Academic discipline and risk perception of technologies

Weisenfeld, Ursula; Ott, Ingrid

Published in:
Research Policy

DOI:
10.1016/j.respol.2010.12.003

Publication date:
2011

Document Version
Peer reviewed version

Academic discipline and risk perception of technologies:

An empirical study

Ursula Weisenfeld[a] and Ingrid Ott[b]

[a]Corresponding author; Leuphana University of Lueneburg,
Scharnhorststr. 1, 21335 Lueneburg, Germany, weisenfeld@uni.leuphana.de,
phone 49 (0) 4131 6772121, fax 49 (0) 4131 6772126

[b]Karlsruhe Institute of Technology (KIT), ingrid.ott@kit.edu,
and Kiel Institute for the World Economy (IfW)

Abstract

This article brings together two areas of research: studies on risk perception of technologies and studies on vocational/career choice. This is an important link since decisions concerning technologies are influenced by decision makers' risk perceptions and these in turn may be related to educational and career paths.

We analyze students of different academic disciplines with regard to their risk perception of four technologies. The aim is to find out whether there is a relationship between area of study (as a precursor of vocational and career choice) and risk perception of technologies regarding health, environment and society. The four technologies under study are renewable energies, genetic engineering, nanotechnology and information and communication technologies (ICT). Key results are: Irrespective of academic discipline risk of genetic engineering on average is rated highest and renewable energies lowest. This holds for all the risks studied (environmental, health, societal risks). On average, students from different academic disciplines differ in their risk perception. Factor analyses show that common dimensions of risk are the technological areas and not the type of risk. Regression analyses show that the variables influencing perceived risks vary between the technological fields.

Keywords: technologies, risk perception, career choice, academic disciplines, self-selection, socialization.

Acknowledgements

We would like to thank Cornelius Herstatt, Holger Hinz and Karl Schulte for comments and help with data collection, Nils Braakmann and Martin Spieß for their discussions on treating missing values, participants at the TUHH research seminar for valuable discussions on earlier drafts of this paper and two anonymous reviewers for their helpful and acute comments. Of course, all remaining errors are our own. Part of the study has been presented at the TIM conference 2008 in Freiburg and has been published as a working paper of the IfW, Kiel.

1. Introduction

Research on risk perception has become increasingly important for technology management since risk perception affects decision making of people involved in activities related to the research, development, introduction, regulation and use of technologies. Decisions regarding technologies affect various stakeholders (researchers, a company's managers of different functions, customers, 'the public') whose risk perceptions may differ to a great extent and are subject to many influences. While the psychometric paradigm has produced cognitive maps of hazards on an aggregate level, it is the individual predisposition toward various risks that influences behaviour. Perceptions, based on a frame of reference and on (incomplete) information, will be influenced by e.g. additional information[1] (Chatterjee and Eliashberg 1990, Roberts and Urban 1988), affect-laden imagery (Peters and Slovic 1996) and socialization processes (Chatard and Selimbegovic 2007). Culture moulds individuals' beliefs about risk (Kahan 2009). Furthermore, the relationship between knowledge and risk perception has to be taken into account. If people are overconfident, i.e., they think they are more knowledgeable than they actually are[2], that overconfidence may lead to an overly optimistic or pessimistic view on a technology. For example, being familiar with renewable energies on account of reports in the media that it is a desirable approach to

[1] The expectation that knowledge (relevant information) plays a key role in risk perception has led to numerous studies with mixed results (Schütz et al. 2000) and to initiatives such as the Public Understanding of Science campaign launched by the British government.

[2] Alba and Hutchinson (2000, 123) analyze that proposition with respect to consumers: "Are consumers overconfident?".

energy generation may lead to people thinking that they know a fair amount about the technologies involved and attributing low risk to the respective technologies. Similarly, being aware of the controversial discussions around genetic engineering may lead to attributing high risk to the technology.

In the future, many of today's students will be involved in activities and decisions concerning new technologies. Especially top management positions, engineering and high positions in regulatory institutions are associated with university degrees. Hence knowledge about technologies, risk perception and risk attitude of the students will affect innovation processes and thus technology developments. Since in the long run the technological development also affects growth and welfare of entire economies, risk perception of today's students might well be interpreted as one key factor in shaping future technology development.

Earlier studies have shown that students in various academic disciplines differ regarding motives, career expectations and cognitive abilities (Windolf 1995), socio-political attitudes (Haley and Sidanius 2005) or (political) worldviews (Kemmelmeier et al. 2005). We propose that those expectations and worldviews may relate to risk perceptions and thus, students choosing different topics at a university will differ with regard to their perceptions and attitudes of technologies (self-selection) and that within an area of study, risk perception will be different between beginners and advanced students (socialization).

This article addresses antecedents of potential actors' and stakeholders' behavior by analyzing the effects of *self-selection* into an academic discipline and subsequent *socialization* on the perceived risks of four important new technologies: renewable energies, genetic engineering, nanotechnologies, and ICT. These technologies are part of the so-called high technologies sector. They are key change drivers and possible convergence of them is expected to "bring about tremendous improvements in transformative tools, generate new products and services, enable opportunities to meet and enhance human potential and social achievements, and in time reshape societal relationships" (Roco 2007, see also Lipsey et al. 1998). For each technology we distinguish between risks in three areas: health, environment, and society.

The analysis focuses on student groups in Germany. They all have acquired a certain educational degree (usually 'Abitur' or 'Fachabitur', a prerequisite to enrol at university or polytechnic) that makes them a more homogeneous group regarding knowledge compared to the general public, thereby providing the opportunity to look for other influencing factors on risk perception. The analysis differentiates between students in several academic disciplines (i.e. with different majors), namely Cultural Sciences, Business Administration and Economics, Social Work, Environmental Sciences, Teaching, and Technical Studies (engineering), on the one hand, as well as between first term students (beginners) and advanced students, on the other hand.

The remainder of the paper is as follows. Section 2 summarizes key findings in the area of risk perception and section 3 describes vocational or career choice and the associated processes of self-selection and socialization as potentially important factors in the explanation of attitudes and behaviours. Section 4 gives a short description of the four technologies investigated here. Section 5 presents the empirical study and section 6 provides a discussion of results. Section 7 draws conclusions.

2. Risk Perception

There is no perfect knowledge about the development and use of technologies. Owing to high complexity, there is a lack of information at any point of time. Different people have different bits of knowledge, leading to asymmetry of information. If one were to collect all the information, things would be already in the process of changing which involves uncertainty. Thus, information asymmetry (varying information about the status quo) and uncertainty (lack of information about the future) lead to risk being an ubiquitous phenomenon. Technologies create environments and new risks, and the resulting complexity and uncertainty make technological developments less and less predictable and manageable. Of major importance for future technology development is therefore the stakeholders' risk perception which is influenced by various factors and which evolves over time.

'Experts' often assess risk as the expected value of the negative outcomes (the harms) of a decision. This process involves judgement (Fischhoff et al. 1978), and thus the results will vary between individuals, across contexts, and over time. Information is incomplete and developments are uncertain, hence predictions are based on assumptions. Experts might differ on account of different (scientific) judgement, different reference systems, or their dissent might involve politics. Even if there was a consensus amongst experts: the technical concept of risk is of limited use for policy making (Kasperson et al. 1988), rather, the perception of risk is influenced by other factors next to probabilities and magnitudes of risks. To outline the research context, we briefly review the psychometric paradigm, cultural theory and cultural cognition, and individual factors such as an individual's knowledge or socio-demographic variables.

The *psychometric paradigm* posits that, "risk is subjectively defined by individuals who may be influenced by a wide array of psychological, social, institutional and cultural factors" (Slovic 2000, xxiii). Analyses of hazards with different characteristics (*inter-hazard variation*) produce a cognitive map with a limited number of risk dimensions such as voluntariness of taking a risk, controllability and familiarity with risk (Slovic 1987, Renn 1990). Risk perception of hazardous technologies involve dread as a key psychological factor (Peters and Slovic 1996) in 'risk as feelings' (Loewenstein et al. 2001).The social amplification or attenuation of a particular risk (Kasperson et al. 1988) may change public perceptions of that risk.[3]

While the psychometric paradigm differentiates between different *types of risks* (and provides no information on individual or group behavior), cultural theory and its variants differentiate between *types of groups*. With *cultural theory*, Douglas and Wildavsky (1982) put forward the idea that worldviews (positions in the so-called group-grid) describe sets of attitudes that reflect ways of life and that are relevant in risk perception. Thus, there are groups of people with different worldviews (or cultural biases) holding or developing predictable risk perceptions, i.e. there is *inter-group variation*. People attend selectively to risks in a way that reflects their way of life: An individual with a certain worldview will pay attention to one type of risk but dismiss another[4]. A key question is how to assess cultural worldviews. Dake (1991) proposed different scales for cultural biases (hierarchy, individualism, egalitarianism), possibly resulting in individuals scoring high on competing scales. Kahan et al. (2007) use two scales to assign each individual one position within the group-grid, possibly leading to many positions scattered over the group-grid instead of clearly separable groups. Further problems are the failure to categorize respondents that show no cultural bias[5] (Marris et al. 1998) and low scale reliabilities[6]. Measuring cultural worldview and risk

[3] Amongst the four technologies chosen, genetic engineering in particular is subject to affect-laden imagery and amplification of risk (Frewer et al. 2002).

[4] "Common values lead to common fears (and, by implication, to a common agreement not to fear other things)", Douglas and Wildavsky 1982, 8.

[5] "our results suggest that world views are not innate attributes of individuals and/or that they cannot be measured using a psychometric instrument, since it was impossible to categorize (most) respondents according to their world view" (Marris et al. 1998, 646).

[6] As reported e.g. in Peters and Slovic (1996, 1434).

perception in one questionnaire using the same rating scale format may lead to inflated correlations[7].

In *cultural cognition*[8] as one conception of cultural theory, social and psychological mechanisms are expected to shape individuals' beliefs about risk, that is, the conception incorporates aspects of the psychometric paradigm (Kahan 2009). People tend to base their beliefs about benefits and risks of an activity on their cultural appraisals of these activities (Wildavsky and Dake 1990, DiMaggio 1997). Increasing the knowledge base by providing more information may lead to polarization of views.[9]

Analyses of individuals (*inter-individual variation*) yield mixed results with regard to the relationship between factual knowledge and risk perception. Schütz et al. (2000) assume that next to methodological differences between studies, the type of risk and situational factors may play a role. The *familiarity hypothesis* holds that support for a technology will increase with growing awareness of the technology. For example, support for nanotechnology was positively correlated with the perception that nanotechnology's benefits outweigh its risks, a finding consistent with public opinion studies (Cobb and Macoubrie 2004, Macoubrie 2006). Regarding knowledge about science and technology on the one hand and respective risk perceptions on the other hand Allum et al. (2008) in a meta-analysis across cultures find a small but positive relationship between knowledge and attitude towards technology. However, they note that cross-country variation is only 10% which in turn can be accounted for by the percentage of people in tertiary education.[10]

Other factors influencing individual risk perceptions are personal experience with the technology and judgement of one's reference group (Renn 1990). Analyses of *socio-demographic variables* show differences in risk perception particularly with regard to

---

[7] Sjöberg (2004, 49) suggested such a methodological problem regarding the assessed relationship between risk perception and trust: "In those cases, perceived risk and trust were both measured by attitude scales that were formally similar and had the same response scale".

[8] "Cultural cognition refers to the tendency of individuals to conform their beliefs about disputed matters of fact (e.g., whether global warming is a serious threat; whether the death penalty deters murder; whether gun control makes society more safe or less) to values that define their cultural identities." http://culturalcognition.net/, accessed 15.06.09.

[9] Amongst the four technologies chosen, nanotechnology is the least well known and for many people the 'no information condition' applies. Applied to nanotechnology, Kahan et al. (2009) found that predispositions towards nanotechnology affect information selection and interpretation. In a 'no information condition' subjects defined by cultural group showed similar perceptions of benefits and risks of nanotechnology; being exposed to balanced information on nanotechnology individuals attended to that information in a selective fashion mirroring their cultural worldviews (Kahan 2009).

[10] Here we focus on this group; variation of knowledge in this group is expected to be smaller than the variation in the population as a whole.

gender (Pidgeon 2007)[11]. Thus, the way people develop and express perceptions of risk is determined by individual, social, cultural and situational factors. In conclusion, risk perception is a complex construct and there is a whole range of variables that may explain some part of variance.

The present study relates to the psychometric paradigm by looking at four technologies that differ regarding ‘dread’ and ‘familiarity’. Instead of assessing worldviews, we analyse groups of people with supposedly differing values and science orientation as indicated by their choice of academic discipline (inter-group variation; with special attention to self-selection and socialization). Furthermore, we take additional information about the individuals such as gender into account.

3. Academic discipline (vocational and career choice)

Holland (1973)[12] developed a theory of careers and vocational choice and proposed that (six) types of people are attracted to (six) specific working environments: People with certain inclinations and motivations look for a matching workplace and this person-environment fit has a positive impact on job satisfaction as well as on employee performance (Haley and Sidanius 2005). However, a fit between people and environments may also be achieved by institutional selection, socialization and differential success (van Laar et al. 1999). Thus, a person being good in a job may have been socialized or well chosen by the employer, rather than having self-selected into the job. Holland’s proposition that individuals select environments congruent with their type of personality provides a clue for analyzing students’ choice of academic discipline: Students select academic disciplines on the basis of their expectations and inclinations (Pike 2006). The person-environment fit is thought to contribute significantly to educational persistence, satisfaction, and achievement of students[13].

Self-selection refers to individuals selecting themselves into a group. For self-selection to happen there has to be a choice between alternative options such as between jobs or between the study of various academic disciplines. *Socialization* refers to the process by which values, attitudes and practices of individuals are brought into line with those of the group they belong to.

---

[11] Other variables are e.g., income and race; Flynn et al. (1994) call the combined effect of race and gender the ‘White male effect’; see also Kahan et al. (2007) for the white male effect in risk perception..

[12] For a summary of Holland’s work see Gottfredsen (1999).

[13] Therefore, institutional selection of students based on school grades rather than on motivation and inclination might be counterproductive (Gottfredsen 1999).

Already when enrolling in university and selecting a subject, students of various disciplines display significant differences regarding values: “Students choose a subject the disciplinary culture of which has an affinity to their own values and norms or, alternatively, reject subjects with an image that stands in contrast to their own orientations” (Windolf 1995, 225). Unlike the USA, UK or France, Germany still has a relatively homogeneous university sector (Windolf 1995, 208). Even if this is about to change (Deutschland magazine 2008), so far a key determinant for enrolment in a university is the subject studied and not the university per se. Choosing a subject to study (self-selection), be it sciences, engineering, business, culture or social relations, is associated with cognitive orientations, values and norms. Students enrolling in different subjects differ regarding career expectations, cognitive abilities, preferred lifestyle and with respect to their attitude towards science (Zarkisson and Ekehammar 1998). This attitude evolves and may vary over time: During their studies, students do not only acquire specialized knowledge but are also exposed to the standards, supervision and peer culture of their disciplines amongst which are considerable differences (Weidman et al. 2001). That disciplinary culture as a ‘code of ethics’ is important for the production, acquisition and use of knowledge (Windolf 1995, 210).

Investigating the relationship between academic discipline and socio-political attitudes, Elchardus and Spruyt (2009) identified both selection and socialization effects of education: Social Science students are more likely to expose an egalitarian view while students in Law or Economics are more likely to hold an individualistic position.[14] Similarly, Kemmelmeier et al. (2005) ascertained that students with hierarchy-enhancing (HE) beliefs sort themselves into respective HE courses (Business and Economis) and students with hierarchy-attenuating (HA) beliefs choose HA majors such as Sociology. Windolf (1995) found a strong career orientation both for students of Business and Engineering. Trautwein and Lüdtke (2007) analyzed the relationship between study field chosen and students’ epistemological beliefs for beginners (self-selection) and for advanced students (socialization). The results indicate that both self-selection and socialization are at work in the context of attitudes towards science: Certainty scores, i.e. high scores indicating the belief that scientific knowledge is certain and not subject to change, were lower for ‘soft’ disciplines like humanities, arts, and social sciences and decreased with time.

[14] The authors also stated significant differences of the effects between different academic disciplines Furthermore, the observed socialization effects were weak.

Risks are matters of social conflict, and the definition of 'the problem' provides legitimacy (Dietz et al. 1989) for positions (for example pro or against a technology) and actions (for example promoting research or destroying genetically modified crops). Studies have found significant relationships between academic discipline on the one hand and political orientation (Kemmelmeier et al. 2005), racial prejudices (Sindanius et al. 1991), egalitarian attitudes (Chatard and Selimbegovic 2007) and values and norms (Windolf 1995) on the other hand. The *social identity approach* posits that people adopt attitudes and beliefs typical for their group as their own (Wood 2000, 557). Socialization then contributes to the development of perceptions and goals which are of course key to actions and strategies of people in various positions. Thus, self-selection and socialization are important factors in the explanation of choice of an academic discipline and for risk perception.

We are specifically interested in the relationship between academic discipline and risk perception of technologies: To analyze this, we investigate students from six majors in technical and non-technical academic disciplines regarding their risk perceptions of four different technologies. We briefly describe the technologies in the following section.

4. Technologies

In what follows we sketch some of the opportunities and threats associated with those technologies considered in our survey, namely renewable energies, nanotechnologies, ICT, and genetic engineering. These technologies differ regarding both *familiarity* of people (i.e. factual and self-assessed knowledge) and the degree of public discussions being characterized by *dread* (inter-hazard variation): Nanotechnologies are little known in the public, ICT are well known and much used, genetic engineering incorporates 'dread', and renewable energies have positive connotations.

The term *renewable energies* covers forms of energy generated from resources that are naturally replenished such as sunlight, wind, water, or geothermal heat. Non-renewable energies are naturally scarce and are associated with huge environmental burden. Rickersen et al. 2005, 47, state that "the risk profiles of renewable technologies differ significantly from those of fossil fuel and nuclear plants. In particular, use of renewable energy options generally pose little or no environmental, fuel price or security risks." Lower dependency on foreign energy sources, greening of industries and increasing public environmental awareness are key drivers for the development and diffusion of renewable energies (Greenwood et al. 2007). Yet, the materials, industrial processes, and construction equipment used to create them may generate waste and pollution with the consequence that some renewable energy systems may create environmental problems. Risks are mostly discussed in the context of investment failure (UNEP 2006) which could hamper further development of the technology.

ICT cover technologies for the generation, transmission, storage and manipulation of information and communication. During the last decades the wide-spread diffusion of ICT and its rapid further development had a great impact on societies, and ICT are still major drivers of economic and social change. The implementation of ICT also plays a key role in the shift towards knowledge-based societies, but "as the digital access divide decreases a digital use divide is emerging" (OECD 2008). Nevertheless, so far the risks inherent in ICT as perceived by the public are not very extent. Most objections refer to societal risks such as loss of control, technological dependence or surveillance associated with 'smart objects'.

Genetic engineering "refers to the process of inserting new genetic information into existing cells for the purpose of modifying one of the characteristics of an organism" (United Nations 1997). It plays a key role in many areas such as agriculture, food, medicine, and chemical industry. While many actors and institutions support its developments, others oppose it fiercely. Worldwide, albeit to a different degree, it has been debated very controversially. The issues cover economic, ethical, health and social concerns. The application of genetic engineering to the agro-food sector and the health sector is a prominent example of the importance and complexity of stakeholder issues. While medical applications are favorably, even uncritically, judged (TAB 2002), genetically modified food is seen as not necessary or even as being dangerous. However, the knowledge about genetic engineering can be described as vague, with little connection between bits of knowledge (Eurobarometer, Pfister et al. 2000).

The term *nanotechnologies* covers technologies and devices working at an atomic and molecular scale (dimensions smaller than 100 nanometers). The manipulation of nanostructures allows for ongoing miniaturization, leads to using newly discovered properties of materials and provides multiple possibilities in animate and inanimate contexts. Nanotechnologies form part of technological platforms (Robinson et al. 2006). While genetic engineering is based on the 'code of life', nanotechnologies are concerned with molecular structures. Thus, both technological fields really are at the centre of 'things' and may be used in many fields. They differ with regard to the public awareness: Genetic engineering has been discussed for more than three decades, whereas nanotechnologies are hardly known by the public (Kahan et al. 2009). Recent discussions are carried out mostly by experts and include both assumed opportunities and the search for appropriate rules of regulation in order to cope with the risks incorporated in the still quite young technology.

All in all, renewable energies have a positive image, there are hardly any risks perceived but significant benefits. ICT have mainly a positive image, there are some societal risks associated with them. Genetic engineering is controversially discussed; risks are perceived with regard to health, the environment and society (e.g. human enhancement). Nanotechnologies, despite incorporating some facets of controversial discourses, are still rarely known by the public and debates on possible risks are mainly carried out by specialists.

5. Empirical Study

5.1 Context of the Study and Propositions

In 2005 the European Commission published the results of an empirical study on Europeans, Science and Technology. Citizens from 25 European countries were asked about their knowledge (including a knowledge quiz), interests and perceptions regarding science and technologies. Aiming at a representative study of citizens of 15 years of age and over (Eurobarometer 224, 2005, 130) and assessing variables such as age, gender, education and occupation, results for a number of socio-demographic groups are available. The report concludes that "Europeans consider themselves poorly informed on issues concerning science and technology" and that "the gap between science and society still exists. Efforts must namely be made in order to bring science and technology closer to certain categories of people who are less exposed to the scientific field, and who therefore have a more sceptic perception of science and technology" (Eurobarometer 224, 2005, 125). However, detailed analyses of specific population groups are not carried out.

Such an investigation of special groups has been performed by Lüthje (2008): Differentiating between people with a technical and an economic background, Lüthje asked engineering and business administration students (beginners and advanced students) as well as professionals (engineers and managers) about various aspects of cooperation (amongst others: task preferences, information style, risk attitude in innovation projects, goal orientation and time preferences). With regard to risk attitude in innovation projects[15] there are no significant differences between engineering and business student beginners, but in the group of advanced students and in the group of professionals, (prospective) engineers display a lower preference for (financial) risks than (prospective) managers. However, risk has been limited to financial risk of innovation projects and the student sample consists of two disciplines that are to some extent similar to each other[16].

The present study investigates German students' risk perception of the four previously described technologies and in the three areas health, society, and environment. The students differ regarding their choice of academic discipline as represented by their major (self-selection) and regarding the study progress (socialization). We interpret the choice of an academic discipline as self-selection thereby indicating a certain attitude towards technology and possible inherent risks. Study progress is assumed to reflect some kind of socialization and we capture this issue by distinguishing between beginners (first term) and advanced (third term and above) students.

Given the presented context we propose that

> *Proposition 1(self-selection):*
>
> Students of different academic disciplines differ regarding risk perception: Individuals select an academic discipline congruent with their type of personality which in turn is related to risk perception.
>
> *Propostion 2 (socialization):*
>
> The differences in risk perception between choice of academic disciplines increase with time spent at university: In HE disciplines (Technical Studies, Business and Economics) risk perception will be lower and in HA disciplines (Cultural Sciences, Social Work) risk perception will be higher for advanced students.[17]
>
> *Proposition 3 (inter-group variation):*
>
> Significant factors in the prediction of risk perception are academic discipline and inter-individual factors.

---

[15] Assessed through three items, e.g. "I prefer projects with relatively low risk (and moderate, but certain profit)".

[16] Engineering and business being similar regarding career orientation (Windolf 1995) and socio-political orientation (hierarchy-enhancing: Kemmelmeier et al. 2005).

[17] Individuals are influenced by course content and internalize some values common in their discipline For 'Teaching' no effects are proposed because of (i) lack of evidence in the literature and (ii) heterogeneity of subjects taught in that discipline. See also the discussion below, section 5.2.

Proposition 4 (inter-hazard variation):

The relationship between academic discipline, individual factors and risk perception varies between technologies.

5.2 Data

Questionnaire and sample

We collected the data within three months (December 2007 to February 2008), from three North German universities (Lüneburg, Hamburg and Flensburg). The analyzed academic disciplines as reflected by the majors can be roughly described as follows: At one end of the range, in *Technical Studies,* compulsory classes cover natural sciences, engineering, and quantitative methods, with business administration as an elective. At the other end of the range, in *Social Work* or *Cultural Studies,* students focus on subjects such as sociology, psychology, arts or media; the only compulsory course on quantitative methods is one basic course during their first term. *Environmental Science*. *Business and Economics*, as well as *Teaching* students are exposed to issues of natural sciences or quantitative methods to varying extents. Especially the curricula of Teaching students are quite heterogeneous both with respect to science and technology and quantitative methods. Table 1 gives the numbers of students in the various disciplines.

The questionnaire included questions on risk perception in the three areas and for the four technologies and questions concerning self-assessed knowledge on these technologies as well as on science and technology in general. Factual knowledge was assessed via a knowledge quiz.[18] In addition, data on socio-demographic characteristics was collected.

[Table 1 about here]

The total sample consists of 1400 questionnaires. 45 questionnaires (≈3%) were excluded from the analysis because respondents filled in less than 75% of the questions which indicates low data quality.[19] For the remaining sample, we ran analyses with

[18] Table 3 provides the questions posed in the knowledge quiz.

[19] We assume that these respondents became unwilling to fill in the relatively long questionnaire. Baltes-Götz (2008, 17) recommends to exclude such cases rather than to impute values in order to avoid deflated coefficients.

dropped cases and with imputed values (multiple imputation). The coefficients and R^2s of the original data (dropped cases) were within the range of the imputed data sets. Hence, we report the results of the original data.[20]

Individual factors: Self-assessed and factual knowledge

We distinguished between two types of knowledge (see Table 2): (i) Self-assessed knowledge: Participants were asked to indicate on a scale from 1 to 11 how well they are informed about the four technologies thereby indicating familiarity or self-assessed knowledge, (ii) Factual knowledge: Students completed a knowledge quiz (Table 3 reports the questions posed). The quiz score represents the number of correct answers and ranges between 0 and 8.[21] Table 2 reports average ratings for the entire sample as well as by academic disciplines. Highest and lowest values are in bold type.

[Table 2 about here]

Respondents seem to be more familiar with ICT and renewable energies whereas they seem to know less about genetic engineering and particularly about nanotechnologies. It is remarkable that the most common rating of familiarity with nanotechnologies is 1, that is 296 respondents (≈22%) indicated that they are not informed.

Almost in every area, Technical Studies students dispose of the highest knowledge whereas students of Social Work are poorly informed within our sample. Analyses of variance show that the differences between academic disciplines regarding factual knowledge and self-assessed knowledge are significant for all variables except for self-assessed knowledge in genetic engineering.

[Table 3 about here]

Four questions of the knowledge quiz (Q2, Q3, Q4, Q5, Table 3) were adapted from the Eurobarometer (2005), and four additional questions relate to the four technologies

[20] Analyses were performed using SPSS 17.

[21] Note that correlation analysis shows highly significant correlations between knowledge (both self-assessed and factual) about science and technology on the one hand and the choice of any field of study on the other hand: Those students choosing a technical field also dispose of more knowledge on technological topics.

investigated in the sample. The highest percentage of right answers is given for the question on radioactivity (Q4), followed by the question on genetic engineering (Q1). This might be owed to the fact that radioactivity and genetic engineering are issues that have been discussed intensely in the media. In contrast, the lowest percentage of right answers is given for the question on nanotechnology (Q7). This corresponds well with the self-assessed knowledge where nanotechnology also ranks last. Compared with the Eurobarometer 2005 (see last column of Table 3), the percentage of right answers is for all four questions higher in our survey.[22] Table A3a in the Appendix provides the quiz results by academic discipline. Again, students of Technical Studies and of Environmental Sciences score higher than students of the other academic disciplines.

Risk perception of the technologies

For each technology, the respondents were asked to rate the health risk, environmental risk and the societal risk as follows (example here: type of risk = <u>health</u> risks and technology = <u>genetic engineering</u>):

I rate the <u>health</u> risks of <u>genetic engineering</u> as …

(1-no risk at all to 11- very high risk)

Table 4 reports the mean ratings of risks by areas (health, environment, and society) for the four technologies for the entire sample. The mean ratings are highest for genetic engineering and lowest for renewable energies. This holds for all the risks studied (environmental, health, societal risks). A detailed analysis by academic discipline can be found in the Appendix (Tables A4a-c). In the case of renewable energies, the differences between lowest and highest mean rankings are very small (health risks: 0.57, environmental risks: 0.53, societal risks: 0.38). With regard to the other three technology fields, students in Technical Studies tend to perceive lower risks and students in Environmental Sciences tend to see higher risks.[23]

[Table 4 about here]

[22] However, in the three years between the Eurobarometer survey and our survey, discussion went on and the respondents in our survey may have taken notice of these discussions.

[23] Students of Technical Studies and of Environmental Sciences both score higher in factual knowledge than students of the other academic disciplines, implying that knowledge per se is not a good predictor of risk perception..

Dimensions of risk perception

A factor analysis of risk perception variables shows that it is the technological areas and not the types of risk that are the relevant dimensions of risk perception (Table 5).

[Table 5 about here]

The factor loadings are based on twelve questions on risk perception[24]. The grouping of the high factor loadings leads to the four factors (i) 'Risks associated with nanotechnologies': Risk_Nano, (ii) 'Risks associated with renewable energies': Risk_RenE, (iii) 'Risks associated with genetic engineering': Risk_GenE, and (iv) 'Risks associated with ICT': Risk_ICT. The extracted factors are based on technologies and not on the areas health, environment and society.

5.3 Relationship between risk perception, study area and study progress

Risk perception and self-selection

Proposition 1 states that students of different academic disciplines differ regarding risk perception. Table 6 shows the mean risk perception factor values reported in Table 5 for students in different academic disciplines. Table 7 shows the results of the differences in means.

[Table 6 about here]

[Table 7 about here]

Technical students seem to be significantly less concerned with risks of nanotechnologies; the differences in means compared to the five remaining groups are all significant. Students of Environmental Sciences and of Social Studies perceive risks to be relatively high. With regard to genetic engineering, students of Technical Studies and the Business/Economics group display lower means than the other groups. Again,

[24] 4 (technologies) X 3 (areas: health, environment, and society).

students of Environmental Sciences and of Social Work perceive risks to be relatively high. For ICT, Technical Studies and Business/Economics students see low risks, students of Environmental Sciences and of Cultural Studies perceive risks to be relatively high.

There are no significant differences in risk perceptions between the various academic disciplines regarding renewable energies. We therefore exclude renewable energies from subsequent analyses.

With regard to the remaining three technologies, the group of Technical Studies shows low risk perception whereas the Environmental Sciences group shows high risk perception. Thus, students of different academic disciplines differ in their risk perception, and the pattern of differences varies with the technology under study.

To conclude: We find Proposition 1 supported.

Risk perception and socialization

Proposition 2 refers to the development of attitudes and perceptions during the students' studies. Depending on their academic discipline, risk perceptions are expected to increase or decrease, that is, pre-existing perceptions will be amplified as a consequence of socialization. Hence in HE disciplines (Technical Studies, Business/Economics), we expect advanced students to display lower risk perceptions than first-term students: During their studies students become more familiar with the technical or economic side of technologies, they identify themselves with their study subject and adopt attitudes and beliefs typical for their group as their own. With the same reasoning, we expect first-term students in HA disciplines to display lower risk perceptions than advanced students in that field. Students in the academic disciplines of Cultural Studies and Social Work get more exposed to the non-technical side of technology including topics such as various stakeholders' positions and society's acceptance. Following the logic of the cultural cognition hypothesis we thus expect any initially existing risk perception to be amplified as a consequence of socialization. We therefore compare the mean rating of the two groups 'beginners' and 'advanced' by academic discipline and do the same for students in the other fields of study (Table 8).

[Table 8 about here]

With respect to the entire sample, significant differences in mean ratings arise between beginners and advanced students, the latter perceiving lower risks for genetic engineering, nanotechnologies, and ICT. In fact, over all academic disciplines, significant differences in means show lower risk perception for advanced students compared to the beginners in their respective discipline. While this confirms our proposition with regard to HE majors, it is contradictory to our proposition regarding HA majors. Specifically, in Cultural Studies the perceived risk also decreases with study progress. This result contradicts our proposition that predispositions are amplified throughout the studies. Hence, Proposition 2 has to be rejected.

Regression analyses

Proposition 3 states that significant factors in the prediction of risk perception are academic discipline (inter-group variation) as well as inter-individual factors. Proposition 4 relates to inter-hazard variation and the corresponding impact of academic discipline and individual factors on risk perception. We performed stepwise regression analyses to analyze the effects of

- choice of academic discipline (coded as six binary variables: Business/Economics, Cultural Studies, Environmental Sciences, Social Work, Teaching, Technical Studies)
- time spent at university (number of terms)
- gender (0=female, 1=male)
- knowledge (self-assessed rating and factual knowledge as number of right answers in the knowledge quiz)
- and interactions (IA) between academic discipline and gender as well as between academic discipline and study progress

on risk perception. Table 9 provides the results.

[Table 9 about here]

For nanotechnology, *factual knowledge* is the most important variable for explaining risk perception (Beta = -0.185): The more factual knowledge in science and technology, the lower the risk perception. *Gender* has a significant impact (Beta = -0.132): Male students perceive risks to be lower.[25] Three majors contribute (in interaction) to the explanation of risk perception: *Technical Studies* students (Beta = -0.079), particularly *advanced technical students* (interaction with study progress: Beta = -0.120) see risks to be lower, *advanced* students of *Cultural Studies* perceive risks to be lower (Beta = -0.070) and *male* students of *Social Studies* see higher risks (Beta = +0.056).

For genetic engineering, neither factual knowledge, nor gender on its own is a significant factor for explaining risk perception. Therefore the coefficients are not reported in Table 9. Again, three majors contribute (in interaction) to the explanation of risk perception: *Environmental Sciences* students (Beta = +0.084) see higher risks, but not *male Environmental Sciences* students (interaction with gender: Beta = -0.095). *Male technical* students (interaction of Technical Studies and gender: Beta = -0.169) and *advanced Business/Economics* students (interaction of Business/Economics and study progress: Beta = -0.081) see risks to be lower. Finally, *self-assessed knowledge* is positively related to risk perception: The more people think they know the higher they see the risks associated with genetic engineering (Beta=0.062).

With regard to ICT, *study progress* is the most important variable for explaining risk perception (Beta = -0.150): The more advanced students are in their studies, the lower the risk perception. Both students of *Cultural Studies* and on *Environmental Sciences* see higher risks.

We might conclude that Propositions 3 and 4 are basically supported but that in the context of the regression analyses the extent to which the effects arise vary between the technologies. Anyway, the results of the factor analysis clearly support Proposition 4.

6. Discussion

The propositions outlined above have been partly supported. Our proposition regarding socialization (Proposition 2) is not confirmed, but we were able to identify selection effects (Proposition 1): On average, students from various academic disciplines differ in their risk perceptions of technologies. Inter-group variation and individual factors are

[25] This confirms other studies on risk perceptions that clearly highlight that on average women dispose of a higher degree of risk aversion then men (e.g. Pidgeon 2007).

significant predictors of risk perception (Proposition 3) and the pattern of differences varies among the technologies considered here (Proposition 4).

However, the explained variances reported in Table 9 are low. Possible explanations are:

- With regard to self-selection (independent variable: academic discipline): Students may discover that their individual person-environment fit is not achieved and with more experience may decide to change the academic discipline. Thus, especially in the first term, the self-selection result is likely to change. Since we collected data at the beginning of the term, there may be more a-typical (first year) students than towards the end of study.
- With regard to socialization (independent variable: study progress): Socialization is measured only within a relatively short time span (a few terms) which might be too short to capture the full extent of the process.
- With regard to knowledge (independent variables: (a) self-assessed, (b) factual knowledge): The sample is more homogeneous than the general population and especially at the beginning of the first term, students usually have similar starting conditions.
- With regard to risk perception (dependent variable: factor values): The technologies differ regarding 'dread' and 'familiarity, but they are similar to each other in that they are 'man-made', and decisions to make use of them usually are not down to the individual (unlike e.g. smoking or riding motorbikes).

These possible explanations point to short-comings of the study: We didn't assess whether students exercised a conscious decision or whether they were indecisive regarding their choice of academic discipline (and might drop out subsequently). Assessing socialization effects in the third term might be too early. Especially towards the end of studies, when writing their bachelor thesis, students need to apply acquired knowledge and develop critiques and this might be a better time for measuring effects. Finally, a long-term study collecting data from individuals at entry and exit of university would provide insights on intra-individual changes.

As illustrated above, the relationship between self-selection and socialization on the one hand and risk perception of technologies on the other varies between technologies. The results presented show that there is consensus amongst the groups about renewable energies posing hardly any risk and genetic engineering being the most risky technology of the four technologies investigated here. However, there are differences regarding the level of risk perception:

Renewable energies have a positive image, people indicate a relatively high degree of familiarity, there are hardly any risks perceived; this holds for all groups analyzed here. There are no significant differences in risk perception between different study areas or with regard to study progress. As shown in Table 2, nanotechnologies are the least understood technology with a median familiarity ranking of 3. However, it is also the technology for which the range of average familiarity rating (Technical studies: 5.15 and Social Work: 2.51) is greatest. In this case, higher familiarity goes with lower risk perception (Technical studies: -0.45 and Social Work: +0.44, see Table 6). Genetic engineering is the most dreaded technology and in all groups, familiarity is rated higher than nanotechnologies. Since genetic engineering is not part of the technical study areas investigated here, it is neither a particular interest in that technology, nor a growing familiarity owing to studying the topic that could account for differences in familiarity. Rather, it might be the exposure to discussions in the media that lead to respondents indicating similar levels of familiarity. With regard to ICT, in both HE and HA disciplines advanced students perceive lower risk than beginners. ICT is a general purpose technology that is wide-spread and many people are accustomed to using it on a daily basis. Performing studies at university usually comes with intense usage of ICT which might put risks into a different perspective. This holds independent of the chosen academic discipline.

7. Conclusion

In our study we considered and combined elements of inter-hazard, inter-group and inter-individual variation of risk perception.

Analyzing technologies that differ on the dimensions ‘dread’ and ‘familiarity’, we expected to find differences between the technologies. Results of both factor analysis and regression analyses support this. Analysis of risk perception variables resulted in four ‘technology factors’ each representing one technology (rather than ‘health’, ‘environment’ and ‘society’ factors), and regression analyses showed that the independent variables not only vary in their level of influence but in the structure of influence on risk perception, depending on the technology investigated.

Instead of assessing worldviews and risk perceptions in one questionnaire (thereby risking inflated coefficients), we used pre-defined groups and compared risk perceptions among academic disciplines. Results support our proposition that this kind of self-selection (and associated type of personality) is partly reflected in perceptions concerning risks.

People are exposed to information and fit this into their frame of mind, they select and interpret additional information and may develop a view on how well informed they are. These inter-individual differences of self-assessed knowledge and factual knowledge may contribute to differences in risk perception. In our study, the influence of knowledge on risk perception varies between technologies: In the case of nanotechnology, factual knowledge is negatively related to risk perception, in the case of genetic engineering, self-assessed knowledge is positively related to risk perception.

Thus, the relationship between knowledge and technological development is not straightforward. Participating in the creation of technological paths, people's intentions, strategies and actions are partly influenced by how chances and risks of the technology are perceived: Risk perception plays a crucial role in technology development. It is not only "science and mathematics" but equally an understanding of risks and chances and the way perceptions develop that could "bring science and technology closer to certain categories of people who are less exposed to the scientific field, and who therefore have a more skeptic perception of science and technology" (Eurobarometer 224, 2005, 125).

Students select themselves into an ongoing learning process and choose a field of study. This self-selection partly will reflect attitudes towards science, preferences for topics and career expectations. Going to university, the teaching and learning of subjects become less uniform. Each discipline has its own culture and its ways for producing and using knowledge. Socialization processes may contribute to the development of 'typical' perceptions, however, it seems that self-selection effects are key to attitudes and that socialization only plays a minor role.

In an organization people take on roles and tasks: A financial controller, a researcher and a marketing manager differ in their screening and evaluation of innovations and in their level and type of information. In general, scientists and developers may be better informed about technical aspects, marketing managers may be better informed about user needs and usage patterns. Homophily (Lazarsfeld and Merton 1954) between members of a group (or a department in an organization) may strengthen attitudes and confirm perceptions. This may affect intra-organizational interaction between managers of different departments as well as inter-organizational interaction. For example, Kim and Higgins (2007, 510) propose that “the prominence of members’ prior careers influenced the rate at which companies form alliances”.

It is this kind of knowledge about selection and socialization processes that could further the *understanding* of cooperation partners’ perceptions as well as the ability to deal with differences in perceptions.

Future research could involve investigating the link between academic discipline and world view and a panel study to monitor socialization effects on an intra-individual level.

References

Alba, J.W., Hutchinson, J.W. 2000. Knowledge calibration: What consumers know and what they think they know, Journal of Consumer Research 27, 123-156.

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.

Baltes-Götz, B. 2008. Behandlung fehlender Werte in SPSS und Amos, Universitäts-Rechenzentrum Trier.

Chatard, A., Selimbegovic, L. 2007. The impact of higher education on egalitarian attitudes and values: Contextual and cultural determinants, Social and Personality Psychology Compass 1/1, 541-556.

Chatterjee, R., Eliashberg, J. 1990. The innovation diffusion process in a heterogeneous population: A micromodeling approach, Management Science 36(9), 1057–1079.

Cobb, M.D., J. Macoubrie 2004. Public perceptions about nanotechnology: Risks, benefits and trust, Journal of Nanoparticle Research, 6, 395-404.

Dake, K. 1991. Orienting Dispositions in the Perception of Risk: An Analysis of Contemporary Worldviews and Cultural Biases, Journal of Cross-Cultural Psychology 22 61-82.

Deutschland magazine (2008), The best universities, http://www.auswaertiges-amt.de/diplo/en/WillkommeninD/LernenUndArbeiten/Studium/Eliteunis.html, updated 28.01.2008.

Dietz, T., Stern, P.C., Rycroft, R.W. 1989. Definitions of conflict and the legitimation of resources: The case of environmental risk, Sociological Forum 4 (1) 47-70.

DiMaggio, P. (1997), Culture and cognition, Annual Review of Sociology, 23, 263-287.

Douglas, M., Wildavsky, A. B. 1982. Risk and culture: An essay on the selection of technical and environmental dangers. Berkeley: University of California Press.

Elchardus, M., Spruyt, B. 2009. The Culture of Academic Disciplines and the Sociopolitical Attitudes of Students: A Test of Selection and Socialization Effects. Social Science Quarterly 90 (2).

Eurobarometer 224 (2005): Europeans, Science and Technology, http://ec.europa.eu/public_opinion/archives/ebs/ebs_224_report_en.pdf.

Fischhoff B, Slovic P, Lichtenstein S, Read S, Combs B 1978. How safe is safe enough? A psychometric study of attitudes towards technological risks and benefits. Policy Science 9 (2) 127–152.

Frewer L, Miles S, Marsh R (2002): The media and genetically modified foods: evidence in support of social amplification of risk. Risk Analysis 22, 701–71.1.

Flynn, J., Slovic, P., Mertz, C.K. 1994. Gender, race and perception of environmental health risks. Risk Analysis 14 (6) 1101 - 1108.

Gottfredsen, G.D (1999). John L. Holland’s Contributions to Vocational Psychology: A Review and Evaluation, Journal of Vocational Behavior 55, 15–40 (1999).

Greenwood, C., Hohler, A., Hunt, G., Liebreich, M., Sonntag-O’Brien, V., Usher, E. 2007. Global trends in sustainable energy investment. United Nations Environment Programme and New Energy Finance Ltd. 2007.

Haley, H., Sidanius, J. 2005. Person-organization congruence and the maintenance of group-based social hierarchy: A social dominance perspective, Group Processes & Intergroup Relations 8 (2), 187-203.

Holland, J. L. (1973). Making vocational choices: A theory of careers. Englewood Cliffs, NJ: Prentice-Hall.

Kahan, D.M. 2009. Cultural Cognition as a conception of the Cultural Theory of Risk, Cultural Cognition Project Working Paper No. 73, http://www.culturalcognition.net/.

Kahan,D.M., Braman,D., Gastil, J., Slovic,P., Mertz, C.K. 2007. Culture and Identity-Protective Cognition: Explaining the White Male Effect in Risk Perception, Journal of Empirical Legal Studies 4 (3), 465–505.

Kahan, D.M., Braman, D., Slovic, P., Gastil, J., Cohen, G. 2009. Cultural cognition of the risks and benefits of nanotechnology. nature nanotechnology 4, 87-90.

Kasperson, R.E., Renn, O., Slovic, P., Brown, H.S., Emel, J., Goble, R., Kasperson, J.X., Ratick, S. 1988. The social amplification of risk: A conceptual framework. Risk Analysis 8 (2) 177-188.

Kemmelmeier, M., Danielson, C., Basten, J. 2005. What’s in a grade? Academic success and political orientation, Personality and Social Psychology Bulletin 31 (10), 1386-1399.

Kim, J. W., Higgins, M. C. 2007. Where do alliances come from? The effects of upper echelons on alliance formation. Research Policy 36 (4), 499-514.

Lazarsfeld, P. F., Merton, R. K. (1954). Friendship as a social process: A substantive and methodological analysis. In Berger, M., Abel, T., Page, C. (Eds.), Freedom and Control in Modern Society, 18□66, New York: Van Nostrand.

Lipsey, R., Bekar, C., Carlaw, K. 1998. What requires explanation? In General purpose technologies and economic growth, ed. Helpman, E.,55-83. Cambridge.

Loewenstein, G.F., Weber, E.U., Hsee, C.K., Welch, N.2001. Risks as feelings, Psychological Bulletin 127 (2), 267-286.

Lüthje, C. 2008. Der Prozess der Innovation. Das Zusammenwirken von technischen und ökonomischen Akteuren, Tübingen: Mohr Siebeck.

Macoubrie, J. 2006. Nanotechnology: Public concerns, reasoning and trust in government, Public Understanding of Science 15, 221-241.

Marris, C., Langford, I.A.,O'Riordan, T. 1998. A Quantitative Test of the Cultural Theory of Risk Perceptions: Comparison with the Psychometric Paradigm, Risk Analysis, Vol. 18, No. 5,635-647.

OECD (2008): OECD Information Technology Outlook 2008 Highlights, http://www.oecd.org/dataoecd/37/26/41895578.pdf.

Peters, E., Slovic, P. 1996. The role of affect and worldviews as orienting dispositions in the perception and acceptance of nuclear power, Journal of Applied Social Psychology 26 (16), 1427-1453.

Pfister, H.-R., Böhm, G., Jungermann, H. 2000. The cognitive representation of genetic engineering: Knowledge and evaluations. New Genetics and Society 19, 295-316.

Pidgeon, N. 2007. Gender theories and risk perception: A secondary analysis: Full Research Report, ESRC End of Award Report, RES-160-25-0046. Swindon: ESRC.

Pike, G.R. 2006. Vocational Preferences and College Expectations: An Extension of Holland's Principle of Self-Selection, Research in Higher Education 47 (5), 591-612.

Renn, O. 1990. Risk perception and risk management. Risk abstracts, Institute for Risk research, university of Waterloo, Ontario, 1-9.

Rickerson, W., Wong,H., Byrne,J., Young-Doo Wang, Sasser, S. 2005. Bracing for an uncertain energy future: Renewable energy and the US electricity industry. Risk Management Matters 3 (1), 46-61.

Roberts, J. H., Urban, G. L.. 1988. Modeling multiattribute utility, risk, and belief dynamics for new consumer durable brand choice. Management Science 34, 167–185.

Robinson, D. K, Rip, A., Mangematin, V. 2006. Technological agglomeration and the emergence of clusters and networks in nanotechnology (Working paper GAEL 2006-5), Grenoble, France: Université Pierre Mendès France.

Roco, M.C. 2007. Governance of converging new technologies integrated from the nanoscale, Keynote at PICMET 2007. http://www.picmet.org/new/Conferences/2007/keynotes.aspx#Roco

Schütz, H., Wiedemann, P.M., Gray, P.C.R. 2000. Risk perception and beyond the psychometric paradigm (Heft 78). Jülich, Germany: German Research Centre Jülich, Programme Group Human Environment Technology.

Sidanius, J., Pratto, F., Martin, M., Stallworth, L. 1991. Consensual racism and career track: Some implications of social dominance theory, Political Psychology 12, 691-721.

Sjöberg, L. 2004. Principles of risk perception applied to gene technology, EUROPEAN MOLECULAR BIOLOGY ORGANIZATION EMBO reports 5, 47-51.

Slovic, P. 1987. Perception of risk, Science 236, 280-285.

Slovic, P. 2000. Introduction and overview, in: Slovic, P. The perception of risk, London.

TAB 2002. Technology acceptance and controversies over technology: Positive changes in the state of opinion – consistent attitude patterns, TAB working report No. 83, http://www.tab.fzk.de/en/projekt/zusammenfassung/ab83.htm.

Trautwein, U., Lüdtke, O. 2007. Epistemological beliefs, school achievement, and college major: A large-scale longitudinal study on the impact of certainty beliefs, Contemporary Educational Psychology 32, 348-366.

UNEP 2006. Financial risk management instruments for RE projects.

United Nations 1997. Glossary of environment statistics, Studies in Methods, Series F, No. 67, New York.

van Laar, C., Sidanius, J., Rabinowitz, J. L.,, Sinclair, S. (1999). The three Rs of academic achievement: Reading, 'riting, and racism. Personality & Social Psychology Bulletin, 25(2), 139-151.

Weidman, J.C., Twale, D.J., Stein, E.L. 2001. Socialization of graduate and professional students in higher education: A perilous passage? ASHE-ERIC Higher Education Report 28 (4), San Francisco.

Wildavsky, A. Dake, K. 1990. Theories of risk perception: Who fears what and why? Deadalus, 114, 41-60.

Windolf, P. 1995. Selection and self-selection at German mass universities, Oxford Review of Education 21 (2), 207-231.

Wood, W. 2000. Attitude change: persuasion and social influence, Annu. Rev. Psychol. 51, 539-570.

Zarkisson, I., Ekehammar, B. 1998. Social attitudes and education: Self-selection or socialization? Scandinavian Journal of Psychology 39, 117-122.

Table 1: Overview of sample

variable		N=1355
		valid %
sex	female	56.6
	male	43.3
age	≤ 20	33.8
	21-25	53.5
	26-30	8.3
	> 30	4.4
academic disciplines	Technical Studies	33.7
	Education	23.8
	Business/Economics	19.5
	Cultural Studies	13.9
	Social Work	7.9
	Environmental Sciences	1.2
study progress	beginners	80.0
	advanced	20.0

Table 2: Self-assessed and factual knowledge: Ratings by academic discipline

academic discipline		I am informed about … natural sciences and technology … as follows (1= not informed - 11= very well informed)					
		self-assessed knowledge; mean ∈ [1;11]					factual knowledge; quiz score ∈ [0;8]
		natural sciences & techno-logy	renew-able energies	genetic enginee-ring	nano-techno-logies	ICT	
entire sample	mean	6.41	6.41	5.27	3.74	6.07	4.59
	(sd)	(2.37)	(2.26)	(2.19)	(2.33)	(2.45)	(1.83)
	median	6	7	5	3	6	5
	modus	6	8	4	1	6	6
	N	1355	1353	1352	1349	1351	1352
Technical Studies	mean	**8.12**	**7.43**	5.27	**5.15**	**6.67**	**5.89**
	(sd)	(1.85)	(1.98)	(2.30)	(2.26)	(2.39)	(1.35)
	median	8	8	5	5	7	6
	modus	9	8	5	6	8	6
	N	445	445	445	444	445	445
Cultural Studies	mean	5.06	**5.66**	5.13	2.88	5.84	3.83
	(sd)	(1.81)	(2.10)	(2.01)	(1.90)	(2.34)	(1.50)
	median	5	5	5	3	6	4
	modus	5	5	6	1	6	3
	N	184	184	184	182	183	184
Business / Economics	mean	5.62	6.02	**5.10**	3.45	6.19	3.94
	(sd)	(2.12)	(2.13)	(2.06)	(2.13)	(2.37)	(1.79)
	median	6	6	5	3	6	4
	modus	6	6	4	1	6	4
	N	258	258	256	258	257	255
Teachings	mean	5.90	5.92	5.45	2.93	5.51	4.09
	(sd)	(2.17)	(2.26)	(2.25)	(2.00)	(2.48)	(1.65)
	median	6	6	5	2	6	4
	modus	6	6	4	1	6	4
	N	315	313	315	313	313	315
Social Work	mean	**4.99**	5.91	**5.46**	**2.51**	5.50	**3.79**
	(sd)	(2.06)	(2.34)	(2.23)	(1.89)	(2.55)	(1.69)
	median	5	6	5	2	5	4
	modus	4	4	4	1	6	3
	N	104	104	103	104	104	104
Environmen-tal Sciences	mean	5.63	6.56	5.19	2.88	**4.06**	5.00
	(sd)	(2.16)	(2.50)	(2.14)	(1.89)	(2.01)	(1.26)
	median	6	6	5	3	4	5
	modus	3	6	3	1	5	4
	N	16	16	16	16	16	16

Table 3: Factual knowledge: Quiz results

	our sample			EU 2005
	% don't know	% wrong answer	% right answer	% right answer
Q1 Naturally, tomatoes have genes.	9.8	10.8	79.4	n.a.
Q2 Lasers work by focusing sound waves.	28.3	13.9	57.8	47
Q3 Antibiotics kill viruses as well as bacteria.	12.4	21.3	66.3	46
Q4 Radioactive milk can be made safe by boiling it.	14.1	0.7	85.2	75
Q5 Electrons are smaller than atoms.	10.9	21.3	67.8	46
Q6 For a certain irradiation angle of the sun, the power generation of a photovoltaic power plant will be higher in the summer than in the winter.	35.7	27.9	36.4	n.a
Q7 With the scanning tunneling microscope it is possible to move single atoms.	64.0	26.0	10.0	n.a.
Q8 With respect to speed, fiberglass technology is superior to copper.	35.4	6.0	58.6	n.a

Table 4: Mean ratings of risks by areas: Health, environment, society

I rate the … health …risk as follows (1-no risk -11 very high risk)		technologies			
		renewable energies	genetic engineering	nanotech-nologies	ICT
health	mean	2.79	7.02	5.26	4.490
	(sd)	(1.92)	(2.36)	(2.18)	(2.43)
	median	2	7	6	4
	modus	1	6	6	6
	N	1346	1351	1317	1339
environment	mean	3.25	6.97	5.48	5.00
	(sd)	(2.25)	(2.63)	(2.32)	(2.43)
	median	3	7	6	5
	modus	1	8	6	6
	N	1349	1349	1314	1341
society	mean	2.79	7.31	5.22	5.42
	(sd)	(2.03)	(2.58)	(2.32)	(2.70)
	median	2	8	6	6
	modus	1	9	6	6
	N	1344	1344	1312	1337

Table 5: Risk Perception for four technologies in three areas (health, environment, society): factor loadings

	extracted factors and loadings			
	Risk_Nano	Risk_RenE	Risk_GenE	Risk_ICT
health risks of				
renewable energies	0.110	**0.843**	-0.011	0.057
genetic engineering	0.203	0.014	**0.859**	0.075
nanotechnologies	**0.811**	0.091	0.244	0.088
ICT	0.031	0.092	0.161	**0.812**
environmental risks of				
renewable energies	0.025	**0.861**	0.058	0.030
genetic engineering	0.149	0.007	**0.822**	0.162
nanotechnologies	**0.782**	0.095	0.260	0.177
ICT	0.199	0.021	0.138	**0.746**
societal risks of				
renewable energies	0.098	**0.829**	-0.011	0.035
genetic engineering	0.301	0.012	**0.650**	0.174
nanotechnologies	**0.815**	0.093	0.157	0.221
ICT	0.181	0.010	0.068	**0.691**

extracted factors:
Risk_Nano= nanotechnologies' risks
Risk_RenE= renewable energies' risks
Risk_GenE= genetic engineering's risks
Risk_ICT= ICTs' risks
68% variance explained

Table 6: Self-selection: Mean factor scores (mean) and standard deviation (sd) of risk perception by academic discipline

Factors	Risk_Nano		Risk_RenE		Risk_GenE		Risk_ICT	
academic discipline (N)	mean	(sd)	mean	(sd)	mean	(sd)	mean	(sd)
Technical Studies (432)	**-0.45**	(0.92)	-0.04	(0.98)	**-0.15**	(1.02)	-0.09	(0.96)
Business/Economics (240)	0.13	(0.91)	0.03	(1.00)	-0.06	(1.00)	**-0.16**	(0.99)
Cultural Studies (177)	0.17	(0.93)	-0.03	(0.97)	0.17	(0.95)	0.32	(1.04)
Teaching (291)	0.27	(1.06)	**0.07**	(1.04)	0.12	(0.97)	0.02	(1.01)
Social Work (95)	**0.44**	(0.78)	0.03	(1.09)	0.20	(0.91)	0.12	(0.97)
Environmental Sciences (15)	0.30	(1.00)	**-0.35**	(0.73)	**0.47**	(1.09)	**0.64**	(0.82)

factors:
Risk_Nano= nanotechnologies' risks
Risk_RenE= renewable energies' risks
Risk_GenE= genetic engineering's risks
Risk_ICT= ICTs' risks

Table 7: Differences in mean factor values between academic disciplines (t-test, significance)

Groups	Risk_Nano	Risk_RenE	Risk_GenE	Risk_ICT
Technical Studies vs. Cultural Studies	0.000	0.892	0.000	0.000
Technical Studies vs. Business Economics	0.000	0.361	0.252	0.371
Technical Studies vs. Teaching	0.000	0.172	0.000	0.117
Technical Studies vs. Social Work	0.000	0.569	0.002	0.051
Technical Studies vs. Environmental Sciences	0.002	0.234	0.020	0.003
Cultural Studies vs. Business/Economics	0.665	0.535	0.019	0.000
Cultural Studies vs. Teaching	0.321	0.334	0.609	0.002
Cultural Studies vs. Social Work	0.014	0.668	0.787	0.111
Cultural Studies vs. Environmental Studies	0.611	0.220	0.243	0.248
Business Economics vs. Teaching	0.119	0.713	0.034	0.033
Business/Economics vs. Social Work	0.003	0.978	0.028	0.018
Business/Economics vs. Environmental Sciences	0.492	0.151	0.048	0.002
Teaching vs. Social Work	0.099	0.771	0.483	0.419
Teaching vs. Environmental Sciences	0.908	0.133	0.176	0.020
Social Work vs. Environmental Sciences	0.550	0.101	0.299	0.048

Table 8: Socialization: Mean factor scores (mean), standard deviation (sd) and significance levels (sig; t-test) of mean differences in risk perception by study progress (beginners: 1st term, advanced: >1st term) and by selected academic disciplines

factors	Risko_Nano			Risk_GentE			Risk_ICT		
academic discipline (N)	mean	(sd)	sig	mean	(sd)	sig	mean	(sd)	sig
entire sample[1] (1134)			0.000			0.038			0.000
beginners (883)	0.03	(1.00)		0.02	(1.00)		0.08	(1.02)	
advanced (251)	-0.30	(0.97)		-0.13	(1.00)		-0.33	(0.89)	
Technical Studies (428)			0.001			0.708			0.000
beginners (138)	-0.35	(0.92)		-0.16	(0.99)		0.05	(0.98)	
advanced (290)	-0.66	(0.88)		-0.12	(1.06)		-0.39	(0.84)	
Business/Econ (238)			0.400			0.276			0.063
beginners (171)	0.10	(0.95)		-0.02	(0.87)		-0.10	(0.84)	
advanced (67)	0.21	(0.83)		-0.16	(1.05)		-0.34	(1.04)	
Cultural Studies (177)			0.064			0.040			0.017
beginners (144)	0.23	(0.94)		0.24	(0.94)		0.41	(1.04)	
advanced (33)	-0.10	(0.85)		-0.14	(0.95)		-0.06	(0.96)	
Teaching (291)			0.984			0.825			0.337
beginners (278)	0.27	(1.05)		0.13	(0.96)		0.03	(1.00)	
advanced (13)	0.26	(1.32)		0.05	(1.22)		-0.24	(1.32)	

[1] Social Work and Environmental Sciences have been excluded since there are no advanced students in the sample.

Table 9: Regression analyses

	coefficients				
	not standardised		standardised		
	regression coefficient B	Standardfehler	Beta	T	sig
nanotechnologies					
(Constant)	0.739	0.077		9.589	0.000
Technical Studies	-0.166	0.099	-0.079	-1.684	0.092
factual knowledge	-0.103	0.017	-0.185	-5.913	0.000
gender	-0.265	0.065	-0.132	-4.050	0.000
IA:[1] Technical Studies * study progress	-0.111	0.039	-0.120	-2.859	0.004
IA: Cultural Studies * study progress	-0.084	0.032	-0.070	-2.595	0.010
IA: Social Work * gender	0.504	0.244	0.056	2.068	0.039
R =0.402; R^2 = 0.162; Standard error of estimate 0.916					
genetic engineering					
(Constant)	-0.074	0.100		-0.738	.461
Environmental Sciences	0.753	0.283	0.084	2.663	0.008
self-assessed knowledge	.0036	0.018	0.062	2.053	0.040
IA: Technical Studies * gender	-0.371	0.069	-0.169	-5.408	0.000
IA: Business/ Economics * study progress	-0.078	0.028	-0.081	-2.798	0.005
IA: Environmental Sciences * gender	-1.898	0.627	-0.095	-3.025	0.003
R =0.189; R^2 = 0.036; Standard error of estimate 0.972					
ICT					
(constant)	0.133	0.047		2.818	0.005
study progress	-.121	0.023	-.150	-5.328	0.000
Cultural Studies	0.397	0.081	0.137	4.878	0.000
Environmental Studies	0.665	0.255	0.073	2.606	0.009
R =0.211; R^2 = 0.044; Standard error of estimate 0.981					

[1] IA= interaction term

Tables appendix

Table A3a: Quiz results: factual knowledge by academic discipline

		Right answers in %							
academic discipline		Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8
entire sample	mean	79.4	57.8	66.3	85.2	67.8	36.4	10.0	58.6
	N	1322	1322	1322	1322	1321	1320	1321	1321
Technical Sciences	mean	91.7	**87.2**	73.3	**93.4**	**91.2**	**54.6**	**15.5**	**81.3**
	N	445	445	445	445	445	445	445	445
Cultural Studies	mean	75.5	31.0	60.9	81.0	51.1	25.5	7.1	50.5
	N	184	184	184	184	184	184	184	184
Business/Economics	mean	72.6	44.2	57.4	**74.8**	56.8	29.3	8.2	50.2
	N	258	258	258	258	257	256	257	257
Teachers	mean	73.3	50.0	67.9	82.9	57.5	26.4	7.6	43.8
	N	315	315	315	315	315	315	315	315
Social Work	mean	**66.4**	**38.5**	**61.5**	86.5	**51.9**	**26.9**	4.8	**42.3**
	N	104	104	104	104	104	104	104	104
Environmental	mean	**100**	62.5	**82.3**	87.5	87.5	31.3	**0**	50.0
Sciences	N	16	16	16	16	16	16	16	16

Table A4a: Mean ratings of *health* risks by academic discipline

academic discipline		renewable energies	genetic engineering	nano-technologies	ICT
		I rate the … health risks … as follows 1-no risk at all … 11-very high risk			
Technical Studies	mean	**2.57**	**6.45**	**4.40**	4.19
	(sd)	(1.90)	(2.33)	(2.15)	(2.36)
	median	2	6	4	4
	modus	1	6	6	3
	N	444	444	441	443
Cultural Studies	mean	2.86	7.43	5.68	5.02
	(sd)	(1.81)	(2.18)	(2.02)	(2.44)
	median	2	8	6	6
	modus	2	9	6	6
	N	184	184	179	182
Business / Economics	mean	2.81	6.97	5.40	**4.17**
	(sd)	(1.90)	(2.35)	(2.10)	(2.37)
	median	2	7	6	4
	modus	1	8	6	2
	N	257	257	250	253
Teaching	mean	3.05	7.36	5.80	4.68
	(sd)	(2.05)	(2.34)	(2.13)	(2.46)
	median	3	8	6	4
	modus	1	6	6	6
	N	309	315	303	311
Social Work	mean	2.93	7.88	6.21	4.93
	(sd)	(1.97)	(2.11)	(1.70)	(2.49)
	median	2	8	6	5
	modus	2	8	6	6
	N	103	102	99	103
Environmental Sciences	mean	**2.00**	**8.13**	**6.25**	**5.62**
	(sd)	(0.97)	(2.58)	(2.08)	(2.75)
	median	2	8.5	6	6
	modus	2	11	6	2
	N	16	16	16	16

Table A4b: Mean ratings of *environmental* risks by academic discipline

academic discipline		renewable energies	genetic engineering	nano-technologies	ICT
		I rate the … environmental risks … as follows 1-no risk at all … 11-very high risk			
Technical Studies	mean	3.23	**6.43**	**4.56**	**4.54**
	(sd)	(2.27)	(2.63)	(2.17)	2.37
	median	3	6	5	4
	modus	1	6	6	6
	N	446	445	439	443
Cultural Studies	mean	3.13	7.45	5.96	5.82
	(sd)	(2.14)	(2.51)	(2.16)	(2.34)
	median	3	8	6	6
	modus	1	8	6	6
	N	184	184	180	182
Business / Economics	mean	**3.34**	6.71	5.50	4.80
	(sd)	(2.26)	(2.68)	(2.54)	(2.48)
	median	3	7	6	5
	modus	1	8	6	6
	N	263	261	255	259
Teaching	mean	3.28	7.42	6.12	5.17
	(sd)	(2.32)	(2.48)	(2.34)	(2.34)
	median	3	8	6	5
	modus	1	8	6	6
	N	311	312	302	313
Social Work	mean	3.33	7.70	6.35	5.42
	(sd)	(2.36)	(2.47)	(1.91)	(2.42)
	median	3	8	6	6
	modus	2	9	6	6
	N	106	107	98	105
Environmental Sciences	mean	**2.81**	**8.81**	**6.67**	**7.00**
	(sd)	(1.52)	(2.95)	(2.74)	(2.56)
	median	2.5	10	7	7.5
	modus	2	11	7	6
	N	16	16	16	16

Table 4c: Mean ratings of *societal* risks by academic discipline

academic discipline		renewable energies	genetic engineering	nano-technologies	ICT
		I rate the … societal risks … as follows 1-no risk at all … 11-very high risk			
Technical Studies	mean	2.67	**6.64**	**4.22**	**5.12**
	(sd)	(2.05)	(2.68)	(2.28)	(2.74)
	median	2	7	4	5
	modus	1	8	6	6
	N	441	442	439	441
Cultural Studies	mean	2.84	7.95	5.66	6.25
	(sd)	(2.04)	(2.30)	(2.09)	(2.60)
	median	3	8	6	6
	modus	1	8	6	6
	N	184	183	179	182
Business / Economics	mean	2.84	7.37	5.49	5.14
	(sd)	(1.97)	(2.43)	(2.18)	(2.58)
	median	2	8	6	5
	modus	1	9	6	6
	N	257	257	251	254
Teachers	mean	**2.91**	7.64	5.81	5.46
	(sd)	(2.10)	(2.51)	(2.24)	(2.57)
	median	2	8	6	6
	modus	1	9	6	6
	N	312	312	301	312
Social Work	mean	**2.91**	7.84	**6.19**	5.83
	(sd)	(1.97)	(2.57)	(1.78)	(2.77)
	median	2	8	6	6
	modus	1	11	6	6
	N	104	104	98	103
Environmental Sciences	mean	**2.53**	**8.53**	6.13	**6.07**
	(sd)	(1.81)	(2.33)	(2.59)	(2.37)
	median	2	9	6	6
	modus	1	8	6	6
	N	15	15	15	15