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Associations with plant genetic engineering: A perception analysis of students' hopes and fears

Public perceptions of plant genetic engineering are of increasing research interest. Although within the current debate on the cultivation of genetically modified plants many related ethical, political and economic issues need specific consideration, young students' views on this socio-scientific issue are largely unexplored. Therefore, our current analysis focussed on perceptions of Bavarian tenth graders (N = 572) with regard to their hopes and fears in the context of plant genetic engineering. By applying a mixed-methods approach, students rated their individual hopes and fears on a 4-point Likert scale (quantitative part) and gave a written statement about their individual associations (qualitative part): Hereby, hopes scored much higher than fears (medium effect). The subsequent categorisation of qualitative data resulted in five categories for hopes and four categories for fears. Hopes were mainly associated with economic or ecological aspects as well as with the overall fight against world hunger. Fears dealt mainly with negative consequences on human health and the fate of the environment. Additionally, subjective and objective knowledge were analysed for their influence on students' perceptions. Subjective knowledge had a significant influence on hopes, objective knowledge did not. This background information is relevant for the age-appropriate preparation of biology lessons: Hopes and fears need to be specifically addressed in order to optimise educational efforts and to support students to become responsible citizens.

Keywords: associations, genetically modified food, mixed methods approach, knowledge, science education

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Introduction

Genetic engineering as a "process of inserting new genetic information into existing cells for the purpose of modifying one of the characteristics of an organism" (UN, 1997, p.36) is a highly discussed public issue. The cultivation of genetically modified (GM) plants and their availability on the global market have rapidly increased during the last decade (Maghari and Ardekani, 2011), reaching even a 100-fold increase since the mid-1990s (James, 2012). The most widely cultivated GM plants are soybean and maize followed by cotton and canola (FAO, 2012). Although European countries such as Spain, Portugal, Czech Republic, Slovakia and Romania cultivate GM maize (James, 2012), in Germany, the support for GM products is negligible to non-existent. In Bayern, for instance, cultivation of GM plants was completely terminated in 2009. By contrast, in developing countries genetic engineering is often thought to offer new opportunities for improving agricultural systems and positively supplement traditional techniques. For instance, GM plants when specially adapted to local environmental conditions may considerably increase harvest success and help to feed a fast-growing population.

Not surprisingly, genetic engineering became an important but controversial socio-scientific issue with regard to ethical, social, political and economic questions. On the one hand, supporters emphasise huge benefits for farmers and consumers as well as even substantial environmental advantages, for example with regard to the potential reduction in pesticide pollution. On the other hand, opponents tend to put specific emphasis on hazardous risks and unpredictable long-term effects (Knight, 2009). Nevertheless, plant genetic engineering practices mainly affect industrial countries and emerging nations (James, 2012), while developing countries currently benefit only slightly. This dissemination raises the question whether world hunger really is a main focus of this technique or if it is simply a matter of financial gain. In Europe, the public debate over genetic engineering typically is accompanied by extensive reporting in the media. This journalism within a large volume of information often dramatises risk information, and therefore acts as a kind of risk amplifier (Frewer *et al.*, 2002). Owing to such possibly one-sided reports, a fair potential for misinforming the general public exists.

Public opinion towards genetic engineering differs widely: While the US public is relatively unconcerned (Sjöberg, 2008), Germans almost entirely oppose the issue. This is reflected by the fact that GM products (or products containing GM ingredients) in Germany by law require mandatory labelling whereas on the American market they do not (Gruère *et al.*, 2008). The results of the Eurobarometer survey in 2010 showed European opponents on average outnumbering supporters by far. Currently, in Europe, the level of support has dropped to the level measured in 1993 (Gaskell *et al.*, 2011). The US public is generally more supportive: In 2010, only one third of US consumers were concerned about GM products (Deloitte, 2010). In Germany, public rejection of genetic engineering is at a very high level and even impacts scientific research. Owing to restricted conditions, a substantial number of research groups as well as companies have scaled down their research activities or have moved abroad.

In educational contexts, teachers need to give attention to socio-scientific issues in order to prepare young students to become responsible members of society. Consequently, in Germany, national education standards demand socio-scientific issues to be included as essential parts of biology lessons in order to enable students to individually reflect on issues such as genetic engineering (Sekretariat der Kultusministerkonferenz, 2005). Regarding plant genetic engineering, students should not only understand the methodology, but also need to develop awareness about the public debate and the most relevant potential risks and benefits. Thus, specific knowledge about students' perceptions would help teachers in implementing appropriate teaching in classrooms.

Debates over genetic engineering have led to a number of studies on public perceptions. The most frequently reported perceptions were negative ones pointing to anxiety, anger and fear (WHO, 2005). For instance, fear about genetic engineering is positively influenced by consumer concern for the environment and negatively by faith in the technology of food production (Šorgo *et al.*, 2012). Industry representatives and scientists particularly suspect that education, simply by imparting knowledge, may substantially help to reduce individual fears about genetic engineering (House *et al.*, 2004; Connor and Siegrist, 2010). Nevertheless, factual knowledge alone may not have a large impact on perceptions of genetic engineering: Šorgo and Ambrozic-Dolinsek (2010) reported a substantially higher influence of perceptions than of knowledge on the acceptance of GM products. Other studies, however, did not support any relationship between knowledge and acceptance (e.g. Christoph *et al.*, 2008; Ekborg, 2008; Connor and Siegrist, 2010).

Verdurme and Viaene (2003) saw a knowledge increase not necessarily as leading to more positive perceptions or higher acceptance due to the fact that well-informed consumers ask more critical questions or that existing negative perceptions are strengthened by providing more information. Nevertheless, Gupta *et al.* (2012), in reviewing socio-psychological determinants of acceptance and perceptions related to emerging technologies such as genetic engineering, reported cognitive factual knowledge as one of the most often stated or cited determinants. In line with this, various further studies support the positive influence of knowledge on perceptions (e.g. Prokop *et al.*, 2007; Wnuk and Kozak, 2011; Fonseca *et al.*, 2012). Summing up these controversial findings, no clear answer about a potential knowledge impact on students' perceptions is currently possible.

Consequently, our present study focused on the investigation of students' perceptions of plant genetic engineering and the relationship to students' knowledge. We based our study on the research of Gebhard *et al.* (1994) which monitored young cohorts' hopes and fears with regard to genetic engineering and reproductive biology. Their mixed methods approach consisting of a quantitative and qualitative survey revealed hopes and fears as just moderately rated, on average. Hopes referred to the cure of diseases as well as to the optimisation of agriculture, but participants were very frightened of misuse of genetic engineering and of undesirable side effects. Gebhard *et al.* (1994) concluded that education in the context of genetic engineering, besides imparting knowledge, needs to acknowledge students' hopes and fears. Todt and Götz (1997) used a questionnaire to collect the most common hopes and fears as well as to evaluate the related risks. In general, their results were similar to those of Gebhard *et al.* (1994), with students expressing their hopes for the cure of diseases and being frightened of misuse.

Our study, in line with Gebhard *et al.* (1994), focussed on students' individual scoring of their hopes and fears on the one hand, and their associations regarding plant genetic engineering on the other. In contrast to Gebhard *et al.* (1994), we monitored a younger age-group (between 15 and 18 years of age) and focused particularly on plant genetic engineering. Besides the continuous debate about genetic engineering during the last two decades, scientific research has advanced and applications have been refined, thus leading to possible changes in students' perceptions. Considering students' knowledge regarding plant genetic engineering, we assessed their subjective and objective knowledge and analysed the relationship between knowledge and students' hopes and fears. Subjective knowledge refers to what students think they know about plant genetic engineering, while objective knowledge is defined as their real knowledge (Costa-Font *et al.*, 2008). It is important to distinguish between subjective and objective knowledge due to the fact that they might affect students' perceptions differently (House *et al.*, 2004; Connor and Siegrist, 2010). We posed three research questions: (a) how do students score their hopes and fears regarding plant genetic engineering; (b) what kind of associations do students have regarding plant genetic engineering, and (c) what kind of relationship exists between students' knowledge and their hopes and fears?

Methodology

We applied a mixed methods approach by combining qualitative and quantitative approaches (Johnson and Onwuegbuzie, 2004). Consequently, we used a two-part paper-pencil and-test based on the study of Gebhard *et al.* (1994). The quantitative part consisted of two 4-point Likert scales (no – little – some – much hope/fear) with which students rated their hopes and fears regarding plant genetic engineering. For the qualitative part, students were asked to write a short statement about their hopes and another about their fears. The qualitative analysis of these statements would provide a deeper insight into students' perceptions. In order to assess students' objective knowledge, a paper-and-pencil multiple choice questionnaire with 14 questions was used (Table 1). Additionally, students' subjective knowledge was surveyed with a 3-point Likert scale (ill-informed – moderate – well-informed) on which students rated their individual knowledge of plant genetic engineering.

Table 1: Sample questions from the multiple choice questionnaire completed by the students in the survey.

Question	Alternative answers
In Germany, GM foodstuffs:	(a) are prohibited goods (b) have to be labelled [correct] (c) are not sold (d) are banned export goods
What is the mandatory distance between fields with GM plants and fields with conventional plants?	(a) 15 metres (b) 150 metres [correct] (c) 1500 metres (d) 15000 metres

Source: own composition

Our sample consisted of 572 Bavarian tenth graders (final class of *Realschule* (professionally oriented secondary school), M = 16.7; SD = 0.7) from 29 different classes (quasi-experimental design). Gender was about equally distributed (51.2 per cent females). Since genetic engineering is a compulsory part of the Bavarian tenth grade curriculum (Bavarian Ministry of Education, 2008), a basic knowledge about the applications, risks and benefits of this technique was expected.

For statistical analyses, we applied parametric procedures by using PASW Statistics 18 (Version 18.0.0). Quantitative data were compared by using a paired t-test and a one-way ANOVA. For *post-hoc* comparisons of the one-way ANOVA, we used Hochberg's GT2 test procedure in consequence of different subsample sizes (Field, 2009). Effect sizes were calculated according to Field (2009), considering values of 0.10 as small, of 0.30 as medium and of 0.50 as large effect (Cohen, 1992). Correlation analysis was performed applying Pearson's or Spearman's correlation coefficient according to the respective assumptions. Reliability analyses of the Likert scales resulted in Cronbachs' alpha scores of 0.85 for both scales, and of 0.74 for the knowledge questionnaire.

The qualitative data analysis followed the approach of Mayring (2008), iteratively categorising individual statements and following the method of inductive category development.

Results

In general, the individual scores of hopes and fears were low (hopes: M=2.01; 95% CIs [1.95-2.08]; fears: M=1.71; 95% CIs [1.65-1.77]). Most students (45.8 per cent each) rated both hopes and fears as low. Almost 28 per cent of the students reported no hopes and 43 per cent reported no fears, respectively[1]. About 24 per cent reported some hopes, while a mere 2.4 per cent scored high. About 11 per cent reported some or much fear (Table 2). When comparing all scores, hopes were significantly higher than fears ($t(571)=7.029$, $p<0.001$, effect size $r=-0.28$). Moreover, no correlation between both Likert scales was observed (Pearson's correlation coefficient $r=0.04$, $p=0.294$).

After the categorisation process, we extracted five main categories for hopes and four for fears. Consistency among raters was investigated by an intra- and inter-rater reliability analysis using Cohen's kappa statistic (based on 10 per cent of participants (randomly selected)) (Cohen, 1960). For the Cohen's kappa scores, see Table 3. According to Landis and Koch (1977), our Cohen's kappa scores can be regarded as 'substantial' (0.61-0.80) to 'almost perfect' (>0.80). Categorisation of students' statements was done according to our category system, while one statement could have been classified into several categories.

The most frequent categories mentioned for hopes were *farmers*, *world hunger* and *progress* (Table 4). The categories *consumers* and *environment* each accounted for more than 10 per cent of all statements. Fears often described *hazardous risks*, *human health* and *environmental impact*, while *ethics* only was listed by 7.6 per cent of all statements. Some rare statements did not match our main categories and these were collected into the category of 'others' (less than 2.5 per cent each). Note that about 50 per cent of the students did not give any statement on hopes (n=209) and about 43 per cent on fears (n=141) and these subsamples were excluded.

The most frequent combinations of categories were *world hunger+human health* (20.0 per cent) and *farmers+hazardous risks* (11.4 per cent). The combinations *farmers+human health* and *farmers+environmental impact* were often mentioned as well (each 9.5 per cent).

Analysis of students' subjective knowledge revealed that only 6 per cent of the students felt well informed, while 46 per cent felt moderately informed and 48 per cent ill informed. Considering the between-group comparison with regard to students' scoring of their hopes and fears, students' hopes differed significantly (ANOVA: $F(2, 561)=6.932$, $p=0.001$, $r=0.16$; Figure 1). *Post-hoc* comparisons using Hochberg's GT2 test procedure indicated that the well informed group rated their hopes significantly higher than the other groups. However, the ill informed and the moderately informed

[1] For the subsequent qualitative analysis, all students without hopes (n=158) or without fears (n=246) on the rating scale (quantitative part) were excluded as they did not write any statements.

Table 2: Distribution of Bavarian tenth graders' hopes and fears regarding plant genetic engineering (percentage of all answers; n=572).

Rating	Hopes (%)	Fears (%)
No	27.6	43.0
Little	45.8	45.8
Some	24.1	8.7
Much	2.4	2.4

Table 3: Cohen's kappa values for the intra- and inter-rater reliability analysis of the category system for the qualitative analysis (based on randomly selected 10 per cent of participants).

Perceptions	Cohen's kappa	
	Intra-rater reliability	Inter-rater reliability
Hopes	0.96	0.87
Fears	0.95	0.69

Table 4: Percentage of the main categories of Bavarian students' (a) hopes (n=205) and (b) fears (n=185) with regard to plant genetic engineering (percentage of all answers, one answer could have been classified into several categories), and exemplary excerpts for each category.

	Category	Percentage	Excerpt
Hopes	Farmers	40.0	"By using green genetic engineering farmers can be sure that their crops are bountiful and that they will not have any crop failures".
	World hunger	28.3	"Since production will increase, there will be more food. Thereby world hunger could be reduced".
	Progress	23.9	"Changes through green genetic engineering will facilitate a better life on earth".
	Consumers	11.2	"Consumers will get more and better products at cheaper prices".
	Environment	13.7	"Green genetic engineering could be applied for pest control without using chemical pesticides".
Fears	Hazardous risks	42.2	"Unpredictable side effects could appear, maybe years later when it is already too late".
	Human health	41.6	"We cannot know if the modified genes in plants will have any negative impact on human health".
	Environmental impact	53.1	"Nature could be damaged permanently through green genetic engineering".
	Ethics	7.6	"Through genetic engineering genes are modified, but humans should not interfere with nature".

Source: own composition

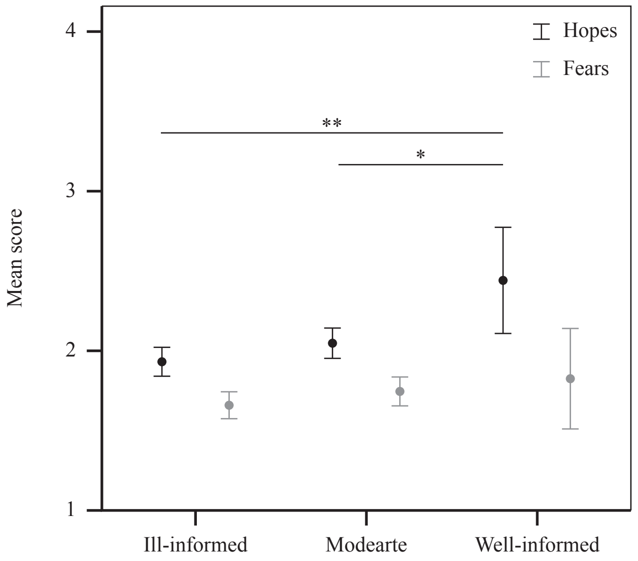

Figure 1: Comparison between ill informed, moderately informed and well informed groups of Bavarian students of the rating of their hopes and fears regarding plant genetic engineering (n=564).
Error bars represent 95% confidence intervals.

groups did not significantly differ with regard to their hopes. The relationship between subjective knowledge and students' hopes was significant (Spearman's correlation coefficient r=0.12, p=0.005). The scoring of students' fears did not differ significantly between the three groups of subjective knowledge (ANOVA: F(2, 561)=1.396, p=0.249; Figure 1) and the correlation analysis revealed no significant relationship (Spearman's correlation coefficient r=0.06, p=0.145).

Students' objective knowledge, according to the results of the multiple choice questionnaire, was rather low (M=5.30; 95% CIs [5.13-5.47]). Our analysis revealed no significant correlation between students' objective knowledge scores and their scoring of hopes and fears (Pearson's correlation coefficient: hopes: r=0.06, p=0.190; fears: r=0.08, p=0.070), but the relationship between students' subjective and objective knowledge was significant (Spearman's correlation coefficient r=0.16, p<0.001).

Discussion

The main focus of our study was students' scoring of their hopes and fears (quantitative) as well as their associations with plant genetic engineering (qualitative). It was surprising how low hopes and fears scored regarding plant genetic engineering issues. About three-quarters of our students did not report any hope or, at least, scored it very low. Similarly, nearly 90 per cent did not report any fear or just low fears, respectively. This level in both perceptions was quite unexpected, especially in view of the high topicality of plant genetic engineering and the continuing presence in public media. Nevertheless, it is quite in line with Gebhard *et al.* (1994) who about two decades ago described a similar pattern: In that study a high percentage was low scoring in both the hope and the fear domain as well. Nevertheless, two decades of intensive controversial discussion raised expectations in producing impacts in our target perceptions. One reason for not doing this may lie in the high rejection rate of German consumers which maybe prevents any contact with this issue. In fact, the issue of plant genetic engineering may not play an important role in our students' daily life. The lack of relevance or a low interest and limited knowledge about this issue may provide a possible explanation. Additionally, students may simply be tired of reflecting about this issue, as Gebhard *et al.* (1994) already had hypothesised.

Furthermore, a general uncertainty about this issue may provoke our low scoring of hopes and fears. Poortinga and Pidgeon (2006) monitored opinions about GM food and rated about half of their participants as ambivalent towards support of or opposition to GM food, so that as a consequence the majority had an undecided position. Individual hopes scored significantly higher than fears (medium effect). While a quarter of all our participants reported some or much hope, only about 10 per cent reported high fear. This proportion, however, is quite in contrast to earlier studies where anxiety, anger or fears were always dominant variables (e.g. Laros and Steenkamp, 2004; Šorgo *et al.*, 2012). However, the percentage of the highly scoring hopes is similar to Gebhard *et al.* (1994) (about 25 per cent each), although their percentage of high fears was four times higher than ours (40 per cent to 10 per cent); this discrepancy may point to a strong decrease of students' fears during the last two decades. Today, we need to take into consideration that plant genetic engineering is not as new and unknown as it was 20 years ago. Therefore, nowadays students are more familiar with the discussion about this issue and the associated risks. Additionally, governmental control and legal regulations in Germany may have been conducive to decreasing fear. Laros and Steenkamp (2004) found a positive influence on the fear of genetic engineering of consumers' concern for the environment, and a negative influence of faith in the technology of food production. Referring to our results, this explanation would point to a low concern for the environment and a high faith in technology of our students. Unfortunately, in our present study we did not include a measure of adolescent environmental attitudes or behaviour as it would be available in the established 2-MEV scale or the GEB-scale (Bogner and Wiseman, 1999, 2006; Kaiser *et al.*, 2007; Roczen *et al.*, 2013).

The lack of correlation between hopes and fears suggests independence of both variables and supports their two-dimensionality. Most studies dealing with perceptions on genetic engineering prefer the independent measuring of positive and negative perceptions (e.g. risks and benefits; Siegrist, 2003; Poortinga and Pidgeon, 2006; worries and benefits; Stewart and McLean, 2008). Eiser *et al.* (2002) reported trust and risk perceptions as independently influencing attitudes towards particular food technologies. Based on the controversial discussion about plant genetic engineering, we presume such an independence of hopes and fears.

A statements analysis revealed for about half of our students no relevant associations towards plant genetic engineering: Either they were overwhelmed by this task, or writing a statement was of no importance for them, just reflecting their low rating of hopes or fears. Most associations of students' hopes dealt with economic advantages for farmers and consumers as well as with the general fight against world hunger. Another frequently mentioned category was *progress* by referring to general improvements and the facilitation of a better life on earth. These findings reflect the full range of aspects and arguments represented in the public debate. Similar to Gebhard *et al.* (1994), we found a high percentage of students referring to economic aspects, suggesting that students may take up the common position of genetic engineering supporters who promise high yields. The same holds true for the category *world hunger* as it, too, is an often mentioned argument of supporters. The societal benefit of fighting world hunger makes genetic engineering more acceptable and leads to the acceptance or even ignorance of fears since the trade-off is seen as advantageous enough (Stewart and McLean, 2008).

Our categories were similar to those of other studies (e.g. Knight, 2009). For instance, Massarani and Moreira (2005) conducted focus group discussions about the most important advantages of genetic engineering among Brazilian students concluding two main categories: increased productivity and the elimination of world hunger. Hill *et al.* (1999) reported for different age cohorts (age 11-12, 13-14 and 15-16 years) almost no change in individual perceptions. Such surprising constancies are quite in line with other studies in the environmental perception sector (e.g., Bogner, 1998; Kaiser *et al.*, 2013). Within the close field of our study, our results additionally appear similar to those obtained in other countries and other age groups. Interestingly, about 15 per cent of our students also expressed hope for positive effects on the environment (e.g. pest control without using chemical pesticides), in spite of the fact that the general public usually associates genetic engineering with a negative environmental impact (e.g. the hybridisation of GM plants with wild species). Those uncommon associations of students may indicate a more in-depth knowledge about GM plants within this specific subsample.

The most frequently stated fears reflected the common arguments as they feature in the public debate: Negative effects on human health, general hazardous risks such as unpredictable long-term effects as well as negative environmental impacts. Consequently, our categories of fears match other studies' findings (e.g. Todt and Götz, 1997; Ekborg, 2008). Stewart and McLean (2008) describe fears as the dominant emotion driving public opinion on genetic engineering. The potential environmental impact and possible personal risks are so drastic that fear plays an important role in the rejection of this technology (Stewart and McLean, 2008). In contrast to our results, Gebhard *et al.* (1994) reported a high percentage of participants being frightened of any misuse, concluding that genetic engineering is assessed positively in general but could develop negatively if falling into 'wrong' hands or getting out of control. This may indicate a general suspicion towards science and industry (Christoph *et al.*, 2008). Additionally, a lack of trust in food production processes and controlling institutions might be relevant (Pardo *et al.*, 2002; Stewart and McLean, 2008). Generally, students' fears focused on risks and possible negative effects, while ethical aspects such as interference with nature or religious reasons were mentioned only rarely.

Interestingly, the ambivalence of students' scoring of hopes and fears is apparent in their statements as well. The most frequent combination of categories is *world hunger* and *human health*, thus emphasising the conflict between possible societal and economic benefits, on the one hand, and potential personal health risks, on the other hand. Students' individual trade-off between both positions is crucial for their opinion making and their acceptance of plant genetic engineering (Stewart and McLean, 2008). Unfortunately, a measurement of acceptance was not included in our study and this would need consideration in further studies.

Subjective knowledge regarding plant genetic engineering was rated rather poor, only 6 per cent felt well informed; in contrast, nearly half of the students assessed themselves as ill informed. The first score is in contrast to Gebhard *et al.* (1994) where about a quarter of their sample announced a 'well informed' (24 per cent). Pardo *et al.* (2002) investigated the awareness and knowledge of genetic engineering in Europe and reported for 80 per cent of their sample a partial or minimal information level. Therefore, it was not surprising how low subjective knowledge was rated by the students, thus indicating a need for broader educational efforts in order to equip students with specific knowledge about plant genetic engineering. In line with this, students' objective knowledge scored rather low and correlated positively with the subjective knowledge, thereby showing that students assessed their own subjective knowledge exactly. Brucks (1985) and House *et al.* (2004) proved this correlation between objective and subjective knowledge in their studies as well. In contrast to the objective knowledge which bears no relationship to students' perceptions, the subjective knowledge significantly correlated with hopes: well informed students scored their hopes higher than moderately and ill informed counterparts. This relationship points to the specific importance of education in this context (see below). Gebhard *et al.* (1994) reported a similar relationship between subjective knowledge and hopes, on the one hand, and fears on the other. Furthermore, Pardo *et al.* (2002) detected corresponding effects when analysing the influence of subjective knowledge on peoples' perception of benefits and risks.

Focusing on the relationship between objective knowledge and perceptions, we are in line with several other studies reporting no significant correlation (e.g. Christoph *et al.*, 2008; Connor and Siegrist, 2010). The different effects of subjective and objective knowledge on perceptions of genetic engineering were reported in some other studies comparing both knowledge types (e.g. Costa-Font *et al.*, 2008; House *et al.*, 2004).

Conclusion

Commonly it is questionable whether factual knowledge alone can cause significant changes in the perceptions of genetic engineering and in the acceptance of GM products. Ruddell (1979) assumed that education in nutrition might reduce consumers' reliance on general information and increase the number of arguments involved in decision making, but will not initiate any changes in consumers' individual perceptions. Our data, however, strongly support for subjective knowledge a significant relationship to hopes by failing to interfere with fears; this is not true at all for objective knowledge. Therefore, educational efforts need to achieve both: the increase of knowledge about genetic engineering techniques and the addressing of students' perceptions in order to help them to find their individual positions on this issue. In this context, it is necessary to give attention to students' hopes and fears. Our study shows hopes and fears as generally based on the common arguments as pointed out in the public debate. Although the level of hopes was significantly higher than fears, most students were ambivalent in both their ratings and their associations, thus emphasising that there is need for further information on this socio-scientific issue.

Implications for teaching

In order to address both teaching factual knowledge about genetic engineering and acknowledging individual perceptions as well, we strongly suggest incorporating hopes and fears when building upon a solid fundamental knowledge base. Specific actual issues in the field of plant genetic engineering, for instance, the recent case of the GM potato 'Amflora', are excellent stepping stones to building upon everyday issues and might help to address individual hopes and fears. Consequently, hopes and fears which we have shown to be unrelated could be connected. The most important guideline for teachers is to handle this issue in a neutral manner, in order to encourage students to define and develop their individual points of view within this complex matter. Education should not interfere with pro- or contra-positions, it should support a student's critical thinking. Knowledge about individual hopes and fears for sure help teachers to provide appropriate lessons.

Further research needs to extend our present study: For instance, the acceptance of genetic engineering needs integration as well as environmental attitude and behaviour frameworks do (see above: Šorgo *et al.*, 2012). Considering our rather young age group, we assume an ongoing process of forming own opinions, thus the age group of undergraduates and graduates is expected to add further insights into the issue of this present study.

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