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ABSTRACT

Many studies have confirmed that students' interest in physics decreases during the secondary school level and that girls are, in general, less interested in physics than boys. This is an interim report of a six-year cross sectional and longitudinal study investigating the structure of interest in physics and technology and the relationship of school conditions to the development of interests during grades five through ten. Test items were developed related to eight physics topics, seven contexts for work with the topics, and four levels of activities. Results based on the cross sectional study are reported: (1) students' interest in physics; (2) students' interests in various contexts and classroom activities; (3) interest in physics in relation to parental behavior; and (4) instructional climate. Ideas for making physics more interesting for girls are listed. Examples of the test items and 31 references are appended. (YP)

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DEVELOPMENT OF STUDENTS' INTEREST IN PHYSICS IN RELATION TO CHARACTERISTICS OF INSTRUCTION AND OUT-OF SCHOOL CONDITIONS

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Introduction

Within the framework of a broad-based study initiated by the IPN[1] on the change of students' interests in physics and technology during secondary level I (e.g. grades 5 to 10 = ages 11 to 16) we chose as our approach to analyse the following: the interest structure relating to physics and technology, as well as the change in these structures and certain conditions which might hinder or promote the development of interests and attitudes in this field.

Before detailing the starting point of the study, the selection and operationalization procedure for the variables and the establishment of the design as well as presenting certain results a brief explanation shall be given of what is understood by the construct "interest" in the study.

Following Rubinstein (1965, p. 136), the interest construct can be conveyed by the following characteristics: interests always refer to objects, direct thoughts and intentions towards the object in question, encourage activity and have an emotional component. On the one hand interest leads to human activity in the long term, on the other it always has reference to contents. Definition of interest-led action is often limited to the consideration of cognitive activities (cf. e.g. Oerter, 1981; Schiefele, 1974). Interests, then, stimulate cognitive treatment of learning objects. In this context, interest is to be understood as the relation of an individual (subject) to a particular object. This relation between individual and object is also determined by certain valencies which the individual attributes to the object. These valencies (values, meanings) which the individual ascribes to the object partly originate in the former's own experiences with the latter and are partly adopted and internalized within the framework of the socialization process (Oerter, 1981).

We proceed from the assumption that the development and differentiation of interest structures are part of the self-concept and ego development. According to Döbert, Habermas & Nunner-Winkler (1977), the process of self-concept and ego development is linked to cognitive development. They assume that the individual achieves, in a way which may be compared to Piaget's (1947/1972) stages of cognitive development, different stages of role-taking and changes in orientation of life according to the different developmental tasks with which the individual is confronted (cf. e.g. Havighurst, 1967). On the basis of the different role-taking and the changing life orientations, the individual acquires increased interaction competence. We assume that in connection with this the individual's valence structure changes, which results in differentiation and specification of the interest structures, where the first channeling is a consequence of familial socialization (such as support from the father/mother, including the perceived model behavior, as well as the perceived extent of stimulation to activity and support given).

The starting point

A wide range of studies have repeatedly confirmed that students' interests, particularly in physics, systematically decrease in the course of secondary level I and that girls are in gerneral less interested in physics than boys are (e.g. Todt et al., 1974). An international overview of research in students' interest in science and technology is provided by Gardner (1985). From the point of view of educational theory, interest may be seen as the medium and the goal of educational processes (Sauer, 1975; Schiefele, Hausser & Schneider, 1979). The data we have which show that students' interest in physics decreases is thus in direct opposition to the goal of instruction, which is that interest should be present at the *end* of the learning process. Interest as an objective of physics instruction can therefore be understood as continuing interest in physics and technology after leaving school, or at least a certain degree of openness towards this area rather than disinterest or even dislike.

The studies available to date present evidence of differences in interest - in some cases quite substantial - between classes within the same year and between schools (Haladyna & Thomas, 1979; Fräser, 1980), as well as differences and changes in interests with regard to various themes and objects. This raises the question of the causes and conditions to which the decrease can be attributed. The studies show that the causes of a decrease in students' interest in certain scientific objects are not to be found in school alone. Instead, changing social orientation, among other things, seems to play a significant role. More detailed analysis of the differences and changes depending on age and instruction would appear necessary. Assuming that content-related interests represent *one* condition for cognitive motivation, we anticipate that the results of such an analysis will provide a basis for the development of a catalogue of measures through which instruction can promote cognitive motivation.

Selection and operationalization of the variables

The framework of the study is determinded by two questions:

(1) What structure should this interest in physics and technology have?

(2) Which conditions inside and outside school promote or hinder the development of this interest structure?

According to the design question 1 relates to the dependent variables and question 2 to the independent variables.

In delineating the structure of the dependent variables we did not follow any specific interest theory, but drew on the results of a curricular Delphi study carried out by Häussler et al. (1980; in press). In this study, a group of experts were asked to give their ideas what meaningful physics education for today and tomorrow should be like. The first step was to formulate statements from the experts referring to desirable physics education. Each statement was to contain 3 formal elements:

(1) situations, contexts, motives, etc., in or for which education in physics is meaningful today and will be so in the immediate future (Statement element I: situation/context/ motive);

(2) areas of physics, familiarity with which is required for an understanding of physics, or which are considered to have significance for physics in connection with the situations, contexts and motives named in fulfillment of the preceding condition (Statement element II: area of knowledge);

(3) the appropriate or desirable modality of an individual's disposition over, or of his dealing with an education in physics (Statement element III: dispositional modality).

The Delphi study[2] produced 492 individual statements which could be grouped into 54 statement bundles, 14 for the statement element "situation/context/motive", 28 for the statement element "areas of knowledge" and 12 for the statement element "dispositional modality". The three statement elements may be regarded as three dimensions of desirable physics education, the statement bundles as categories of these dimensions. The dimensions, as well as the categories, serve in our study as a framework for elaborating the structure of students' interests in physics and technology. A questionnaire was developed as an inquiry instrument which contained, however, fewer categories than those mentioned above. Each item was constructed in line with the dimensions of topics, contexts and activities.

The constructional framework comprises:

Eight *physics topics*

T1 optics	T4 mechanics	T7 structure of matter
T2 acoustics	T5 electricity	T8 radioactivity and nuclear power
T3 heat	T6 electronics	

Areas were selected which are included in all physics syllabi for secondary level I.

Seven *contexts* for work with physics topics

C1 Physics as a vehicle to enhance emotional experience
C2 Physics as a vehicle to understand technical objects in everyday life
C3 Physics as a basis for vocations I (technical vocations, vocations related to research in physics)
C4 Physics as a basis for vocations II (medicine, art, counselling)
C5 Physics as an intellectually challenging scientific enterprise I (qualitative level)
C6 Physics as an intellectually challenging scientific enterprise II (quantitative level)
C7 Physics and its impact in society.

Four levels of *activities*

A1 Activities on a receptive level (learning, receiving information, gaining insight, getting to know)
A2 Learning by doing (handling things, constructing, assembling, dissembling, trying out)
A3 Engaging in higher cognitive operations (planning an experiment, verifying an assumption, solving a problem, thinking up a new method, making calculations)
A4 Evaluating technical developments in conjunction with controversial issues (taking an active part in debates, making critical appraisals, estimating and forming opinions on certain things).

The topics were systematically combined with the contexts and activities and suitable items formulated. 11 items were developed per topic. The structure of the context by activity combination was kept constant for all topics so that the students' responses could be evaluated with specific reference to topic, context and activity. The following are three examples of items:

- Learning more about how colours in the sky occur (blue sky, red glow of evening, rainbow). (T1, C1, A1)

- Constructing various blocks from pulleys and ropes and testing them. (T4, C5, A2)

- Calculating the size of the smallest oil particles form the size of an oil film on water. (T7, C6, A3)

The response format is a five-level rating scale constructed as follows: My interest is.... very high (5), high (4), medium (3), low (2), very low (1). A more detailed description of this part of the questionnaire is provided by Häussler (1985).

To facilitate classification of the results, the students were also asked to indicate their interest in the individual topics, contexts and activities. For this the number of topics and contexts was increased and the activities were specified (cf. Hoffmann et al., 1984; Hoffmann & Lehrke, 1985. For some examples of test items see Appendix).

We assume that instruction which concentrates on activities at the level of higher cognitive operations demands more formal-operational thinking, whereas instruction which concentrates mainly on activities on the learning-by-doing level is more oriented towards concrete-operational thinking in the sense of Piaget's (1947/1972) theory of cognitive development. Analogous relations can also be assumed for individual contexts. On this basis, various effects of physics instruction on the development of students' interests may be hypothetically derived. For example, physics instruction which is centred too soon around activities on the higher cognitive operations level could be *one* of the reasons for the decrease in students' interests in physics.

In addition to data on students' *general interests in physics and technology*, our study is also designed to obtain data on
- students' *interest in physics as a school subject* in comparison whith their interests in other school subjects,
- and the extent to which students occupy themselves with

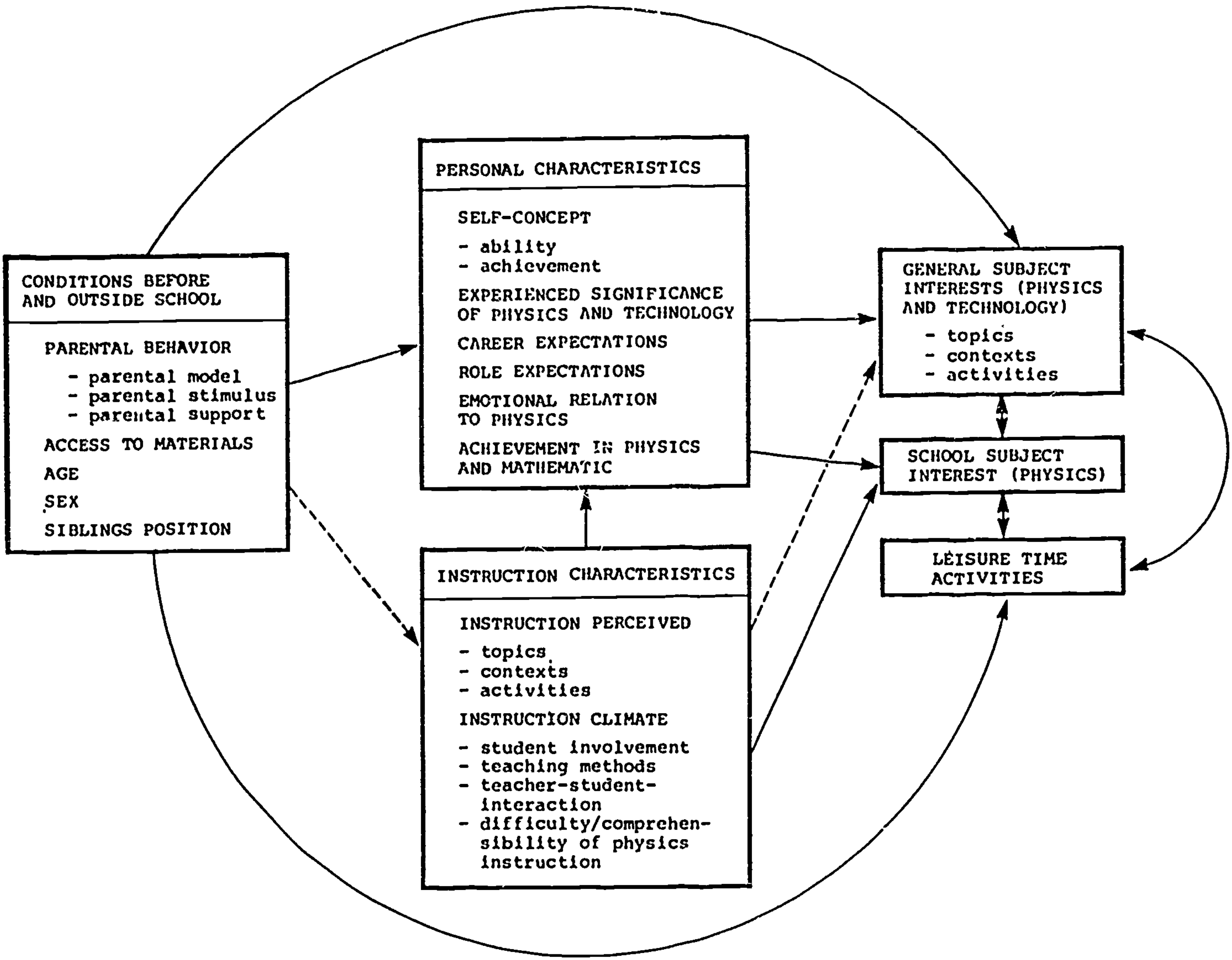
physics and technology during their leisure time as an indication of their *out-of-school interest.*

We proceed from the assumption that students' general interest in science and technology may be relatively high, while their interest in physics instruction can be high or low depending on their experience of it. An analogous assumption would be a combination of low general interest and high school subject interest. In this context, the students first encounters with physics instruction are presumably of particular significance.

The background to our chosen design of independent variables is given by Gardner, 1975; Haladyna et al., 1982; Ingenkamp & v.Saldern, 1983; Simpson & Troost, 1982; Todt, 1978; Walberg, 1976; and others. We selected a design encompassing the following independent variables: student characteristics, teacher characteristics, instruction characteristics, characteristics of teacher-student interaction, class characteristics and school characteristics. Figure 1 provides an outline of all variables which are investigated among the students and their assumed influence structure. (A description of all variables which are investigated among the students is provided by Hoffmann, Lehrke & Todt, 1985; for the whole questionnaire see Hoffmann et al., 1984).

Firstly, the students are to indicate which *topics* were dealt with in class and in how much detail; how often particular *contexts* were mentioned and how often they had opportunity to carry out particular *activities* during physics instruction. Secondly the students are to indicate how they experience the instruction climate, i.e. to what extend they were involved in the instruction procedure and encouraged to engage in their own activities *(student involvement)*, and to what extend particular *teaching methods* were used. The latter includes, for example, how often particular stimuli were given for meaningful reception learning as described by Ausubel (1968) or motivation impulses via conceptional conflicts as described in Berlyne's conflict theory (1960), or how often students had opportunities to carry

Figure 1: subjective conditions of students' interests in physics and technology



out experiments. Further dimensions of the instruction climate upon which the students are to give information are *teacher-student interaction* as well as the degree of *difficulty and comprehensibility of the physics instruction.*

For the selection of the variables we adopted a pragmatic approach which corresponds to the paradigm of applied research (cf. Rost, 1985). It therefore differs from basic research in psychology (cf. Häussler, Hoffmann & Rost, 1986, pp. 32) on the following grounds:

- Legitimation of the research issue does not result from a theory (theory extension or modification), nor from a comparison of various theories (e.g. decision experiment), but from a justification context independent of specific theory and related to practice.

- Interest in the accrual of knowledge for its own sake is not the stimulus for research activity, but interrest in "utilizable" knowledge - in this case educationally utilizabel knowledge. In making our selection of variables for the investigation, we aimed therefore mainly to include those variables which may be influenced within the context of the educational system, and which are directly or indirectly subject to modification within school.

- A large number of technicalities had a considerable influence on the selection and operationalization of the variables and arrangement of the design. These included, for instance, the limitation of students' work on the questionnaire to two school periods, the fact that the questionnaire has to be given to whole classes, the necessitiy of obtaining clearance from the education authorities for the contents of the questionnaire and the necessity of obtaining permission from parents for their children to take part in the study.

Investigation method and sample

In order to trace development related changes in students' interests on the one hand, and changes caused by environmental (in-school and out-of-school) conditions on the other, we decided to conduct a longitudinal study from grade 5 to grade 10.

The first data for this longitudinal study were obtained during May and June 1984. The inquiry is scheduled for 1989. A total of 51 school classes from the fifth grade in all three school forms of the tripartite system (Hauptschule, Realschule, Gymnasium) took part in the inquiry. The schools were spread over various "Länder" (states) within the Federal Republic of Germany. The same classes are to take part in the study annually through to grade 10.

Concurrent with the start i.e. the first inquiry of the longitudinal study, a cross-sectional study (I) was conducted throughout all six grades to verify the results of the longitudinal study. The cross-sectional study also provided preliminary information on the validity of the inquiry instruments which had been developed. The sample comprised 24 classes per grade.

Fresh inquiries among 24 grade 9 classes are to be conducted annually as a further check on the longitudinal study results in view of changes in interests over time (cross-sectional study II). The whole design of the study is given in Figure 2.

The class samples for the longitudinal study, as well as for the cross-sectional studies I and II are taken from the same schools (cf. Hoffmann, Lehrke & Todt, 1985).

Selected results

As yet the data collection of the longitudinal study as well as the cross-sectional study II is not finished (cf. Fig. 2) the following report of results is only based on the cross-sectional study I.

Figure 2: Design of the Investigation

grade						
10	C_1					L
9	C_1	C_2	C_2	C_2	L/C_2	C_2
8	C_1			L		
7	C_1		L			
6	C_1	L				
5	C_1/L					
year of inquiry	'84	'85	'86	'87	'88	'89

L = longitudinal study N = approx. 1200 students

C_1 = cross-sectional study I N = approx. 4000 students

C_2 = cross-sectional study II N = approx. 600 students

sample characterists:

longitudinal study: 48 classes

cross-sectional study I: 24 classes per grade 5 to 10

cross-sectional study II: 24 classes grade 9

selected from "Hauptschulen" (secondary modern schools)
"Realschulen" (intermediate schools)
"Gymnasien" (grammar schools)

half the number of classes from large town (with more than 100.000 inhabitants) half the number of classes in rural areas (catchment area with less than 50.000 inhabitants).

Students' interests in physics

At first glance, the data obtained from the cross-sectional study (I) in 1984 would appear to confirm the results of previous investigations. If the results are examined more closely, however, it can be observed that there is no general decrease in students' interests in physics. Although initial analysis of students' separate interests in topics, contexts and activities indicates that for most of the given physics topics average interest (relative frequencies of the students' statements) clearly declines between grades 5 and 10, there are certain topics where this is not the case: radioactivity/nuclear power, astrophysics, communication technology. In these areas the interest of both boys and girls remains almost constant, or increases in relation to interest in other topics.

A sharp decline in interest can be observed, rather more prominent for girls than boys, during the seventh grade (i.e. between the end of grade 6 and the end of grade 7). This is the grade where, for most of the classes taking part in the survey, physics instruction first began. A number of the students had already had physics instruction, or technology instruction where physics contents also featured, in grade 5 or 6. A comparison of statements made by students who had had physics instruction with those made by students who had not reveal differences, some of them quite significant. Fifth and sixth-grade students with physics instruction expressed significantly lower interest in most of the given physics topics than their contemporaties without instruction. The same applies to topics which had had not yet been dealt with during instruction.

For contexts and activities the differences are not so significant. Our task now is to conduct further analyses to account for these results, a task which we hope the longitudinal study will help us to fulfil. The latter has so far indicated significant differences in the interest of boys and girls in most physics topics. Quite striking is the evidence that as early as at the end of grade 5, i.e. before physics instruction has commenced for most classes, girls express significantly less interest in physics topics than boys. Exceptions are the topics acoustics, optics, and atomic theory. The greatest discrepancy between the sexes is for electronics. A more detailed description of these data is provided by Hoffmann & Lehrke (1985).

The four topic areas in physics judged by students on average as most interesting are astrophysics, computers, flight and electronics (for boys) and the structure of matter (for girls). In grade 10 telecommunications replaces flight for boys, while radioactivity and nuclear energy replace the structure of matter for girls. According to students, however, these areas are dealt with hardly at all in instruction and if they do occur, then only in grade 9 or 10.

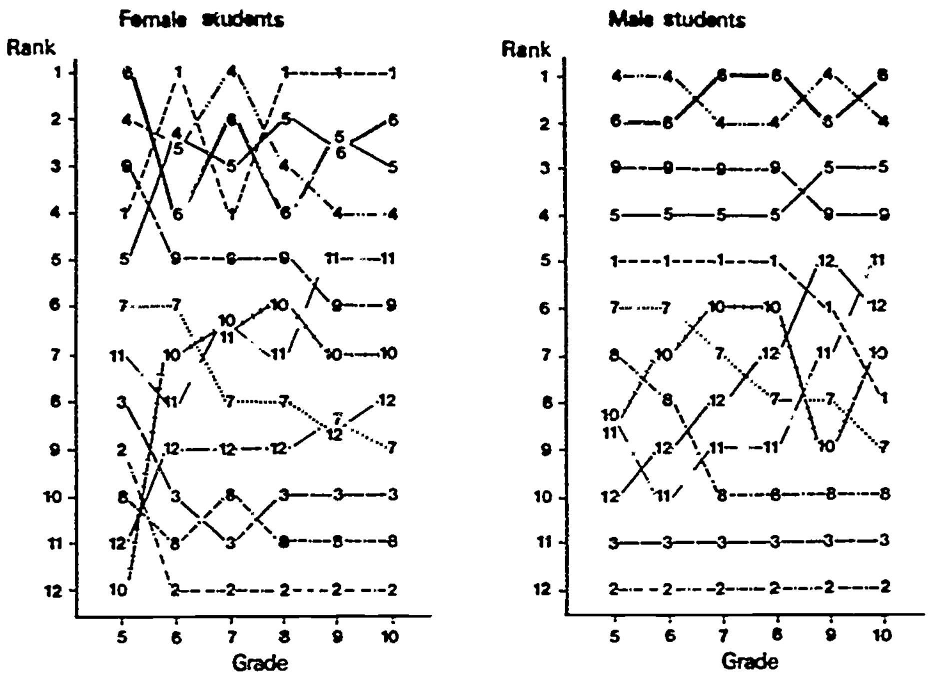
Students' interests in various contexts and activities in relation to physics instruction

When introducing and working with different areas in physics class various contexts and forms of activities can be chosen. If we now compare (cf. Figure 3) the rank-order of average student interest in particular activities with the rank-order of frequency with which these activities appear in physics instruction (again on average and in the opinion of the students), it may be observed that the students show high interest in the activities at the learning-by-doing level in particular (in Fig. 3 these are activities 4, 5 and 6). On the other hand, they show relatively low interest in activities at the level of higher cognitive operations (7, 8). The activities grouped under 9, "inventing something designing a device", represent an exception here. It can be assumed that this is due to the formulation of the item: the students may regard the activities as practical rather than theoretical.

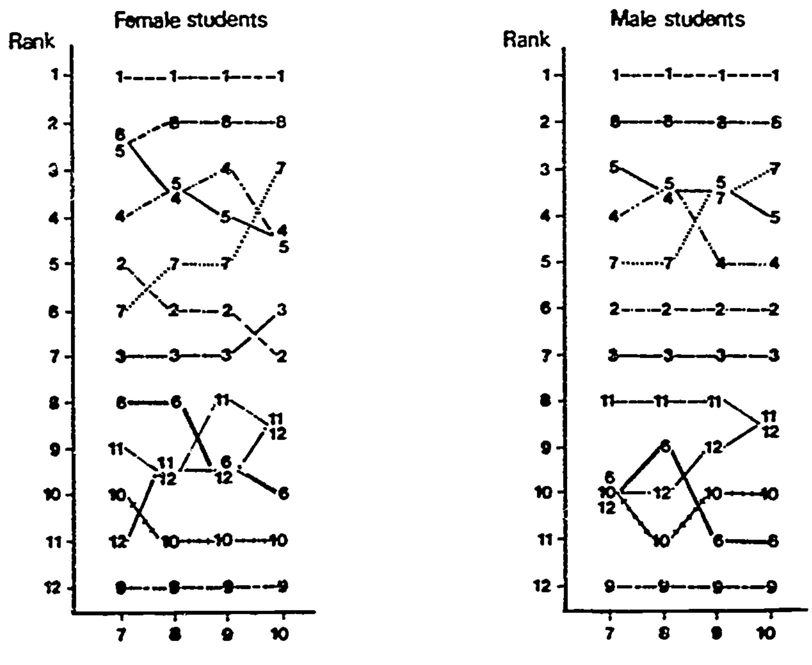
Examination of the frequency, as judged by the students, with which the individual activities were included in instruction reveals that the very activities in which the students express lower interest occur in instruction more often than those in which they express high interest.

Figure 3: A. Rank order of students' interests in specific forms of activity involving physics in instruction (grades 5 to 10).
B. Rank order of the activities according to the criterion of how often, in the students' opinion, there was opportunity to engage in them in instruction (grades 5 to 10).

A)



B)



1. Watching the teacher or fellow students conduct a physics experiment
2. Reading a physics text
3. Listening to a talk on physics (given by a teacher or another student)
4. Building something, setting up an experiment
5. Conducting an experiment yourself; taking measurements
6. Testing something, taking a device apart or putting it together
7. Thinking about how the validity of an assumption could be tested by an experiment
8. Calculating something, predicting exactly the result of an experiment, solving problems
9. Inventing something, designing a device
10. Discussing with others a particular technical innovation
11. Examining your own opinion on physics and technologecal issues
12. Assessing the value or practical use of a technological or physics innovation

Thus we see that, in the students' opinion, the activities grouped under "8" (calculating something, predicting exactly the result of an experiment, solving problems), activities which we attribute to the level of higher cognitive operation, rank second in the order of frequency for grades 7 to 10. Yet as far as the interests of the students are concerned these activities are second or third from last.

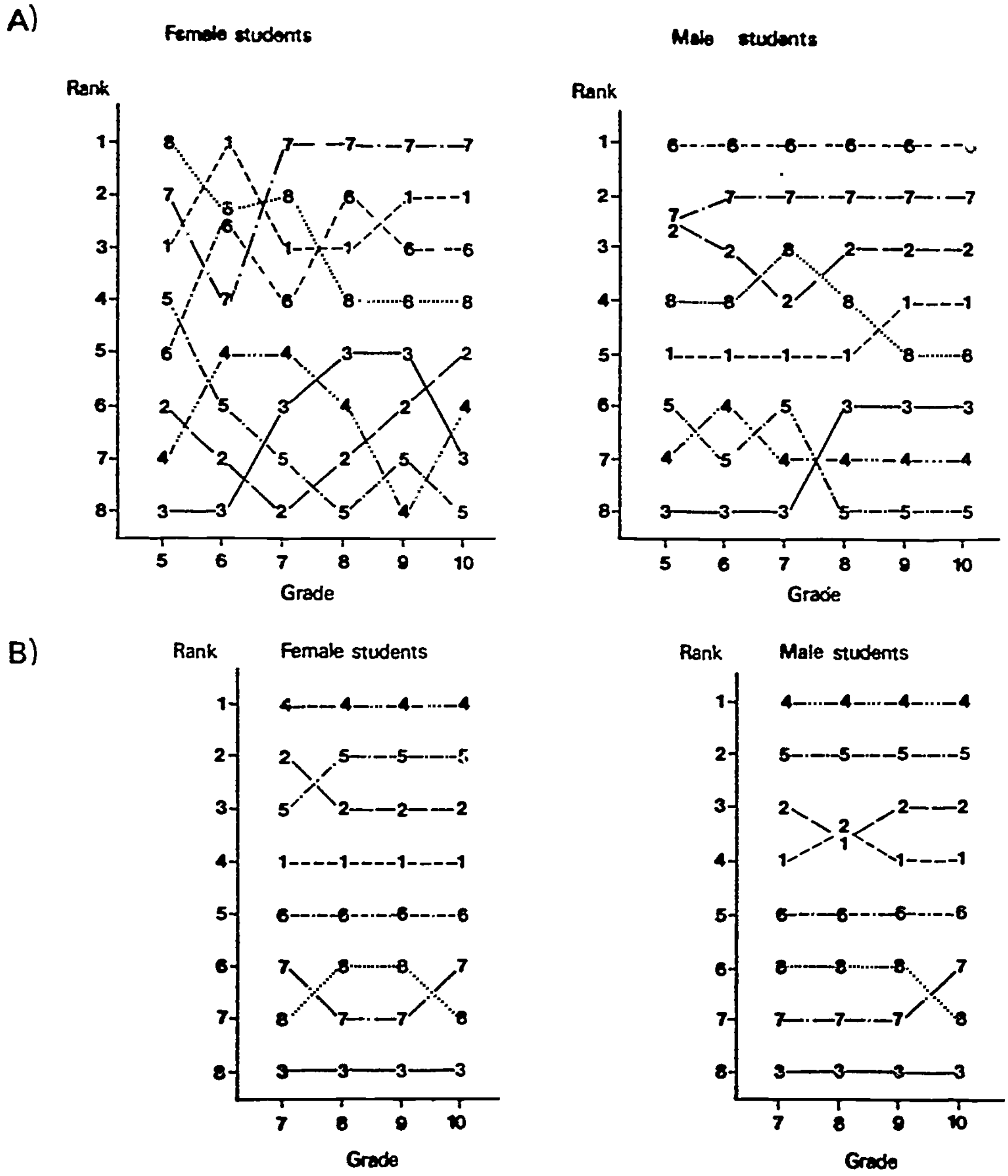
A similar situation exists for students' interests in particular contexts and the contexts used for work with physics topics in instruction (cf. Fig. 4). The contexts "description and explanation of experiments, processes and phenomena" (4) and "natural laws which allow us to calculate exactly specific quantities in physics" (5) are, in the students' opinion, most frequently employed in instruction. They rank, however, lowest in the scale of students' interests.

In the same way as for activities at the level of higher cognitive operation (especially 7 and 8), a certain proximity to instruction oriented to formal-operational thinking may be supposed for contexts 4 and 5.

As long as it may be assumed that the results cannot be attributed exclusively to error in students' subjective judgement, one may suppose that physics instruction is partly geared to a level of cognitive development which a large number of students have not yet reached. According to Kubli (1981, 21f.) it is to be assumed that even if a student has already reached the stage of formal operational thinking, he will begin at an earlier level of cognitive development when confronted with a new problem.

Factor analyses and varianz analyses of student responses to the item block where topics are combined with contexts and activites indicate that the topics play by far a more prominent role in determining male students' interest in physics than female ones. On the other hand contexts and activities seem to be more relevant for female students' interest in physics.

Figure 4: A. Rank order of students' interests in specific contexts for work with physics topic areas in grades 5 to 10.
B. Rank order of the contexts according to the criterion of how often, in the students' opinion, they were dealt with during instruction (grades 5 to 10).



1. Processes and phenomena which can be directly observed and experienced
2. Technical divices with which we often come into contact (e.g. means of transport, tools, electrical appliances, heating systems)
3. The type of work involved in specific jobs of a technical/technological nature or connected with physics
4. Description and explanation of experiments, processes and phenomena in physics
5. Natural laws which allow us to calculate exactly specific quantities in physics
6. The application of technological developments which can benefit us now and in the future
7. The application of technological developments which involve considerable risks to ourselves and to the environment
8. How particular phenomena were interpreted in terms of physics in past centuries

The fact that various contexts and activities influence students' interest in certain topics in physics or their readiness to tackle them can be seen in Figure 5 for "optics" and "mechanics".

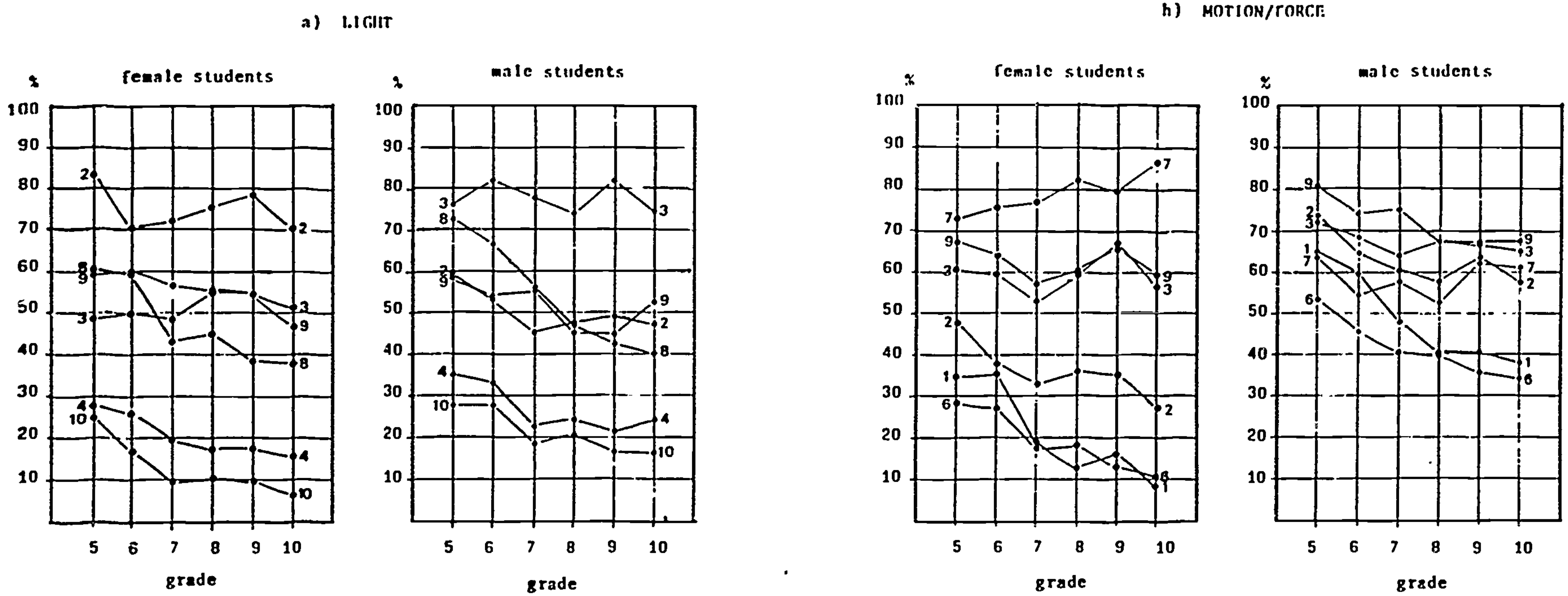
Contexts and forms of activities that students show an interest in can be used as a vehicle for stabilizing existing interests and for expanding their readiness to explore other areas of physics.

Thus, "learning something about how spectrums depend on the color" (Fig. 5a/4) and "calculations of optical images (Fig. 5a/10) are of little interest to girls and boys. A concrete application (e.g. an aid for color blind people (5a/9) or building simple optical equipment oneself (5a/8) would motivate them much more. Girls are especially interested in natural phenomena (5a/2), boys in technical works (5a/3).

Simple machines are a common introduction to mechanics. This introduction is, however, not very interesting, especially for girls (5b/1 and 6). The inclusion of kinetics in considering problems in traffic safety would be more motivating for girls and boys (5b 3,9). While boys show the same interest in a pump that works as an artificial heart (5b/7) and one that pumps petroleum (5b/2), girls find the former more interesting.

Figure 6 illustrates genderdifferencies in students' interests in physics in more detail. Grade 7 students are taken as an example. The results look very similar for students from grade 7 to 10. Three classe with high, medium and low interest have been identified by latent class analysis (LACORD, Rost 1988) for female and also for male students. The strukture of interests is very similar among the classes of each sex. They only differ in the intensity of interests. But there are markable differences in the interest structures between the sexes: High interest of female studetns must be viewed as completely different from high interest of male students. In comparison to the topics, the contexts and activities play by far the greates role in determining espexially female students' interest in physics.

Figure 5: Percentage of female and male students with "great" and "very great" interest in selected context-activity combinations in connection with the topics a) light and b) motion/force. (Answers on a 5-point scale from "very great" to "very little".) The numbers in the figure correspond to the item number in the test (Hoffmann, et al. 1984).



2. Learning more about how colours in the sky occur (blue sky, red glow of evening, rainbow).

3. Learning more about how satellites can be used to investigate and observe the earth (e.g. discovery of natural resources or plant deseases, weather observation, military reconnaissance, espionage).

4. Learning more about the relationship between refraction and colour of light.

8. Building a simple optical device (e.g. microscope, telescope or camera) using glass lenses and black cardboard.

9. Designing a device with which colour-blind people can distinguish colours.

10. Calculation the size of an object (e.g. on a projector slide) reproduced on a screen using a glass lense.

1. Learning more about how devices function which intensify force (e.g. block, lifting platform).

2. Learning more about how oil can be pumped from a great depth (e.g. 3,000 metres) to the surface.

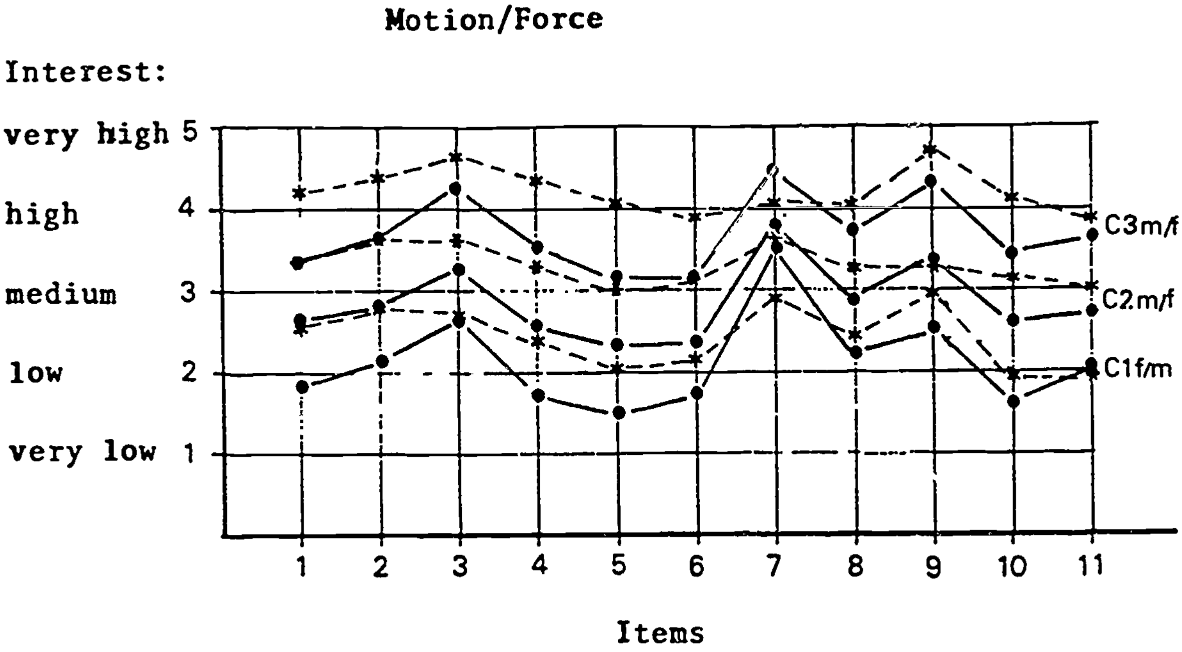
3. Learning more about how the probability of a car accident and the seriousness of its consequences increase at higher speeds.

6. Finding out more about the force-saving devices used in vehicle repair workshops.

7. Finding out more about the artificial organs (e.g. the heart as a blood pump) and joints used in modern medicine.

9. Designing a safety vehicle in which driver and passengers would receive only minor injuries - if at all - in an accident.

Figure 6: Mean values of students (grade 7) with high (C3), medium (C2) and low (C1) interest in 11 items concerning topic T4 "motion/force". The classes have been identified by latent class analysis.
●——● female students; *----* male students.



Students' interest in physics in relation to parental behavior

The parental behavior as experienced by the students was analysed seperately for male and female students, too.
The girls are given technical toys significantly less often by their parents, they receive significantly less frequent stimulus from their parents to help with repairs, to have anything to do with physics and technology or take up a scientific career.

According to the experiences of female students four classes of different parental behavior have been identified by latent class analysis each for the mothers and for the fathers. According to the experiences of male students three classes of parental behavior are to be distinguished.

As can be seen in Figure 7 parental behavior of the father as well as of the mother influences significantly male and female students' interest in physics. For female students this influence tends to be mor prominent for the topic mechanics, electricity and electronics.

Instruction climate

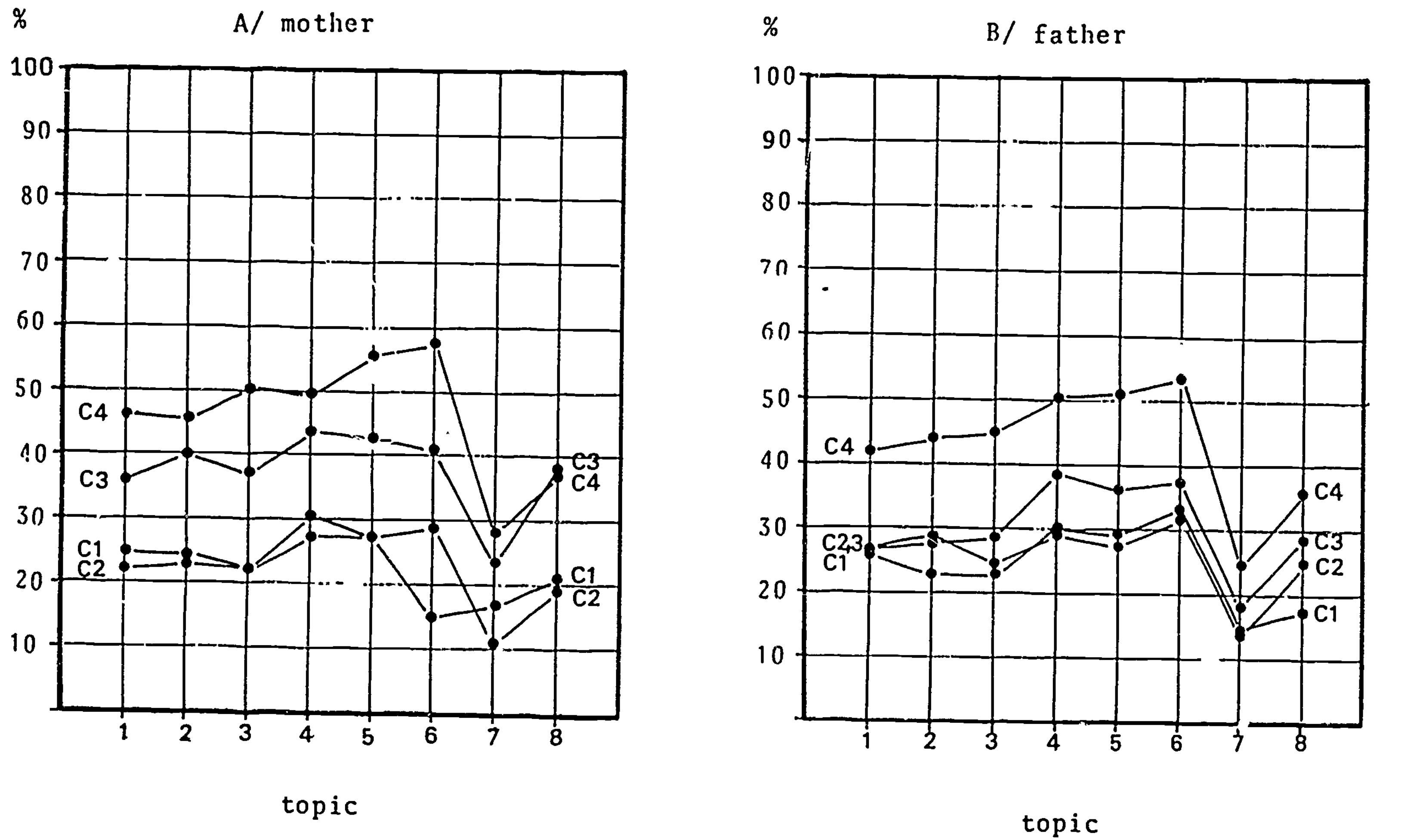
To ascertain to what extent school physics in general creates a stimulating and pleasant climate which enables further learning beyond the classroom the students have to answer 58 items which especially concern the instruction climate.

How students perceive the climate of instruction is significantly related to their interest in physics and their self-concept. This relationship becomes even more distinct for female students in grades 7 to 10. For both female and male students there is a close connection between their interest and how comfortable they feel in the lessons, how well the teacher is able to arouse their curiosity and how far the teacher is prepared to go into their questions and interests. Further impoortant aspects are the extent to which the teacher gives a general outline when starting a new topic, and whether she/he connects the topic to the students' own experience, as well as the use of student experiments. If latter are fun, allow new discoveries to be made and give the students scope to do something themselves, they appear to be even more important for girls than for boys.

The results of the study indicate physics classes on the average are not very stimulating (for girls even less so than for boys) and do little to promote activities involving the physical and technical world outside the classroom.

As a final result it should be mentioned that boys consistently rate physics as an interesting school subject, whereas girls equally consistently give it a low interest rating in comparison to other school subjects.

Figure 7: Percentage of female students belonging to the group with highest interest in physics in relation to four levels of parental behavior concerning physics and technology. The four classes of parental behavior have been identified by latent class analysis each for mothers and fathers of the female students. Class index C4 includes high (C1 low) parental model behavior, stimulus and support.



T1 optics
T2 acoustics
T3 heat
T4 mechanics
T5 electricity
T6 electronics
T7 structure of matter
T8 radioactivity/nuclear power

Some Aspects on Making Physics More Interesting, Especially for Girls (Based on an Analysis of 88 Items from the Kiel Interest Study)[a]

A Interest in treating the social importance of physics is relatively high in general; for the girls even more important the older they are and the more they can relate to an immediate connection. Thus, for example, topics like noise protection, speed limits, energy conservation in the home or avoiding environmental damage are more interesting for them than discussing peaceful or militant use of satellits or lasers.

B The connection between topics for discussion and everyday experiences generally stimulate interest, but for girls they are only interesting when they can relate them to their own experiences: camera, microscope, measuring devices for noise levels, and loudspeakers are more interesting for them than lifting gear, pulleys, electricity in the home and what goes on in household appliances.

C Physics that "moves the soul" is generally interesting. Girls, however, seem to be affected more by what they can directly experience with their senses (the colors in the sky, thunder storms, Brown's movements). They are, however, clearly less interested in "astonishing" technical advances (e.g. the efficiency of a microchip) than boys.

D The discovery of or the testing of physics laws for themselves is not felt to be very interesting. This is especially true for a quantitative treatment of a physics problem. Interest increases when a (at least potential) application reference is there and the necessity or the use of a quantification can be learned. For girls it is better when "male domains" (e.g. cars, cranes, motors) are avoided in favor of use in medicine or in environmental protection. Reference to one's own body (e.g. effects of noise or radioactivity on the human organism, man-made organs, color blindness, reduction of accident injuries through prevention or the ..ficiency of man's senses) is generally valuable, especially for girls. This should, however, not be exhausted by a short-term motivation on the part of the pupils. Attention should be paid to applying the newly acquired physical knowledge to the original problem to show their ability to explain and to solve the problem.

E Girls and boys evaluate a glimpse into the working world in different ways. While girls have little interest in jobs in the auto industry or in electricity or electronics, boys and girls are interested in physical equipment in a doctor's office or a clinic or at a weather station.

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Notes

[1] The study is being conducted by L. Hoffmann, M. Lehrke & P. Häussler, all research members of the Institute of Science Education (IPN) at the University of Kiel, in cooperation with Prof. E. Todt from the University of Giessen.

[2] The Delphi technique is a survey form whereby a large number of participants, i.e. experts selected according to certain criteria, communicate with each other in a particular way. First, each participant individually formulates an anonymous written contribution on a specific issue. The synthesis of all the contributions is then sent back to the participants to be reworked by them. In this way each participant is informed of the contributions of the other participants and can continue to work on this broader base of information. There are usually 3 or 4 of these rounds of work (cf. Häussler et al., in press).

[3] Taken from: Häußler, P./Hoffmann, L.: Zusammenfassung und Ergänzung zum Workshop "Folgerungen aus empirischen Studien für die Lehrplanarbeit Physik" vom 8.-9.11.1988 in Soest. Kiel 1988, Anlage 2 (polyscript).

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EXAMPLES OF THE TEST

1/ Example of an introductory text.

MOTION AND WAYS OF SAVING FORCE

Since ancient times, mankind has dreamed of being spared physical exertion. The ancient Greeks were masters at saving forces and were already familiar with the block and tackle, an effective construction of ropes and pulleys with which they could, for example, erect temple pillars.

Today there are many devices which spare us effort. A hydraulic lifting platform is used, for example, for hoisting cars in garages; a pump brings oil from great depths to the earth's surface and a slight touch on the gas pedal is all that is needed to bring a sports car to a speed of 180 km/h!

But are we always aware of the power we have unleashed? Anyone with a knowledge of physics can easily calculate that a head-on collision of a car against a wall at a speed of only 50 km/h is equally as dangerous as a fall from a height of 10 metres.

As most accidents occur at relatively low speeds in urban traffic, many people consider that cars specially designed for safety provide a solution to this problem. Our knowledge of physics has allowed us to produce, for example, safety belts which prevent the wearer from being flung through the front windscreen in a collision, as well as the so-called crushable zones at the front and rear of the car, in which the metal parts deform on impact, thus absorbing kinetic energy and reducing the force of the blow in an accident.

How high is your interest in the following activities connected with this topic? Please turn over.

2/ Examples of testitems

	My interest is: very high	high	medium	low	very low
1. Learning more about how devices function which intensify force (e.g. block, lifting platform).	☐	☐	☐	☐	☐
2. Learning more about how oil can be pumped from a great depth (e.g. 3,000 metres) to the surface.	☐	☐	☐	☐	☐
3. Learning more about how the probability of a car accident and the seriousness of its consequences increase at higher speeds.	☐	☐	☐	☐	☐
4. Learning more about how the kinetic energy of a vehicle can be converted into other forms of energy (e.g. in the brakes or crushable zones).	☐	☐	☐	☐	☐
5. Learning more about how the kinetic energy of a vehicle can be calculated from its speed.	☐	☐	☐	☐	☐
6. Finding out more about the force-saving devices used in vehicle repair workshops.	☐	☐	☐	☐	☐
7. Finding out more about the artificial organs (e.g. the heart as a blood pump) and joints used in modern medicine.	☐	☐	☐	☐	☐
8. Constructing various blocks from pulleys and ropes and testing them.	☐	☐	☐	☐	☐
9. Designing a safety vehicle in which driver and passengers would receive only minor injuries - if at all - in an accident.	☐	☐	☐	☐	☐
10. Considering how the braking distance of a car can be calculated from the speed reached before braking.	☐	☐	☐	☐	☐
11. Investigating accident statistics and discussing the effectiveness of speed limits.	☐	☐	☐	☐	☐

A On the following pages you will find topics which can be dealt with in physics lessons. Please indicate

a) how high your interest in this topic is,
and,

b) if you have already started physics: in how much detail the topic - or parts of it - have been covered in your class

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1. Light: How light changes direction when it strikes lenses or mirrors, and how optical instruments allow objects to be magnified or viewed in close-up

a) My interest is

- ☐ very high
- ☐ high
- ☐ medium
- ☐ low
- ☐ very low

b) The topic was

- ☐ covered in great detail
- ☐ covered in some detail
- ☐ dealt with, but not in detail
- ☐ touched upon
- ☐ not covered at all

---

2. Tones, sounds and noises: How they are produced and how they spread

a) My interest is

- ☐ very high
- ☐ high
- ☐ medium
- ☐ low
- ☐ very low

b) The topic was

- ☐ covered in great detail
- ☐ covered in some detail
- ☐ dealt with, but not in detail
- ☐ touched upon
- ☐ not covered at all

---

3. Motion and forces: How the motion of a vehicle can be described in terms of physics and how force can be saved with simple machines

a) My interest is

- ☐ very high
- ☐ high
- ☐ medium
- ☐ low
- ☐ very low

b) The topic was

- ☐ covered in great detail
- ☐ covered in some detail
- ☐ dealt with, but not in detail
- ☐ touched upon
- ☐ not covered at all

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B On the following pages you will find a few angles from which physics topics can be approached.

Please indicate

a) how high your interest is in dealing with a topic from a particular angle

and

b) if you have already started physics: how often this particular aspect was dealt with in your physics lessons in the last few months.

> 1. Processes and phenomena which can be directly observed and experienced

a) My interest is

- ☐ very high
- ☐ high
- ☐ medium
- ☐ low
- ☐ very low

b) This aspect has been dealt with

- ☐ very often
- ☐ often
- ☐ sometimes
- ☐ seldom
- ☐ never

> 2. Technical devices with which we often come into contact (e.g. means of transport, tools, electrical appliances, heating systems)

a) My interest is

- ☐ very high
- ☐ high
- ☐ medium
- ☐ low
- ☐ very low

b) This aspect has been dealt with

- ☐ very often
- ☐ often
- ☐ sometimes
- ☐ seldom
- ☐ never

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C On the following pages you will find a few activities which can be carried out in physics lessons

Please indicate

a) how high your interest is - in general or in conjunction with particular topics - in carrying out a specific activity, either alone or with others,
and

b) if you have already started physics: how often in the past few months you have had the opportunity to carry out the activity.

1. Watching the teacher or fellow pupils conduct a physics experiment

a) My interest is

- ☐ very high
- ☐ high
- ☐ medium
- ☐ low
- ☐ very low

b) We have carried out this activity

- ☐ very often
- ☐ often
- ☐ sometimes
- ☐ seldom
- ☐ never

2. Reading a physics text

a) My interest is

- ☐ very high
- ☐ high
- ☐ medium
- ☐ low
- ☐ very low

b) We have carried out this activity

- ☐ very often
- ☐ often
- ☐ sometimes
- ☐ seldom
- ☐ never

3. Listening to a talk on physics (given by a teacher or another pupil)

a) My interest is

- ☐ very high
- ☐ high
- ☐ medium
- ☐ low
- ☐ very low

b) We have carried out this activity

- ☐ very often
- ☐ often
- ☐ sometimes
- ☐ seldom
- ☐ never