review of Research. *Review of Educational Research, 75,* (3),417–453.

Stake, J. E. (2006) The Critical Mediating Role of Social Encouragement for Science Motivation and Confidence Among High School Girls and Boys. *Journal of Applied Social Psychology 36* (4) , 1017–1045

Stake, J. E. & Nickens, S. D (2005). Adolescent Girls' and Boys' Science Peer Relationships and Perceptions of the Possible Self as Scientist. *Sex Roles 51*(1/2), (2005), 1 – 11.

Steinke, J. (1997). A portrait of a woman as a scientist: breaking down barriers created by gender-role stereotypes. *Public Understanding of Science 6,* 409–428

Steinke, J. (1998).Connecting theory and practice: women scientist role models in television programming. *Journal of Broadcasting and Electronic Media 42*, 142–151

Steinke, J. (1999). Women scientist role models on screen: a case study of *Contact*. *Science Communication 21* (2), 111–136.

Steinke, J. (2004). Science in Cyberspace: Science and Engineering World Wide Web Sites for Girls*. Public Understanding of Science, 13* (1), 7-30

Steinke, J. (2005). Cultural Representations of Gender and Science: Portrayals of Female Scientists and Engineers in Popular Films. *Science Communication, 27*, (1), 27-63

Steinke, J., Lapinski, M. K., Crocker, N., Zietsman-Thomas, A., Williams, Y., Evergreen, S., & Kuchibhotla, S. (2007). Assessing media influences on middle school-aged children's perceptions of women in science and engineering using the draw-a-scientist test (DAST). *Science Communication, 29,* 35-64.

Steinke, J. & Long, M. (1996). A Lab of Her Own? Portrayals of Female Characters on Children's Educational Science Programs. *Science Communication, 18* (2) , 91-115

Stempel III, G. H., Hargrove, T., & Bernt, J. P. (2000). Relation of growth of use of the Internet to changes in media use from 1995 to 1999. *Journalism & Mass Communication Quarterly, 77,* 71-79.

Sturgis, P. & Allum, N. (2004). Science in Society: Re-Evaluating the Deficit Model of Public Attitudes. *Public Understanding of Science, 13* (1), 55-74

Sullivan, T., Norris, C., Peet, M., & Soloway, E. (2000). When kids use the Web: A naturalistic comparison of children's navigation behaviour and subjective preferences on two WWW Sites. *Proceedings of the 6th Annual Conference on Human Factors and the Web* . Retrieved 27/05/2008 from http://www.tri.sbc.com/hfweb/sullivan/Sullivan.html

Tenenbaum, H. R. & Leaper, C. (2003). Parent–child conversations about science: The socialization of gender inequities? *Developmental Psychology, 39,* 34–47.

Terrón Bañuelos, E. (2002). *Analizar paginas web educativas: valores y actitudes con relación a temas transversales*. Retrieved 28/05/2008 from http://www3.unileon.es/dp/ado/ENRIQUE/Invest05.htm

Tractinsky, N. (2004).Towards the Study of Aesthetics in Information Technology. *Proceedings of the 25th Annual International Conference on Information Systems (ICIS). Washington, DC, December 12-15*, pp. 771-780.

Tractinsky, N., Cokhavi, A., Kirschenbaum, M. & Sharfi, T (2006) Evaluating the consistency of immediate aesthetic perceptions of web pages. *International Journal of Human-Computer Studies, 64* (11), 1071-1083.

Tremayne, M. & Dunwoody, S. (2001). Interactivity, information processing, and learning on the World Wide Web, *Science. Communication, 23* (2) 111-134.

Trumper R. (2006). Factors Affecting Junior High School Students' Interest in Physics. *Journal of Science Education and Technology. 15,(1),*47-58

Tuvi, I. & Nachmias, R. (2001). *Educational websites in Chemistry – expectations versus reality*. Retrieved 28/05/2008 from http://cblis.utc.sk/cblis-cd old/2003/3.PartB/Papers/Science_Ed/Physics_Chem_Bio/Tuvi.pdf

Tweddle, S., Avis, P., Wright, J. & Waller, T. (1998). Towards criteria for evaluating websites. *British journal of Educational Technology 29* (3), 267-270

UNESCO statistics retrieved from www.unesco.org.

Van der Heijden, H. (2003): Factors influencing the usage of websites: the case of a generic portal in The Netherlands. *Information & Management, 40(6),* 541-549.

Vílchez-González, J. M. & Perales Palacios, F. J. (2006) Image of science in cartoons and its relationship with the image in comics. *Physics Education, 41*(3), 240-249

Waering, C. (1990). A survey of antecedents of attitudes toward science. *Journal of Research in Science Teaching, 27* (4), 371-386.

Weigold, M. F.,&Treise, D. (2004). Attracting teen surfers to scienceWeb sites. *Public Understanding of Science,13* (3), 229– 248.

Weingart, P., Muhl, C., & Pansegrau, P. (2003). Of power maniacs and unethical geniuses. *Public Understanding of Science, 12*(3), 279–288.

11. Further bibliography

Adojaan, K.; Sarapuu, T. (2003). Improving students' understanding in scientific processes by conceptial web-based models. *e-Learning in Science and Environmental Education Proceedings of the International Conference October 1- 4, 2003, Tartu, Estonia.* Pp. 69-73.

Bevort, E. & Bréda, I. (2008). Jeunes et Media numériques en Europe: appropriation et enjeux éducatifs. In Agora Débat Jeunesse – Dossier « *TIC : construction de soi et autonomie* ». Paris, L'Harmattan

Bodzin, A. & and Gehringer, M. (2001). Breaking science stereotypes. *Science and Children 38* (4), 36-41

Bolmont, E. (2007). What is a scientist's job? From the drawings to the citizenship, *Journal of Science Communication6 (3),*

Boullier, D. (coordinateur) (2007). *WEB CSTI - Culture scientifique et technique sur le Web : mesures des usages et dynamique d'un champ*. Paris

Brandi, M. C., Cerbara, L., Misiti, M. & Valente, A. (2005) Youth and Science in Italy: between enthusiasm and indifference. *Journal of Science Communication 4 (2).*

Cerrato, S. (2002) *Pop-Science on the Internet: How ULISSE Makes the Ends Meet. Informing Science .* Retrieved from http://proceedings.informingscience.org/IS2002Proceedings/papers/Cerra195Uliss.pdf

Davis, J. A., Smith, T.W., & and Marsden, P. V. (2003) *General Social Surveys: 1972-2002 Cumulative Codebook.* Chicago: University of Chicago, National Opinion Research Centre.

European Commission (2004). *Sensibiliser le public à la science et à la technologie : Bilan des actions du cinquième programme-cadre (1998-2002).*

European Commission (2007). *La recherche scientifique dans les medias*. Retrieved from ec.europa.eu/public_opinion/archives/ebs/ebs_282_fr.pdf

Evans, W. (2001). Mapping mainstream and fringe medicine on the internet. *Science Communication, 22*(3), 292-299.

Fluckiger, C. (2008). Les collégiens et la transmission familiale d'un capital numérique. In Agora Débat Jeunesse – Dossier « *TIC : construction de soi et autonomie* ». Paris, L'Harmattan

Fundación Española para la Ciencia y la Tecnología (FECYT) (2005). *Libro blanco e-CIENCIA en España*. Retrieved from http://www.fecyt.es/fecyt/docs/tmp/-1870746289.pdf

Gouthier, D. (2007), Teachers' perception of the European scientists*. Journal of Science Communication6 (3),*

Haynes, R. (1994). *From Faust to Strangelove: Representations of the scientist in Western Literature*. Baltimore: John Hopkins University Press

Hvidtfelt Nielsen, K., Kjaer, C. R. & Dahlgaard, J. (2007) Scientists and science communication: a Danish survey*. Journal of Science Communication 6 (1)*

Institute of Documentary Studies on Science and Technology (IEDCYT) (2005). *Factor de impacto y visibilidad de 4000 sedes web universitarias españolas*. Retrieved from http://www.micinn.es/univ/html/informes/estudios_analisis/resultados_2004/ea0020/EA2004-0020.pdf

Jakobsdóttir, S., Jónsdóttir, B.M. & Hjartarson, T. (2004).Gender, ICT-Related Student Skills, and the Role of a School Library in an Icelandic School.*School Libraries Worldwid* 10 (1/2), 57-72.

Jones, R.A (1997) The Boffin: A Stereotype of Scientists in Post War British Films. *Public Understanding of Science, 6*, 31-48.

Jones, R. A. (1998) The scientist as artist: A study of The Man in the White Suit and some related British film comedies of the postwar period (1945-1970). *Public Understanding of Science, 7,* 135 - 147.

Jones, R. (2001) "Why can't you scientists leave things alone?" Science questioned in British films of the post-war period (1945-1970). *Public Understanding of Science, 10*, 365 - 382.

Kayany, J.M. & and Yelsma, P. (2000) Displacement effects of online media in socio-technical contexts of households. *Journal of Broadcasting and Electronic Media 44* (2), 215-229

Locke, S. (2005). Fantastically reasonable: Ambivalence in the representation of science and technology in super-hero comics. *Public Understanding of Science, 14*, 25-46

Martínez Rodríguez, A. (2006). *Indicadores cibermétricos: ¿Nuevas propuestas para medir la información en el entorno digital?* Retrieved from http://eprints.rclis.org/archive/00009199/

McArthur, L. C. (1998). Report: The Portrayal of Women in Science Books for Junior Readers. *Science Communication, 20*, 247 - 261.

Mercer, N., Dawes, L., Wegerif, R. & Sams, C. (2004) Reasoning as a scientist: Ways of helping children to use language to learn science. *British Educational Research Journal 30* (3), 359-377

Messin, A. (2005). *De l'usage d'Internet à la "culture de l'écran".* University Paris 2 – IFP

NIST (2002) *Communicating the future: Best Practices Conference Summary*. Gaithersburg, USA

Official publications office of the European Communities (2005). Special Eurobaromenter 225- *Social values, Science & Technology*. Retrieved from ec.europa.eu/public_opinion/archives/ebs/ebs_225_report_en.pdf

Perriault, J. (2002). *L'accès au savoir en ligne.* Paris, Odile Jacob

Pignard-Cheynel, N. (2003) *La communication des sciences sur Internet : stratégies et pratiques*. S/dir I. Pailliart. Université Stendhal Grenoble 3

Pinholster, G. & O'Malley, C. (2006) EurekAlert! survey confirms challenges for science communicators in the post-print era. *Journal of Science Communication 5 (3).*

Puusepp, A., Pata, K., Sarapuu, T.(2003). Scientific representation and design in collaborative learning. *e-Learning in Science and Environmental Education Proceedings of the International Conference October 1- 4, 2003, Tartu, Estonia.* pp. 69-73.

Research!America. (2003) *America Speaks: Poll Data Booklet.* Vol. 4. Alexandria, VA

Rogers, R., & Marres, N. (2000). Landscaping climate change: A mapping technique for understanding science and technology debates on the World Wide Web. *Public Understanding of Science, 9*, 141-163

Romero López, K. (2005). *La vulgarisation scientifique auprès du jeune public à la télévision publique française et mexicaine*. University Paris 3.

Singer, D.G. & Singer, J. L. (2001) *Handbook of Children and the Media. SAGE.*

SIRC & ASCoR teams *FP6 project MESSENGER– media, science & society - engagement & governance in Europe.* Retrieved from
http://www.sirc.org/messenger/Final_Report_Draft_1.pdf and
http://www.messenger-europe.org/messenger_materials.html

Stein, J. A. & White, D. Media and New Media in the UK: PUS in print, on the airwaves and on-line. *Final Report. FP5 O.P.U.S. project.* Retrieved 04/06/2008 from
http://www.univie.ac.at/virusss/OPUSReport/

Steinke, J. (1995). Reaching Readers: Assessing Readers' Impressions of Science News. *Science Communication, 16*, 432 - 453.

Sterligov, I. *Interview with Irina Terentieva* (Ирина ТЕРЕНТЬЕВА).
Science and technologies of Russia (electronic edition).

Terzian, S.G. & Grunzke, A. L. (2007) Scrambled eggheads: ambivalent representations of scientists in six Hollywood film comedies from 1961 to 1965*. Public Understanding of Science, 16* (4), 407-419.

Tewksbury, D. (2005) The Seeds of Audience Fragmentation: Specialization in the Use of Online News Sites. *Journal of Broadcasting & Electronic Media 49* (3), 332-348

Thelwall, M. & Aguillo, I. F. (2003). La salud de las web universitarias españolas. *Revista española de Documentación Científica (REDC) 26* (3). Retrieved from http://redc.revistas.csic.es/index.php/redc/article/view/139/193

Treise, D., Walsh-Childers, K., Weigold, M. F., & Friedman, M. (2003). Cultivating the science internet audience: Impact of brand and domain on source credibility for science information. *Science Communication, 24*(3), 309-332.