ON MOTIVATIONAL ASPECTS OF INSTRUCTOR-LEARNER INTERACTIONS IN EXTRA-CURRICULUM ACTIVITIES

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In extra-curriculum activities, the nature of the instructor-learner relationship differs from that in class. This constellation, if accompanied by a smaller gap between the mathematical skills of tutor and learner, has an impact on motivational aspects and on the choice of contents in these activities: The use of problem questions of competition type often plays a dominant role as a means to include many individuals in these activities. A survey is presented which indicates two risks of that approach: On the long term, it seems to have a negative effect on the motivation to work on open or more complex problems. Furthermore, it tends to discourage those with individual reference norm and motivation to participate that is intrinsic and directed on the mathematical content.

SOCIAL FEATURES OF EXTRA-CURRICULUM ACTIVITIES IN MATHEMATICS

Extra-curriculum activities give all members of the party the opportunity to break out of every day school life and to leave curricula, classmates, marks, time pressure, etc. behind. Here, an extra-curriculum activity is meant to fulfil the following criteria: The learners take part voluntarily without any immediate rewards such as winning awards or achieving high grades; the activity is of mathematical character or related to mathematics, e.g. as an application; finally, it is assumed that students of different classes join the group because of some interest in this mathematical offer. In particular, we do not focus on courses intensifying regular teaching and private tutoring.

It should be mentioned that activities like these are found at schools where committed teachers offer regular workshops in mathematics – often as a hobby without any extra-salary. Some universities advertise for studies in mathematics with offers like these. Also, one comes across such courses in societies organizing mathematical competitions.

Voluntary activities call for quite a high self-discipline: there are no institutional sanctions looming in case a member misses a session. In view of duties of every-day school life, it may be hard to find a reason for putting work in something that does not seem to pay off for some time. Voluntary work for mathematics is in general not popular – at least to the author's experience in certain countries like Germany and England. It appears to be hard to compete with part-time job opportunities and the tempting offers of the leisure industry designed for adolescents. It is not surprising

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that the numbers of participants in mathematical competitions decline significantly with advancing age. However, this development is quite drastic[i].

Participants can leave the group easily if they go through a difficult period. When asked for their motivation to do mathematics together, “passion” is often mentioned by both, instructors and learners. The word “passion” is a reminder that activities like these highly depend on the motivational aspects of everybody’s involvement (Roehr-Sendlmeier & Neitzke (1993)).

The organization of a long-term program for mathematically interested young people is a challenge requiring management of knowledge, conceptual design, motivation, and organisation – just to name a few. In mathematics the preparation of those activities is especially difficult. There is hardly suitable literature, let alone a conceptual program for the work with interested high school students. These come as individuals, often with special interests, preferences, and difficulties. A group of mathematically interested students cannot be regarded as a homogeneous constellation – neither in terms of mathematical abilities nor in terms of their expectations, already as school children (Peter-Koop, A. (1998)).

It does not make sense to provide interested students with contents to appear later in the mathematical curriculum. This could work for the moment in the extra-curriculum activity, but it could mean that the participants are bored to death when the very topic is treated later in the regular lessons. An extra-curriculum activity had better concentrate on topics being rather disjoint from or supplementing the curriculum (Renzulli, Reis & Smith (1982)).

Since resources for such topics – especially in an appropriate didactical reconstruction for young students – are still limited an instructor must be willing and able to create a program by himself. Plenty of beautiful mathematics could be made understandable for youngsters, but this takes a lot of energy and time. Let us concentrate on the trainer’s role in this situation: the members of the group hope for a challenge, but do not want to be discouraged if too much is expected from them. There are many different abilities, various levels of mathematical experience, a lot of opinions on how topics should be taught and, as we will see, different motivational aspects to be considered in the planning of the activities.

This could be said about every learning activity with a group of individuals. But the teaching of the mathematics curricula has been developing for generations and has achieved a certain level of sophistication and documentation. Besides, teachers are normally not trained in extra-curriculum training. Apart from those who took part in such an activity at young age themselves, one finds mostly autodidacts in the specialization in this area.

Topics considered interesting by students soon exceed the rigorous mathematical background on the instructor’s side. People who worked with gifted students – a term not to be used here too often for reasons discussed below – know that this requires instructors to cope with the fact that students are sometimes able to think more quickly and thoroughly than the instructor himself.

MATHEMATICAL PROBLEM QUESTIONS OF COMPETITION TYPE

Mathematical problem questions of competition type have many features which are useful for instructors of interested adolescents: These exist in huge numbers, for a variety of topics and degrees of difficulty. They have been collected in a long tradition for different reasons and are, as such, rather well documented and are seen as an important offer for interested students (Kallmann (2002)). Most of these collections contain problems to which a canon of solution strategies can be applied successfully. These are also helpful for instructors because the suggested solutions normally do not leave the area of mathematics that is indicated in the question. For these reasons it is not too difficult to correct written solutions to these problems.

It is widely accepted that those who work on these problem questions make considerable progress in logic, mathematical writing, typical strategies for solving these problems, heuristic thinking, and the basics of the mathematical areas covered by these questions. Furthermore, they appear as an instrument of diagnosis: some problems can be used as indicators of mathematical abilities (Käpnick (1998a)).

The author refers to "mathematical problem questions of competition type" if the following criteria are met:

- The problem is stated with a well-defined task of what is to show.

The learners are sure that the instructor is in possession of a solution.

It is a non-routine problem.

The following observations in a decade of projects as instructor of mathematically interested students were the starting point for investigations in the project presented here:

Instructors tend to choose problem questions of competition type for extra-curriculum activities.

Learners who stay for a longer time in an extra-curriculum activity prefer this approach.

It is difficult for tutors to encourage work on more complex projects once the participants are used to problem questions of competition type.

- There are high school students who are interested in learning more in mathematics than school can offer them, but for whom an emphasis of problem questions of competition type is not attractive in the long term.

The aim of this paper is to check the relevance of these impressions. Therefore, a situation was created to

1. illustrate differences in the instructor's roles depending on the choice of problem types,
2. measure the motivation of students used to competition type problems if these are replaced by open learning environments,

evaluate the learners' expectations and preferences in this setting.

SUBJECTS AND PRELIMINARY DELIBERATIONS

The survey was carried out during an international mathematics camp at Münster, Germany, with 50 students aged between 16 and 17 from 5 countries: the Netherlands, Poland, Czech Republic, Hungaria, and Germany. Each country sent 10 students to the camp. The subjects had been identified for their high abilitites in mathematics in that they were among the best partipants of the Kangourou des Mathématiques competition (the European equivalent of the "Australian mathematics Competition") in their home country in 2002. In Germany, for instance, more than 155.000 students from over 2450 schools took part in the competition in that year. The internationality of the sample is not used for a national comparison analysis. It was considered important to try to work independently of regional and national peculiarities.

From the statistical point of view, a higher sample would be desirable for the future. It should be noted, however, that it is difficult to find opportunities like this camp with an international participation of a comparable level. Since the survey was carried out in order to investigate the relevance of the observations mentioned above, an exact evaluation of statistical characteristics is not in the focus of this aim and would not make sense with this sample size. The results of interviews, which were carried out with 15 students (3 from each country), should be considered equally important.

For the survey, every student took part in two sessions each of 3 hours length. After each session, every participant completed anonymously a standardized questionnaire.

Pre-tests showed high or very high interest in mathematics and more than two thirds took part in regular extra-curriculum activities in mathematics. Almost all (45) claimed to have regular experience with problem questions of competition type. More than two thirds devote regularly their leisure time after school to mathematics.

More than eighty percent of the subjects were male.

EXPERIMENTAL DESIGN

For this experiment, each subject took part in two sessions of three hours each as mentioned above in a fixed group of 12 or 13 members of mixed nationalities. For each of the four groups, the trainer changed on the second day in the second session. Each of the two tutors, a scientist in probability theory with experience in the work with gifted students and the author, had twice a group in the first session and twice in the second.

	Day 1	Day 2
Group A	Tutor I	Tutor II
Group B	Tutor II	Tutor I
Group C	Tutor I	Tutor II
Group D	Tutor II	Tutor I

Table 1: **Organisational plan**

The two tutors worked out guidelines to provide parallel procedures during the sessions. In the first session, the group was given a series of problem questions from competitions around the topic of Markov chains in gambling. In the second session, the other trainer gave problems for which the same mathematical methods at a similar difficulty are useful, but which are lacking a question asking for a definite answer. For example, the subjects were asked to help an insurance company with the decision as to whether a certain life insurance should be offered to a certain number of people. In another problem, the group was asked to work out a simulation to check a certain phenomenon in the theory Markov chains encountered on day 1. None of the problems followed the pattern with a definite question as an objective.

Results

The subjects showed different reactions on the two days. First of all, let us have a look at the participants' interests in the topic:

Statement	Number of this answer on day 1	Number of this answer on day 2
The session was not interesting for me.	7	0
I will try to learn more on the session's topic.	44	35

Table 2: **Interests of the 50 subjects in topics on both days**

Nobody among the subjects considered the second day boring; there is a small number (7 out of 50) who did not like the first day. The first day, however, has a bit more succeeded in encouraging further studies.

The most striking differences between day 1 and day 2 concern motivation and assessment of the trainers' competence.

Statement	Number of this answer on day 1	Number of this answer on day 2
I was highly motivated during the session.	36	17
The tutor is competent.	41	20

Table 3: **Motivation and assessments of trainers' competence on both days**

From the first to the second day, the number of motivated subjects halved. Simultaneously, the number of positive ratings of the tutors' competence halved, too. The latter concerned both tutors equally. Even though the ratings of motivation and of the tutors were not extremely bad on the second day, a clear difference can be observed.

DISCUSSION

During the sessions, the tutors' observations of the subjects' behaviour corresponded to these figures. The motivation on the first day was marvellous. There was both a spirit of competition and a determination to solve as many problems as possible. In the second session, the subjects were challenged to work out suitable objectives for mathematical problems themselves.

A student from the Netherlands rated the first session best of the whole camp (there were 12 sessions altogether) "*because we could do a lot ourselves*". After the second day, a Czech participant said: "*I did not have enough patience: It is tiring to give mathematical arguments all the time. I get a kick out of a pile of clear problems*."

These remarks summarize observations in other programs where mathematical problems are considered as a kind of mental exercise. Among students who prefer an approach with problem questions of competition type, the learning of mathematics has lower priority than the opportunity to show one's own mathematical abilities.

The second day was rather unfamiliar than too demanding. (Only 15 out of 50 considered it as too difficult.) The most irritating fact for the participants was that the tutors could not give definite answers to the – obviously relevant – questions. A student from Germany said: "*If you cannot give a definite answer, why do we work on this?*" Problem questions of competition type seem to be marked by the fact that the learners know that the instructor is in possession of a solution.

It is widely believed that interested and/or gifted students are more demanding and more active than students showing less interest or with average abilities. The results of the experiment underpin the oberservation that their request can be complied with problem questions of competition type. They give them the opportunity to be active as long as they wish and to any degree of difficulty which seems appropriate. Working in a group as in the camp, one can observe that the students co-operate to work off problems given by the tutor. This keeps the level of frustration acceptable because everybody can be sure that sooner or later a bright idea will come up or, in worst case, that the instructor will help.

A group of students with outstanding mathematical abilities was chosen because they should be expected to cope best with new challenges in modelling, simulation and in discussions involving mathematical arguments. To put it much more emotional: Mankind needs them desperately in these areas. But in view of the ratings of the tutors' competence, it seems not to be easy to convince them to put work also on that area of mathematics.

It is interesting to have a closer look at those who appreciated the approach on the second day. Among the 17 students who were highly motivated on the second day, 12 devote their leisure time to reading in mathematics, 8 in natural sciences[ii]. In this group, for these students problem solving of competition type was rated a bit less important than for the average participant. There are found more students among them who intend to study mathematics after school. Among the critics of the second day, one finds almost the whole big group of those who want to study Computer Science at the University (16 out of 19). As a remark aside the author wants to mention that in his project *SamstagsUni* ("Saturday University"), where every high school student is welcome to learn more about an announced topic in the area of mathematics, statistics, physics or engineering in a series of lectures, seminars, exercise classes and talks a significantly lower proportion of participants claims to devote leisure time on mathematical competitions, but a proportion similar to those who favoured the second day to further studies. It would be interesting if the tendency can be confirmed that girls liked the second day more than their male peers.

Apart from these figures, which cannot be claimed to be representative due to the rather small samples, discussions and interviews after the second day indicate that those who were thrilled to show their abilities on the first day were rather unwilling to present themselves on the second day. There are also observations in long term enrichment models that those favouring a competition spirit in mathematics tend to agree with the external reference model.

Since recent results (Plucker & Stocking (2001)) suggest that in the academic self-concept development of academically able students no significant differences among students with strengths in mathematics, verbal areas or both areas can be established, it should be examined further which measures in mathematical enrichment models are suitable for which group of students.

It should be stressed again that problem solving – including competition type questions – has its merits and is not rejected here as an ingredient of enrichment programs. As a possible outlook originating from the results of this survey, it appears desirable to develop areas of problem solving further to learning environments which include the whole variety of mathematical areas like modelling and the construction of mathematical theories and/or which connect different mathematical contents.

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[i] The numbers of the Känguru competition in Germany in 2002 seems representative for the situation: In grades 5/6, there are approx. 57.000, in grades 7/8 approx. 39.800, in grades 9/10 approx. 23.700 and in grades 11/12/13 approx. 9100. It seems difficult to convince older high school students to join in mathematical activities.

[ii] Among all 50 participants of the camp, 18 devote their leisure time to reading in mathematics and 14 in natural sciences.