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## **Manuscript “Noise protection in the classroom”**

1. I would now like to present to you the project “Noise protection in the classroom – Strategies against noise in school”. Perhaps you don’t have these problems here in Finland- I have heard your classes are smaller than ours in Germany where classes are usually overcrowded with 30 or more pupils.
2. This project was part of the audit process of the Hulda-Pankok-Gesamtschule in 2001. The project is now a part of the school’s sustainability management.
3. The school building was constructed in 1961. In those days nobody cared about problems like noisy pupils. Since then, no reconstruction has taken place and the building is not really suitable for children. In 2001 pupils in year 10 measured noise exposure in the school during their physics lessons, as the old building was found to be extremely loud and noisy! The school director, Mr Gniostko, a physics teacher, wanted to obtain some data about this problem to find out what can be done to rectify it.

The headline of the newspaper article is “Pupils are as loud as lorries”, which means that they are louder than 70 decibels in lessons – decibel is the unit we use to measure noise.

4. For this, model apparatus was used which uses software to generate graphs on a computer using the collected information.
5. The pupils brought the data from classrooms, hallways, gym and school yard into the “noise lab” where the data was analysed with the help of computers and graphs were generated.
6. Here you can see a typical graph generated with the use of our data taken from measurements of a lesson in a classroom. You can see the peaks and troughs, the lines of maximum and minimum noise and the noise average. Here we recorded an average of 65-70 decibels in the lesson. In order to assess what this means, you need to know that German regulations stipulate that in order to work in an office environment the noise level should not exceed 55 decibels, and when there is a need for special concentration the level should not exceed 45 decibels. Measurement in decibels is not a linear function but an exponential function, meaning that an increase of one decibel is in fact double the noise.

Learning is hard work and you need a high level of concentration in order to get good results. Perhaps you in the audience have now got a first impression of the real problem in German schools.

7. Let’s see some other graphs. This one reflects a lesson in the sports hall. The average noise level is between 80 and 90 decibels, sometimes the peaks reach as high as 100 decibels. 85 decibels is the maximum allowed noise level in industrial firms.
8. Another one. Measured here is a day in the school woods. It was a little bit windy, so the leaves of the trees were rustling. The average of this noise was a little under 60 decibels. This is a situation which people like. But what are the peaks you can see? This was a group of four pupils coming along and shouting!

9. Here you can see a graph which shows you the second problem in the context of noise: the effect of reverberation. You know echoes. They come into existence if there are hard walls like mountains. The walls of a classroom are hard walls too. So there is an echo, if you as a teacher are producing noise, for example by speaking. This noise will be reflected by the walls, so people hear two signals; the echo and at the same time your speech which is going on. This is very irritating for a clear understanding and for concentration. Pupils with foreign backgrounds and a lack of knowledge of the country's language or pupils with ear damage or concentration problems are discriminated against in such situations. The reverberation time in the classrooms in the old building is up to 1.2 seconds, in the new part of the building up to 0.7. That's okay for pupils and teachers, but not for pupils as described above: concentration problems, ear damage, and foreign speakers. They require a reverberation time of 0.45 seconds. And look at the data of the entrance hall! This is similar to the hall of an old church.

There is now a lot of international scientific research and publication on this matter. If you want no echoes, you have to absorb the energy of the sound before it is be reflected. I think you know the solution: special panels on the walls and the ceiling. It's not a new invention, but you have to examine the noise situation in a room exactly to solve the problem in a good way. A lot of architects don't really know what they are doing when they are planning the buildings and so it is necessary to involve an acoustics specialist. This is not standard practise in Germany.

10. - Especially interesting are the results of subsequent focus tests of the effects of quiet and loud music on concentration levels: a distinctly higher number of error counts during louder music!
  - Noise disturbs an important requirement for learning! I will come back to the details of the test arrangements a little bit later in this presentation.
11. - The conclusion that silence is best was reached, even though the pupils knew the aim of the test and wanted to influence the results towards the idea that music does not disturb them...!
  - Consequences for the pupils: the pupils enjoyed the experience so much that they wanted other pupils to also experience it.
12. - The results of the concentration test worried us. Now we had data on the table which clearly proved our presumptions. So we thought about how to solve the problem together with the pupils, because we didn't want to wait until the city had the money for renovation of the old building.
  - The school bodies discussed these results (and others) in 2002, which led to...
    - ...a reform programme (data, assessment, goals, measures and responsibility), which was published as a sustainability report in 2003.
13. The pupils who carried out the first measurements frequently presented the project publicly, a method which also produces excellent results in learning.
14. The first test group were pupils of 16 years of age. It was necessary for us to find out if we could also deal with the problem with younger pupils at the age of 10 or 11 in the same way, when they start in our secondary school.
15. - In 2004 the execution of the sustainability programme began...
  - The application of the focus tests seems to be useful for the school within the framework of the newly implemented subject independent remedial teaching ("Learning to Learn").

16. - The remedial course was interested in the topic of listening to music whilst preparing homework
- The pupil's hypothesis was: music doesn't disturb!
  - This hypothesis was tested in the next step.
17. – By attaching an MP3 player to the amplifier equipment, you can ensure that everyone will hear the sound.
- The test was structured so the pupils would copy texts in 5 separate sequences, each of 2 minutes. The first session: no music, with the next sessions of ever increasing music loudness, the last session a lower level of loudness for “recreation”, not really okay at 85 decibels.
18. Here are the results: In the top left corner of each cell you can see the number of written words in a session, in the right hand corner the number of the words with incorrect spelling. The second line is the percentage. Each pupil got the same 100%, regardless of whether he or she wrote more or less words in the first session. You can see that the number of written words is going down and the mistakes are increasing with an extended level of noise, not in a steady way, but as a trend. The green colour means there is no problem, yellow is not really a big problem, orange and red results are not acceptable as a good job. The fourth person is a pupil with dyslexia, so her results are bad in the first session, too. Let's look at some graphs created out from this data.
19. Here you can see the results of the first person: reduction of efficiency, increase of mistakes! A lot of pupils produce such graphs in this situation. Please look at the second session, the problem with the concentration started under a low level of music! This was very impressive for the pupils, because they were informed about the test arrangement and tried to get good results. Their right of listening to music while doing homework at home was at risk...!
20. Here you can see the results of the second person: This is interesting, because this person tried two strategies to counter the difficulties of concentration under that noise. She said in the following evaluation session that firstly she tried to write the same amount of words in each session. At the end of the third session she got the impression that she was making a lot of mistakes, so she changed her strategy and tried to concentrate on preventing mistakes. But in doing so she dramatically decreased of the amount of written words. This was so exhausting, she later said, that she stopped writing altogether in the last session.
21. Here you can see the results of the last person, Madita: This is interesting too, because this person is able to repeat the same results over all sessions. This phenomenon is known as party talk problem. You don't understand much of the party talk because it is too loud. The human brain of adult people is able to complete a lack of information up to 50%, because you have the knowledge of the structure of the language, the vocabulary and the experience of party talks as such. This is not possible with a difficult scientific discussion or a completely new topic, but the brain is a masterpiece of evolution and tries to make the best of every situation.
- Madita is a very good pupil with an exceptional efficiency of working and a wide knowledge of the German language, so her graph is like the one of adult people. Later we will try more difficult tasks with the pupils. So Madita – we presume – will also have problems.
- One word on the test arrangement: It is not a scientific based test with control groups and the other necessary conditions of scientific research. We did it

- ourselves. The generated data is interesting enough for us and the results are on the average level of those in the scientific publications we looked at.
22. The third problem with noise is that we as human beings have no natural possibility to check the loudness of noise without technical support. We perceive noise events in a very individual way. So we need subject-dependant technical support for noise prevention.
  23. - Noise measurements in lessons- how accurate? This was discussed with the pupils.
    - A class was chosen to be the pilot class.
    - Initially, the noise level in various lessons of one class would be measured again and saved.
    - The pupils saw the graphs together with information about health dangers in order to see the limiting value of the noise protection act.
  24. The analysis of the pupils' research resulted in:
    - Noise is harmful.
    - Noise levels must be reduced.
    - We need a measurer and a signal giver working independently of individual impressions.
    - Teachers need not, and should not keep shouting!
    - The measuring apparatus must be adjustable for different class situations.
  25. – Here you can see a pilot batch of the 1<sup>st</sup> prototype of our noise analysis apparatus (Lärmampel)
    - Sensors and measuring cells are combined with a computer and signaller
    - A quiet gong sounds when the appointed values are violated.

Before starting the test sequence we discussed the achievable value. 55 decibels? No, that's not realistic, the pupils replied. 65? No, not really, they said. 70 decibels. Okay, let's try this in the first test, they answered.
  26. - 1<sup>st</sup> lesson: the pupils and the teacher agreed that it was a less noisy lesson than normal.
    - 170 violations of 70 decibels = 3.3 times a minute! Together we were very surprised at that result.
  27. - 2<sup>nd</sup> lesson: a work hour, in which the pupils did groupwork
    - 396 violations of 70 decibels = 8.3 times a minute!
  28. - 3<sup>rd</sup> lesson: an undertaking of silent work, it was deadly silent!
    - Only now could we hear noise which occurs beneath the level of speaking: coughing, clearing of throats, the movement of chairs, pen rattling etc.

Pupils are surprised again. They did not realise such events were source of really disturbing noise.
  29. - Prototype 2 of our Noise analysis apparatus (Lärmampel) now uses optical signalling:
    - red = a violation of limits
    - green = underneath the given value

We decided to add an optical signaller, because the permanent gong signals were nerve-racking. Now you can choose the way of signalling.
  30. What were the perspectives in the year 2005?
    - Technical further development of the "Lärmampel" for the start of production
      - (establishment of a pupil created company)
    - Trialling further test arrangements of the impacts of noise on learning.
    - Development of particular behavioural arrangements orientated



- Securing sponsorships                      Letters being finished
  - Financial budget                              Being discussed
  - Utility model registration                  Took place
  - Documentation                                In construction
  - Internal organisation                        In construction
41. This is the vision of silence - Appliance for visualising the noise levels of a school class in lessons, developed by the pupils under assistance of a teacher of technical lessons
- LED circle, red/yellow/green
  - Hardbox (CD-Format) with magnetic rear
  - Microphone/sensor
  - Network independent through solar cells
  - Threshold-setting (tolerated noise level)
  - Threshold display
- You will probably be able to purchase this product at the end of 2007. Please give me your address if you are interested and we will inform you when we begin selling them. Is there anybody here who wants to become the sales manager of our pupils company for Finland?

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This is the paper-version of a lecture at the Finnish-German Cooperation Seminar in Helsinki, 2007-04-03, for more details see [www.umweltschulen.de/audit/duesseldorf/finnland.html](http://www.umweltschulen.de/audit/duesseldorf/finnland.html)