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ABSTRACT

This paper describes a German project that developed students' capabilities for understanding and valuing biotechnology and genetic engineering, focusing on practical fieldwork with schools by an interdisciplinary team. The paper identifies the characteristics of individual and structural preconditions and their development during active project work within the schools. Project work was organized into five phases that involved contacting the schools, building confidence, initiating project work, integrating researchers as participant observers, and terminating the project. Researchers developed surveys for students and teachers, taking into account recent research on school culture. The surveys examined formation of concepts in natural sciences; views on science, technology, and society; and school culture. Results indicated that in all types of secondary schools, formation of concepts was not sufficiently clear or in-depth. The knowledge base on modern technologies was almost totally dependent upon secondhand information from the media for both teachers and students. There was very little inservice training for teachers of biology and related subjects. The gap between present preconceptions and attainment targets was evident when examining questions on school culture. There was general contentment with school life, though students tended to be critical of preparation for responsible citizenship. (Contains 9 tables, 8 figures, and 19 references.) (SM)

The Development of Mature Capabilities for Understanding and Valuing Technology through School Project Work

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Introduction

In 1996 we have started a research project, funded by the Federal Ministry of Education, Science, Research and Technology. Research interest is focused on the development of students' capabilities for understanding and valuing biotechnology and genetic engineering. It is called „schools ethics technology" (SET), consisting of 2 building blocks: (1) a theoretical approach by the Tübingen Centre for ethics in the sciences to form the new school subject „ethics" and develop concepts for educating teachers for this subject, and (2) practical field work with schools by an interdisciplinary team from Heidelberg and Tübingen. This article concentrates on the latter aspect.

The pedagogic considerations for the planning of project work took into account the general underlying theory of stages of social cognition by Selman (1984) and the proposals of Conway and Riggs on "valuing in technology" (1994). Recent findings, that students' views on modern technologies are driven by socio-moral considerations rather independent of factual knowledge give support to our concept (Keck & Renn 1999). The interdisciplinary research group is composed of researchers from the Centre for Ethics in the Sciences at Tübingen University (R.Wimmer, J.Dietrich, F.-T.Hellwig) and from the Faculty of Mathematics and Science Education at University of Education Heidelberg (M.Schallies, A.Wellensiek, A.Lembens). Further, there are co-operating partners in project work from the University of Heidelberg (M.Brumlik, faculty of social- and behavioural sciences) and the University of Hamburg (U.Gebhard, faculty of education, chair for didactics of natural sciences education).

The research project can be seen embedded in the ongoing discussion about the quality of science education, STS- and SATIS- approaches to science teaching and shortcomings of traditional ways of teaching science (Schallies & Wellensiek 1995).These usually concentrate on facts and figures, not taking into account that valuing modern technologies requires also higher competencies. We define competencies as fully developed or mature capabilities for

decision-making and ethical reasoning (K.Platzer, 1999)

description of the object or subject matter
evaluation of appropriateness
    function
    safety
    economics
evaluation of ethics-related criteria
    man-related considerations
    environment-related considerations
    social considerations
    future
rules for balancing opposing needs and obligations
    weighing up alternatives
    minimising unwanted outcomes
    consequences of inaction

decision-making and ethical reasoning (B. Skorupinski 1999)
Scientists are especially qualified and have a responsibility to make statements about new technological developments because they father them and therefore have a greater understanding of them. However, to value aims, goals and consequences with regard to their desirability or acceptability scientists have by no means greater competence or authority than other citizens.
stages of moral development of individuals (M.Brumlik, 1999)
• pre-conventional: individual profit or diminution of burden • conventional: in societal neighbourhood accepted rules • post-conventional: result of a reflective process
" appropriate understanding" of biotechnology / genetic engineering **(A.Wellensiek 1998; J. Dietrich 1998)**
is knowledge of facts, understanding of how to use them, and need ethics for the reflective processes and use it deliberately is understanding science as a methodical endeavour to achieve knowledge and a human activity with effects on society, and dependant on institutions is understanding problems of technologies as interdisciplinary, and to solve them in that manner is to know the difference between technology-orientated and problem-orientated approaches and to put them into practice

Table 1: definitions relevant to „understanding and valuing in technology"

understanding and valuing in the following way: as the ability

- to recognise science as a methodical endeavour for knowledge and a social system for acting
- to recognise problems in the field of new technologies as interdisciplinary problems which could be solved only in an interdisciplinary effort
- to identify and take into account the difference between technological approach and problem orientated approach for solving problems and to use besides factual and instrumental knowledge purposefully ethics as a means of reflection.

This definition emerged from the discussions within our interdisciplinary group and amalgamates concepts from totally different disciplines: (1) the concept of ethics **in the sciences** as a problem-orientated approach to solve real life problems , e.g. exemplified in decision-making and ethical reasoning towards practical tasks of applying biotechnology and genetic engineering in agriculture (Skorupinski 1999), (2) the concept of technology assessment as a problem-orientated approach for shaping a technology appropriately before implementation, not for minimising unwanted effects after implementation has taken place (Platzer 1999), (3) concepts of teaching chemistry and biology (Schallies & Wellensiek 1995) and (4) the considerations of pedagogy – which go back to Kohlberg - that judgements are made corresponding to moral development of individuals (Brumlik 1999). Table 1 gives an overview on the definitions taken from the respective literature.

The definition given above for mature capabilities could be seen as a general attainment target of education preparing school graduates to become for responsible citizens in a participatory democratic society. With this goal in mind it is the aim of our research to describe and identify the characteristics of individual and structural preconditions and their development during active project work in schools.

General organisation of project work with schools

For taking up contact to schools, the geographically well defined „BioRegion“ across the three Länder Rheinland-Pfalz, Hessen and Baden-Württemberg in southern Germany was chosen. It is a centre for research and industry in the field of biotechnology. Partners of BioRegion are university of Heidelberg, Fachhochschule Mannheim, German Cancer research Institute, European Laboratory for Molecular Biology, Max-Planck-Institute for Research in Medicine, BASF/ Knoll AG, Boehringer Mannheim, Merck Darmstadt, the research institute

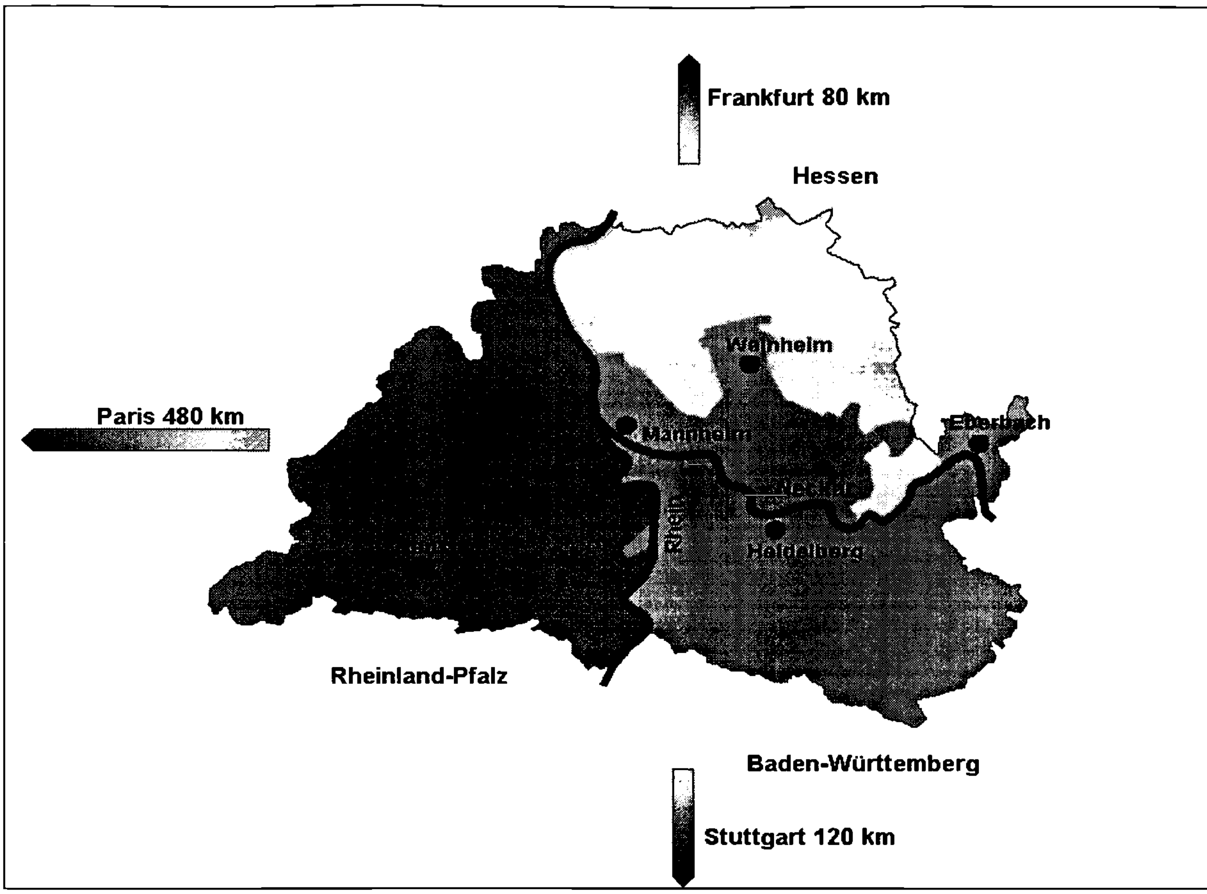

Figure 1: The BioRegion Rhein-Neckar-Triangel

of the protestant church at Heidelberg and about 30 small and medium enterprises. There are 255 secondary public schools situated here. All were approached by circular mail with information about the proposed project „schools ethics technology“, and they were offered to fill in an application form for participation. It was made clear in the mailing that in a “school project” each school is looked upon as an educational unit. Therefore not singular activities of specific teachers were required, but coordinated efforts across grades and subjects.

Parallel activities were started to establish a network of institutions (private, political and governmental) and industrial firms who would be willing to take a part during the project as external experts or external learning locations, thus offering a range of possibilities for schools to choose from. From the beginning it was made clear to everyone that all activities and decisions for co-operation were to be made on a basis of free and mutual commitment.

Research methodology

The research methodology corresponds to the current standard of field research in education, comprising a mixture of qualitative and quantitative methods (i.e. participant observation; questionnaires; video documentation; portfolios). Project work during 1996-1999 was organised in 5 phases: (1) take up of contact with the individual project school, (2) build-up of confidence between students, teachers and researchers, (3) initiation of definite school project work, (4) integration of researchers as participant observers into the field, (5) termination of school project work and evaluation. The role of participant observers is unstructured, flexible, with no specific role taken during research (Lamnek 1995). In this research paradigm it is essential to analyse the situation in which the specific observation was made or the material or research document was generated (Friebertshäuser 1997). Triangulating the observations made by different researchers and by employing different methods is a means to generalise observations or generate theories. The research design employed in this project and underlying theory have already been discussed (Schallies & Wellensiek 1997; Schallies 1998; Wellensiek 1998; Lembens 1998).

In this paper the data obtained by questionnaires will mainly be discussed giving insight into structural and individual preconditions. (The qualitative data will be discussed in the paper Wellensiek, Lembens & Schallies, this Journal).

Three questionnaires (students grade 5-8; students grade 9-13; teachers) were designed, taking into account recent findings of research into „school culture“ and orientated towards the questionnaires used by Ben-Chaim & Zoller (1991) and the „VOSTS“ instrument of Aikenhead, Ryan & Fleming (1989).

There are three main parts to the questionnaires: (1) formation of concepts in natural sciences, (2) views on science, technology and society and (3) "school culture". (This term denotes the range of teaching methods used, the ways of introducing subject content, the range of authentic learning opportunities offered, style of administration, internal flow of information and co-operative action across subject border (Holtappels 1995). A preliminary study in a school not taking part in the actual project had shown that the items were appropriate to the chosen groups respectively.

Distribution of schools

In the BioRegion there are 255 secondary public schools according to the following distribution in the differentiated German school system (table 2). Of these, 45 responded to the mailing in the following distribution: 2 Hauptschulen, 8 Realschulen , 12 Gymnasien and 8 Gesamtschulen (see table 2).

The reason for this is obvious, since at first glance biotechnology / genetic engineering seem to be topics for courses in Biology, grade 13, Gymnasien.

Land	Hauptschulen (secondary schools with practical bias)	Realschulen (secondary schools with intermediate technical bias)	Gymnasien (secondary schools with academic bias)	Gesamtschulen (comprehensive schools)
Baden-Württemberg	76	30	37	2
Hessen	6	11	9	5
Rheinland-Pfalz	41	15	23	0
total	123	56	69	7

Table 2: schools in the BioRegion Rhein-Neckar-Triangel

Process of application / selection of project schools

A first contact was made individually with every school that had responded. The aims of the proposed project were explained, whenever possible to the entire school conference; attainment targets and educational programs were discussed; "fears" towards extra activities and internal reorganisation processes in schools had to be taken care of; uncertainties of the role of industry and their interest in project work were uttered.

In the next step all interested parties were invited to a general conference to have an open discussion with one another and the research team. 80 participants from schools (teachers, headmasters, students, parents), educational authorities, science research institutes, industries of the BioRegion, environmental protection groups and church organisations took part.

A date for final application to participate in the school project was arranged. From the remaining group of applicants 10 schools were chosen with an even distribution according to Länder, type of school and rural/ municipal area. Their basic data are as follows (tab. 3). Project work in schools was to last one whole year.

	Hauptschulen	*Realschulen*	*Gymnasien*	*Gesamtschulen*
project SET	1	3	4	2

	Baden-Württemberg	*Hessen*	*Rheinland-Pfalz*
project SET	4	3	3

Table 3: distribution of schools according to type and Länder

Project schools vary greatly in size and participation in active project work, depending on present „school culture". ("School culture" is a term that puts together the range of methods for teaching applied, the opportunites for partaking in decision making concerning school life for both teachers and students, flow of information, etc.). The rate of participation in the questionnaire survey may serve as an indirect indicator of involvement, since the schools decided themselves how many questionnaires were needed and which classes and grades were taking part (school authorities and school conference had to give approval). A total of 3081 students and 94 teachers filled in the questionnaires. Both comprehensive schools had low participation rates compared to the other types of schools.

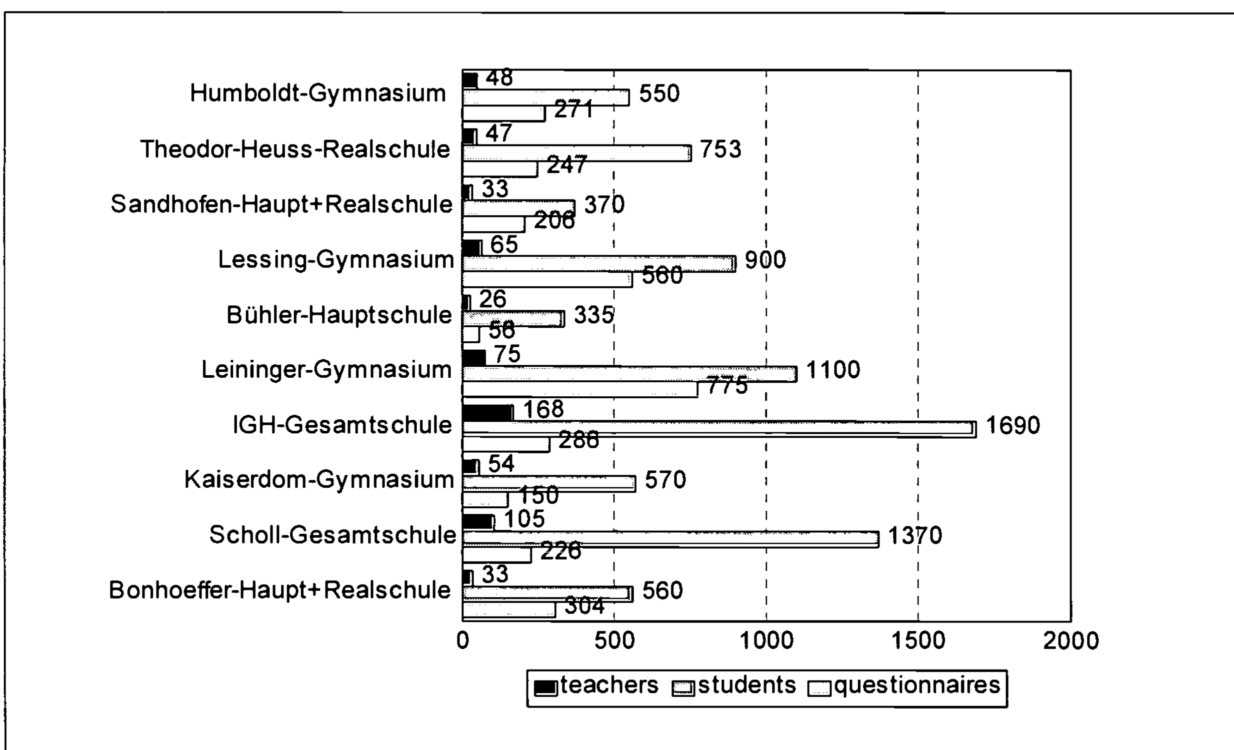

Figure 2: basic data of schools and participation rates (questionnaires)

Results from questionnaires

Since we have an underlying developmental theory on learning, questionnaires were evaluated according to age, and clusters were formed 10 to 12, 13 to 15, 16 to 18 and 19 to 21 years of age respectively.

Q9: *Give a short description of the term " technoloy".* In the German language there is a difference between "Technik" and "Technologie". "Technik" is defined as the creation of products, devices or processes by applying empirical knowledge and knowledge based on scientific discovery. This corresponds to the definition of technology given by Naughton (1994): "technology is the application of scientific and other knowledge to practical tasks that involve people and machines". "Technologie" however is seen as a doctrine of the development of "Technik" in its societal context (Römpp 1995).

In short technology is thought to combine with products and processes on one hand, and to be driven by developments of science in a societal context on the other hand. For a large proportion of the students „technology" is just another word for „Technik" (20.2%), the rest have product- (8.8%) and process-orientated imaginations (13.1%), in neutral connotations, or technology is a metaphor for future / progress (11.1%). A high proportion of the students did not answer (19.3%) or did not know (9.7%).

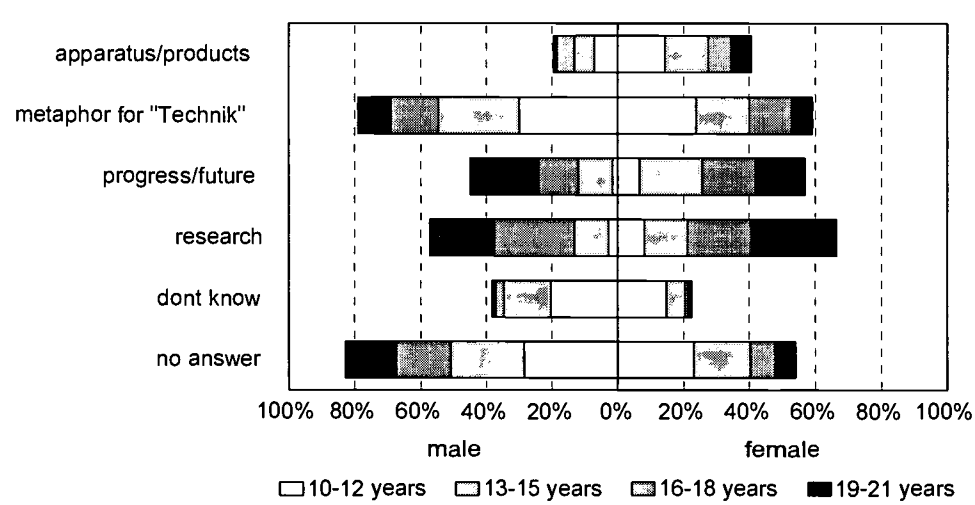

Figure 3: (Q7) Give a short description of the term „technology"

Also, for a high proportion of the students „biotechnology" is just a combination of two terms which can be explained by the individual meanings of biology and technology (26.7%). A very high proportion cannot answer (28.1%) or does not know (13.8%). There is some vague connection to research and knowledge (6.2%). Compared to Q7 and Q8 more students have more definite ideas about the meaning of the term „genetic engineering" like „experiments with genetic material" (20.5%), „cloning" (14,7%) or applications in foodstuffs and agriculture (fig. 4).

With regard to factual knowledge students feel themselves rather badly informed. Only a tiny minority declares himself/ herself as very well informed or well informed. There is a gender difference noticeable and of course an age dependency (fig. 5). Source of information is the media mainly (tab. 4).

Interestingly, the term „ethics" is equally vague in meaning for students as are the technological terms: „ethics" is defined as „just another school subject, equal to religious instruction" (11%) or "same as religious instruction" (11%); 20% of the students could not give an answer to Q 10 „What do you associate with the term ethics?".

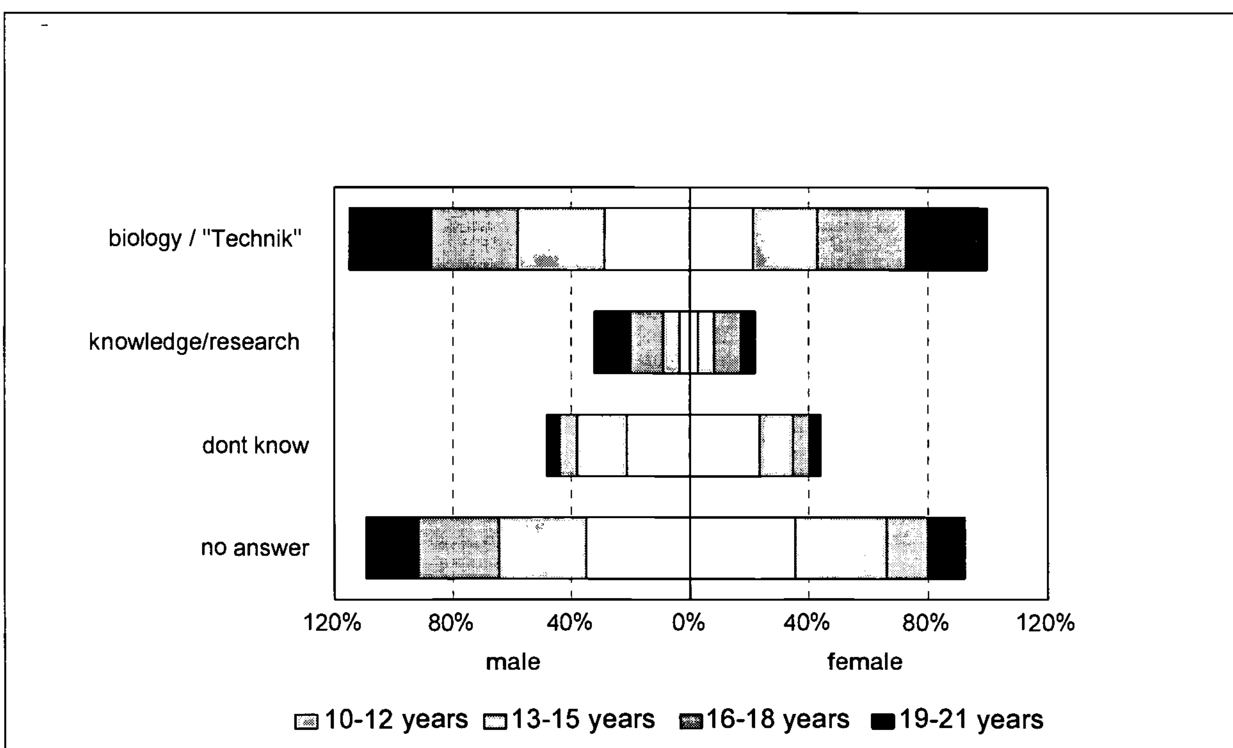

Figure 4: (Q8) What do you associate with the term "biotechnology"?

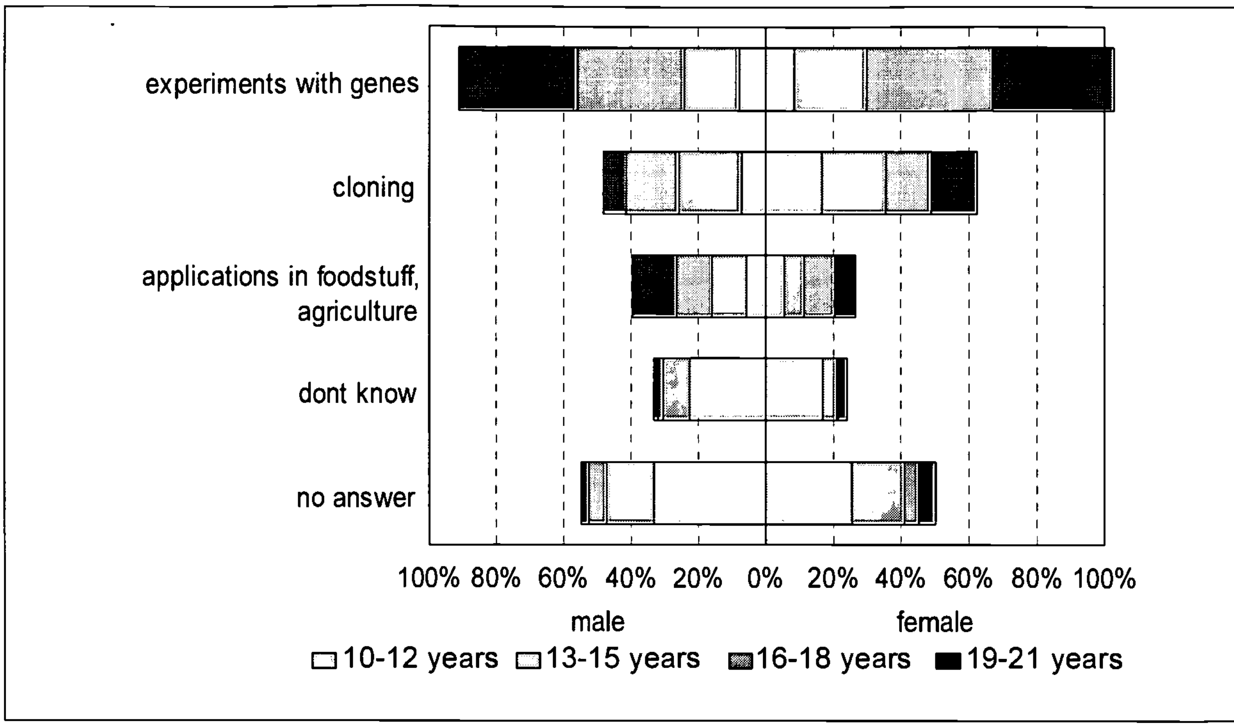

Figure 5: (Q9) What do you associate with the term „genetic engineering?"

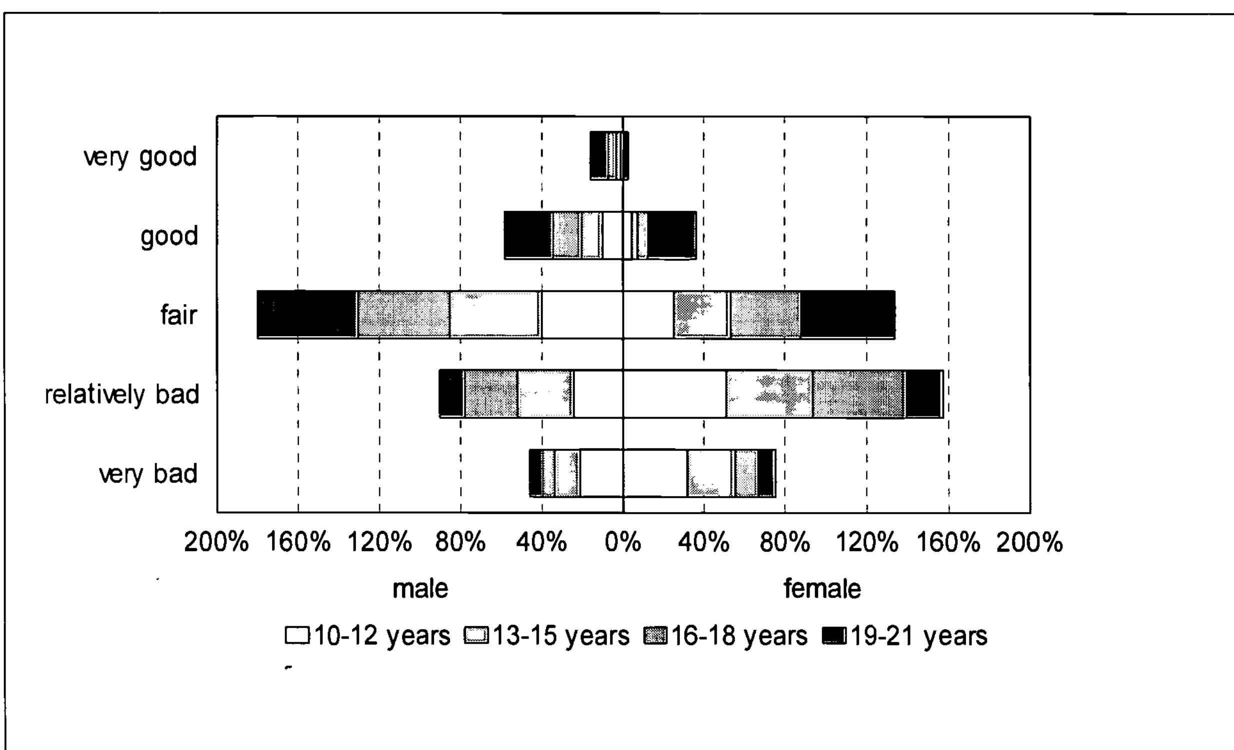

Figure 6: (Q18) How do you rate your understanding of biotechnology / genetic engineering?

The most important source of information for both students and teachers is the media (TV and print media) (tab. 4).

sources of information	**grades 5-8 [%]**	**grades 9-13 [%]**	**teachers [%]**
school	10.0	29.1	–
media	45.6	54.7	73.4
parents/relatives	6.1	2.5	–
peer group	0.3	0.3	–
SET	0.3	0.5	–
other	4.0	3.0	–
no source	17.9	4.3	–
no answer	15.8	5.6	–
pre-service	–	–	5.3
in-service	–	–	9.6

Table 4: sources of information on biotechnology / genetic engineering

Value judgements and views on science, technology and society

The leading question to these aspects was derived from the discussion of Conway & Riggs on "which technology and why". They have formulated the implicate educational goal as follows: *"...(students) become aware that technology is used to make judgements about other people; it is easy to assume that a society without "high" technology is more "primitive" merely because its level of technology is generally lower than ours. Yet often a lower level of technology may still incorporate a fine balance of needs and available resources. Students soon realise that the assumptions they have about the needs of other people must be challenged."* This might be interpreted as a problem-orientated approach for technology assessment in the sense of Platzer.

In the questionnaire two photographs were offered to gain some insight into „which technology and why“: one showed a high-tech tractor in the field, the other a farmer with an ox-plough. Students were asked in the open question to decide which would be the more reasonable solution, and explain why.

The majority of the younger students prefer one dimensional decisions, either pro tractor or pro plough, with definite arguments such as "ox-*plough because its environmental friendly"* (grade 8; f) or *"tractor, because one just has to sit and pay attention where to go"* (graded 5, f). Across the total student population there is also a preference for tractor predominant (*„tractor, because one can cultivate the fields more intensely and get a pay-back of costs through high productivity*" (grade 11; m). Female students prefer open context dependant decisions with a balance of arguments, e.g. "*for every country one solution is best. A farmer in*

Africa would not buy a tractor because he would not be able to bring in a return that would pay back costs. For farmers in Europe an ox-plough would be unthinkable because he would not be able to till the large fields" (grade 13; f). The types of arguments can be categorised in order of frequency rank according to the aspects (1) efficiency of work, (2) nature / environmental protection and (3) economy.

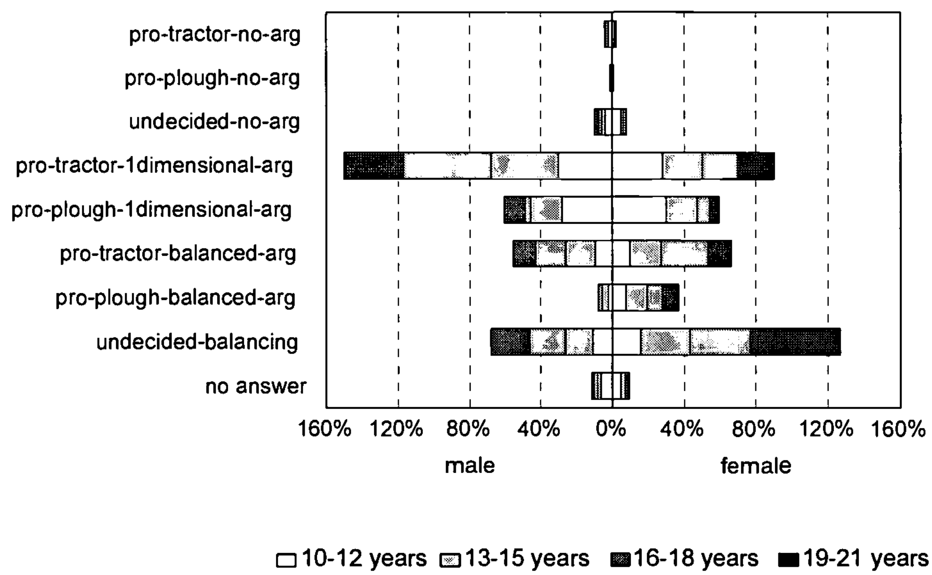

Figure 7: (Q23) tractor or plough? Analysis of argumentation

Questions 24 to 31 were taken from the VOSTS instrument, translated into German and modified where necessary. Only question 25 was given to all grades; the others were given to grades 9-13 only (n=1317; 730 f + 587 m). For the question "Who should decide on the future applications of biotechnology?" (VOSTS 40213) there are 7 statements offered to choose from. To the original statements we had added another statement corresponding to the formulation of Skorupinski on decision-making and ethical reasoning. The great majority of students only chose statements that implied participation of citizens in decision-making, i.e. statements C,D,F. The statements only differ in the rank of participation of scientists compared to citizens, i.e. all to decide, but with a primate of scientists (C), all to decide with no primate of any group (D) or all to decide, but primate to citizens (E). There is an age-dependant trend towards (D).

Scientists and engineers should be the ones to decide on future applications of biotechnology / genetic engineering, because scientists and engineers are the people who know the facts best.	
Your position, basically: (Please read from A to J, and then choose one.)	
Scientists and engineers should decide:	%
A. because they have the training and facts which give them a better understanding of the issue.,	3.8
B. because they have the knowledge and can make better decisions than government bureaucrats or private companies, both of whom have vested interests.	3.0
C. because they have the training and facts which give them a better understanding: BUT the public should be involved – either informed or consulted.	27.4
D. The decision should be **made equally**. Scientists are especially qualified and have a responsibility to make statements about new technological developments because they father them and therefore have a greater understanding of them. However, to value aims, goals and consequences with regard to their desirability or acceptability scientists have by no means greater competence or authority than other citizens.	23.1
E. The **government** should decide because the issue is basically a political one; BUT scientists and engineers should give advice.	2.5
F. The **public** should decide because the decision affects everyone; BUT scientists and engineers should give advice.	15.4
G. The **public** should decide because the public serves as a check on the scientists and engineers. Scientists and engineers have idealistic and narrow views on the issue and thus pay little attention to consequences.	4.1
H. I don't understand.	2.2
I. I don't know enough about this subject to make a choice.	8.2
J. None of these choices fits my basic viewpoint.	2.5

Table 5: "Who should decide on future applications of biotechnology / genetic engineering?"

Students' opinion on the effects of influence of new technologies on the labour market (Q 29; VOSTS 40521) give a mirror image of present controversial public debate: optimists' and pessimists' views are about equal (30.6% vs. 27.6% respectively).

Industries in the field of biotechnology and genetic engineering will provide most of the new jobs in the next twenty years.	
Your position, basically: (Please read from A to I, and then choose one.)	%
A. Yes. New information and rapid change are the keys in society's future.	4.1
B. Yes, because Germany's industries will have to become more efficient by installing hi-tech systems in order to compete.	6.6
C. Yes, because new German industries will produce hi-tech products. Public demand for these products will create new jobs.	2.3
D. Yes. There will be many new jobs. Specially trained people will be needed to run and repair the new technology and to develop new kinds of hi-tech industries.	10.4
E. Yes. Specially trained people will be needed to run and repair the new technology, BUT it will replace some of today's jobs. Overall, the total number of jobs will be about the same.	30.6
F. No. Only a few new jobs will be created. More jobs will be lost because of mechanical or computerized hi-technology.	27.6
G. I don't understand.	0.3
H. I don't know enough about this subject to make a choice.	10.6
I. None of these choices fits my basic viewpoint.	5.6

Table 6: opinons about the effect of new technologies on the labour market

In their view the educational system and the specific cultural aspects (Q28; vosts70711) have a definite influence on the ways how problems in science are being solved (23.7%), as well as personal views of scientists (27.2%) or through the influence of state and industry in a country (16.5%). Only a small minority (7.4%) believes there is no influence because science is neutral and the same scientific methods are applied everywhere leading to the same results.

Scientists trained in different countries have different ways of looking at a scientific problem. This means that a country's education system or culture can influence the conclusions which scientists reach.	
Your position, basically: (Please read from A to I, and then choose one.)	
The country DOES make a difference:	%
A. because education and culture **affect all aspects** of life, including the training of scientists and the way they think about a scientific problem.	23.7
B. because each country has a different system for teaching science. The way scientists are **taught to solve** problems makes a difference to the conclusions scientists reach.	9.5
C. because a country's government and industry will only fund science projects that meet their needs. This affects what a scientist will study.	16.5
D. It depends. The way a country trains its scientists might make a difference to some scientists. BUT other scientists look at problems in their own individual way based on personal views.	27.2
The country does NOT make a difference:	
E. because scientists look at problems in their own **individual** way regardless of what country they were trained in.	5.9
F. because scientists all over the world use the same scientific method which leads to similar conclusions.	1.5
G. I don't understand.	0.7
H. I don't know enough about this subject to make a choice.	3.9
I. None of these choices fits my basic viewpoint.	2.7

Table 7: opinions about cultural influences on scientists

Differences in scientists´ opinion on controversial scientific matter like e.g. the question if genetically modified organisms are harmless are in students´ view caused by insufficient factual knowledge, but also different interpretation of data, differing ethical or political considerations (statements D, E and F 18.4%, 19.8% and 16.9% respectively).

When scientists disagree on an issue (for example, whether or not field studies with geneticall modified organisms are harmless), they disagree mostly because they do not have all the facts. Such scientific opinion has NOTHING to do with moral values (standards) or with personal motives (personal recognition, pleasing employers, or pleasing funding agencies).	
Your position, basically: (Please read from A to J, and then choose one.)	
Disagreements among scientist can occur:	%
A. because not all the facts have been discovered. Scientific opinion is based entirely on observable facts and scientific understanding.	7.9
B. because different scientists are aware of different facts. Scientific opinion is based entirely on a **scientist's awareness** of the facts.	9.4
C. when different scientists **interpret** the facts differently (or interpret the significance of the facts differently). This happens because of different scientific theories, NOT becaus of moral values or personal motives.	11.9
D. **mostly** because of different or incomplete facts, but partly because of scientist's different personal opinions, moral values, or personal motives.	18.4
E. for a number of reasons – any combination of the following: lack of facts, misinformation, different theories, personal opinions, moral values, public recognition, and pressure from companies or governments.	19.8
F. When different scientistss **interpret** the facts differently (or interpret the significance of the facts differently). This happens **mostly** of personal opinions, moral values, personal priorities, or politics. (Often the disagreement is over possible risks and benefits to society.)	16.9
G. because they have been influenced by companies or governments.	1.5
H. I don't understand.	1.2
I. I don't know enough about this subject to make a choice.	5.8
J. None of these choices fits my basic viewpoint.	3.1

Table 8: opinion on the causes for disagreement amongst scientists

A large majority (61%) of students sees the development of understanding technology through school education as a necessary prerequisite for responsible citizenship (Q26; VOSTS 20521).

The success of science and technology in Germany depends on how much support the public gives to scientists, engineers and technicians. This support depends on students – the future public – learning about science and technology.	
Your position, basically: (Please read from A to H, and then choose one.)	
Yes, the more students learn about science and technology:	%
A. the better they will keep the country running. High school students are the future.	10.5
B. the more students will become scientists, engineers and technicians, and so Germany will prosper.	4.9
C. the more **informed** the future public will be. They will be able to form better opinions and make better contributions to how science and technology are used.	53.5
D. the more the public will see that science and technology are **important**. The public will better understand the views of experts and will provide the needed support of science and technology.	12.6
E. No, support does **not** depend on students learning more about science and technology. Some high school students are not interested in science subjects.	7.4
F. I don't understand.	1.0
G. I don't know enough about this subject to make a choice.	2.6
H. None of these choices fits my basic viewpoint.	4.2

Table 9: opinions about the influence of school education on the success of science and technology

„School culture“, however, is not favourable for the attainment of this educational aim: the older the students, the more critical they see especially this aspect of school life: 63.4% male students and 62% of the female students of the age group 16- 21 give a choice to „rather not true / not true“ in the questionnaire for the statement „it is a school where students are well prepared for dealing with current problems in science and technology“.

Discussion

Generally, in all types of secondary schools of the differentiated education system, formation of concepts is not of sufficient clarity or depth. Although it is a definite obligation for schools to develop clear definitions and understanding from the point of view of school authorities and students, the classical courses in natural sciences apparently fail in this respect. The present knowledge base on modern technologies is nearly completely dependant on „second-hand“ information from the media for both teachers and students. Up to now there seems to have been very little in-service training for teachers of biology and neighbouring subjects.

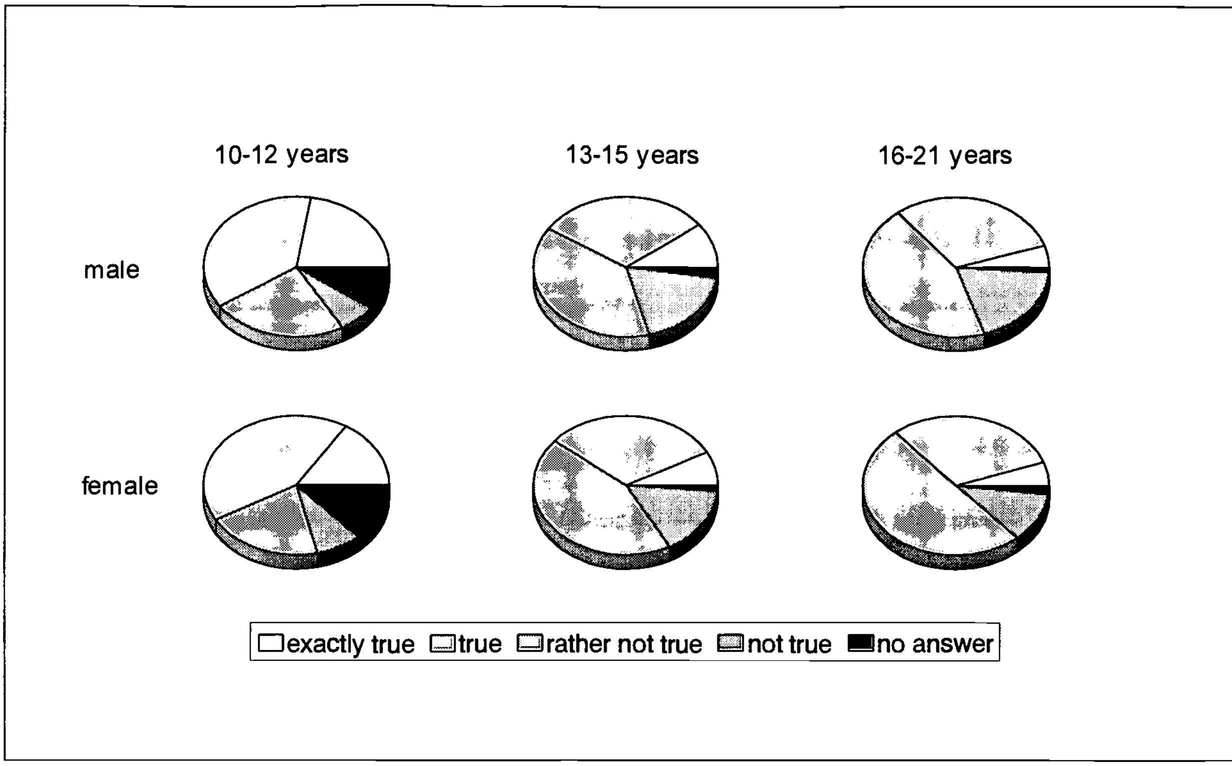

Figure 8: (Q6) „it is a school that prepares students well for current problems in science and technology"

This is rather astonishing, since biotechnology /genetic engineering has been a subject in other European schools systems like Denmark since many years (e.g. Libner 1985), and many national courses for teachers have been offered by scientific associations and teacher educating institutions since then.

Ethical aspects of the applications of technology have never been adreesed in the open questions of the questionnaire. Implicitly they find some recognition in the pattern of statements chosen by the students to Q 31 (VOSTS 70212). With regard to the attainment targets of mature capabilities for understanding and valuing, we find that „naive" preconcepts about science and technology dominate, and a rather conservative idea of technology assessment is prevalent. Contrary to this however, students implicitly reproduce a concept of responsible citizenship and informed public (Q26; VOSTS 20521) that is aware that it is possible as a voter and consumer to influence technological development, and communicate with political and economic subsystems.

The gap between present preconcepts and attainment targets comes to light also when one has a look at the questions on „school culture". Although there is a general content with school life, the aspect of preparation for responsible citizenship is viewed with criticism by students. The older they get, the more critical they are (see fig. 8), also with regard to possibilities for partaking in decision-making concerning school life. Since individual competencies for valuing can only be acquired in active involvement with a social and material environment, we feel that in order to offer students the possibilities for achieving the attainment target of a „rich“ understanding of science and technology and mature capabilities for valuing the specific education in natural sciences, as well as the prevalent general school culture will have to be altered. This could only be reached by an individual school development programme. In project „schools ethics technology“ we have found a means to start an educational realignment, and results obtained will be presented in a second paper.

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