## Humble beginnings

At the beginning of their final two years at secondary school, the pupils who had previously chosen the project-seminar under the name of ‘Documentation and Design of a Human Powered Vehicle’ embarked upon the task their seminar teacher, Mr Sanwald had devised for them.
To begin with, I believe it may be said that, in spite of his enthusiasm, his hopes were not high.
The first meeting held a surprise for many of the participants:
His main objective, it transpired, was not the construction of an HPV, but purely the documentation of its design. A rideable vehicle was more a kind of possible perk if everybody was really really involved.
However, as the levels of enthusiasm were much higher when aiming for an actual hpv than for a pile of paper describing one, many pupils still hoped to get down to actual chains and wheels soon.
Various possible Project goals were discussed:

- Purely designing a theoretically functional hpv
  - rather modest
- Designing a working hpv and constructing a miniature model
  - Possibly to be tested for aerodynamic suitability in the wind tunnel of the project partner BMW
    - still too modest for most
- Buying a ready set for constructing a definitely functional hpv
  - very expensive
  - positive: near certainty of success
  - lack of creative work
- ✓ Design and construction of a human powered vehicle
  - Unanimously chosen

# Experience report on the excursion to FIZ, BMW

The BMW-world has long become one of Munich's well known attractions. The Bavarian capital is one of BMW's most important locations and contains their FIZ: Forschungs- und InnovationsZentrum. Being one of our Seminar's external partners, BMW offered us a tour of this research centre, so on Tuesday the 9th of October, we met a representative of the company in FIZ, which turned out to be an immense complex of buildings designed to centralise the vehicle research and design in order to create a fast and efficient network of personnel.

We were first given an introductory presentation explaining the aims and advantages of such a massive institute. But in particular, we were given detailed information on the advantages of BMW as an employer and the career chances of the employees. The basic message seemed to be that well educated young people from almost any area of expertise, but in particular from the "MINT" subjects can be sure to find a fair, safe and well-paying employer in BMW. These subjects - maths, informatics, natural sciences and technical areas – were therefore also our guide's strong recommendation for subjects to study.

The next part was a tour of some of the FIZ research labs. We were shown various crash- and usage simulators used to test the BMW designs, including high energy signals which must not be allowed to disturb a car's electrical systems, a demonstration of possible materials for constructing cars with their advantages and disadvantages, all underlining the lengths to which BMW goes to achieve excellent quality.

An interesting aspect of the tour was the contrast between the modern, elegant upper levels of the building complex, where mostly design, calculations, marketing and management appeared to take place and the downstairs laboratories and test construction areas which reminded more of a car mechanic's workshop and had the definite air of what our guide described as an "authentic working atmosphere".

The tour certainly gave me a much better idea of the work at FIZ and of the incredible amount of effort required before a car is actually produced. It's also definitely a trip I would recommend to pupils interested in a technical career path. Personally, I was more disappointed than interested in what the BMW representative had to say on the brilliant career possibilities for engineers, because the jobs downstairs, with apparently rather lower salaries, would be more to my taste. In addition to that, our guide came across as a man used to dealing with professional adults in his own area. He was certainly friendly and polite, but little used to dealing with pupils, as well as incorporating a good deal of advertising in his tour. This wasn't really a problem, but one should be aware of this when listening to him and form one's own opinion on his topics accordingly.

## What to build?

The definition of a human powered vehicle was important to begin with. An obvious point was that no engine was permitted, the idea being to construct a purely mechanical vehicle run, as the name indicates by the physical strength of it's user. The definition in the other direction, so to speak, was a little more difficult: at what point is something a vehicle? Harnessing a human to a cart was quickly ruled out. But what about a construction which carries a person's weight on wheels, while they make headway by sort of 'running weightlessly'? A precise definition was never found, but in the end the group settled on the use of pedals and a chain.

This still left the issue of originality:
Almost any kind of vehicle within the given limitations had already been built. There were few options which differed much from a plain bicycle. So yet another ambition had to be rather limited: the vehicle was not going to be a new invention, but rather the pupils' own attempt at the kind of human powered vehicle of which many examples with more or less variation already exist.
This also opened a new chance for collecting information:
As most areas of interest, most people involved in the building of a so called hpv seem to be involved in some form of community of like-minded others. The Internet suddenly showed the world to be full of people tinkering with junk and old bikes in various sheds and garages around the planet, many of them regularly producing quite stunning apparatus, often capable of incredible speed.
In order to profit from their expertise, Pierre Gommeringer offered, and then did, sign into an internet forum for builders of human powered vehicles happily situated in Freising and the vicinity.

## First designs

The first task directly associated with hpvs was actually less aimed at producing real goals, than more an exercise for the group's imagination and a first taste of group work.
The seminar was split into three groups; each was to design an hpv to certain specifications.

1. 'As tall as possible'
    - Entirely enclosed capsule
    - Resting upon four wheels
    - Wheels positioned at ends of long poles, driven by long chains
    - Technically theoretically feasible, but:
    - Enormous expense, constructional finesse
    - Huge weight, very hard to drive
2. 'As low as possible'
    - Unusual position: lying on stomach
    - Head in direction of motion
    - Success: very low, streamlined
    - Main point of criticism: dangerous position
3. 'Aquatic'
    - Basic build: like bicycle
    - Floats made of old canisters (one at front, two at back); attached to bike's frame, back 2 far enough apart for stability
    - Front wheel replaced by streamlined float => steering rudder
    - Paddles attached to back wheel for momentum
    - Problems:
        - chain very expensive to encase reliably for water protection
        - possibly quite unstable
        - high friction surfaces, impetus inefficient => low speed

Overall, none of the resulting plans was very ripe for construction, but the aims of the exercise were reached by spurring everybody's imagination and critically assessing different ideas. In addition, the fun everybody had in the process certainly showed each group to be capable of cooperation.

Pierre Gommeringer also presented the results of his enquiries on the local hpv internet-forum:
The professionals seamed to be even more sceptical regarding the pupils' chances of success than the seminar-participants themselves. Although there were members open to being asked for advice, and any number of them may have been able to supply useful hints, the general amusement at the ambitiousness of the project was great. This forum did not end up as much of a gold-mine of information.
In fact, what turned out to be far more useful, was the seminar-teacher Mr Sanwald's own interest in the area of tinkering. The idea for the project presumably resulting from his personal interests, he had a lot of hands on experience on putting together vehicles, seemingly in all kinds of shapes and sizes, and in fact he brought along for inspiration one of his own creations:
A low-slung bicycle, which took some getting used to, and is apparently rather reluctant when it comes to curbs, but gave everybody an idea of what can be done with some old bikes. Although the pupils' plans were still a little more ambitious…

## Realistic evaluation of possible construction

The next meetings were not devoted to designing vehicles, but to the general conception of a project-plan. In groups of three to six people, the participants evaluated the chances and dangers involved. Whether the actual construction of an hpv was to be attempted was still a matter of debate. Interestingly, although the course unanimously voted in favour of the practical execution of the project, the list of risks was long and the scepticism high. Each group presented their assessment, and in the end,

**The main expected difficulties were:**

- Inadequate material means
  - Money
  - Spare parts
- Failure to complete construction within the set time limit
  - Due to lack of personal involvement on the part of most participants
  - Due to other school related obligations

**However, hopes were presented, too:**

- Possibility of finding a sponsor
  - Eg. Sparkasse
  - Advertising for the sponsor with a presentation of the completed vehicle
- Most parts available from old bikes/visits to salvage and junkyard
- In case of completion of a working hpv:
  - Selling it on e-bay=> making a profit?(suggestion greeted with sniggering)
- Budget from the parents' committee
- Presentation of the vehicle at school summer fête
- Offering rides on the hpv for donations

## Goals:

- end product: documentation
  + functional hpv:
- cool design (attractive for sponsors)
- speed
- doesn't fall apart
- agreement after discussion: road safety not essential, as usage would be minimal
- aspects such as lights, luggage rack and radio desired but optional

## Organisation

Having decided on the basic goals for the seminar, the next step was to get the process started. For this, it was decided that the group should be divided into topical teams: **Management**, **Technicians** and **Designers**

**Management:** Leonie Schulz, David Schwarzer and Hannes Sulzberger

- setting a realistic time-schedule
- arranging and overseeing meetings involving the whole seminar
- managing and calculating financial affairs

**Technicians**: Helmut Fink, Leon Sotzko, Alexander Heider, Pierre Gommeringer

- working out a plan for a functional hpv
- considering materials
- giving structural information to the Designers

**Designers**: Maximilian Wöhrl, Mark Andre Celuch, Jakob Chovas, Lea Bauchrowitz, Kristin Palfreyman

- using information given by technicians to create drawings of finished hpv
- mainly concerned with body of vehicle
- beginning with purely imaginary, motivational drawings
- growing ever closer to real design with more concrete technical information

First basic decisions were made as to the shape of the vehicle, before a long period of work, which was executed within the smaller teams:

- Wheels: Three
  - More stable than two, less friction than four
- Body: important
  - For looks
  - For aerodynamics

The outcome of this productive time was as follows:

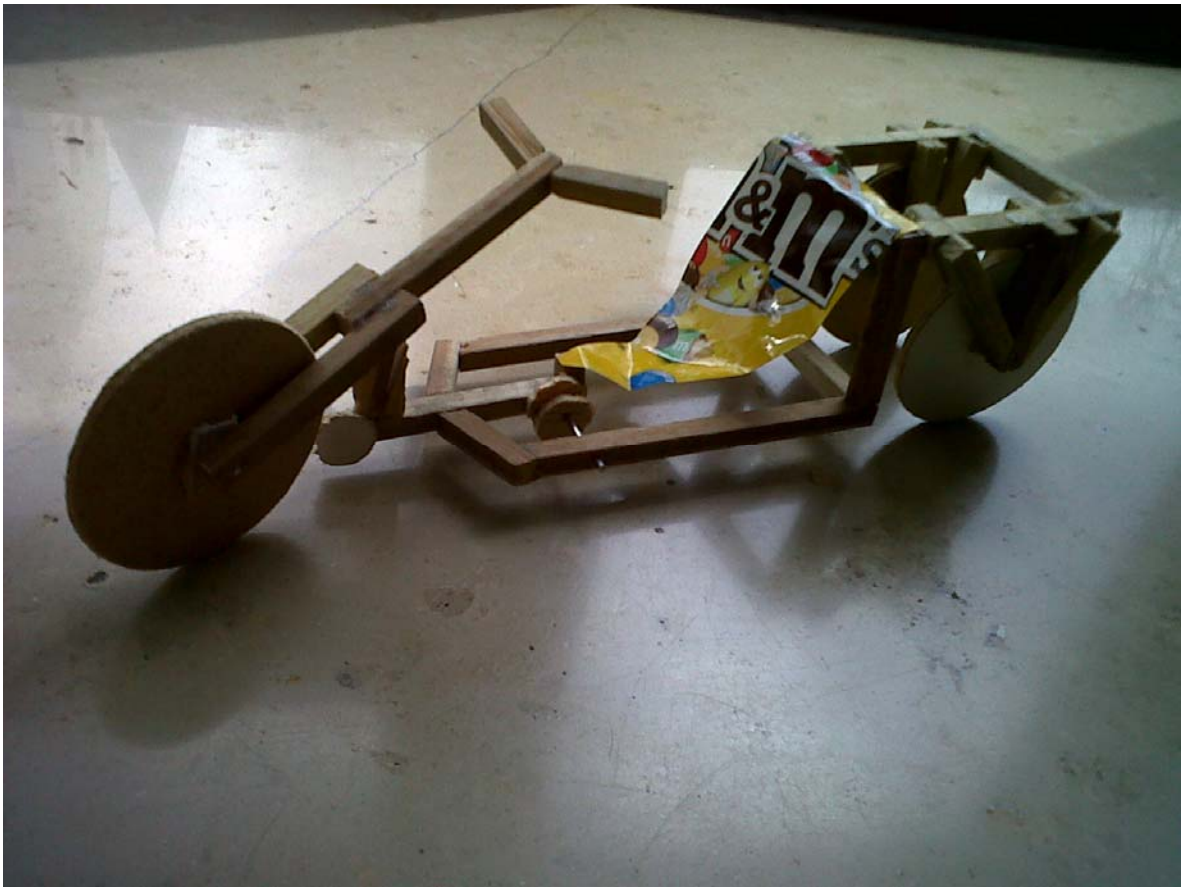
- **Managers' Plan of Action:**

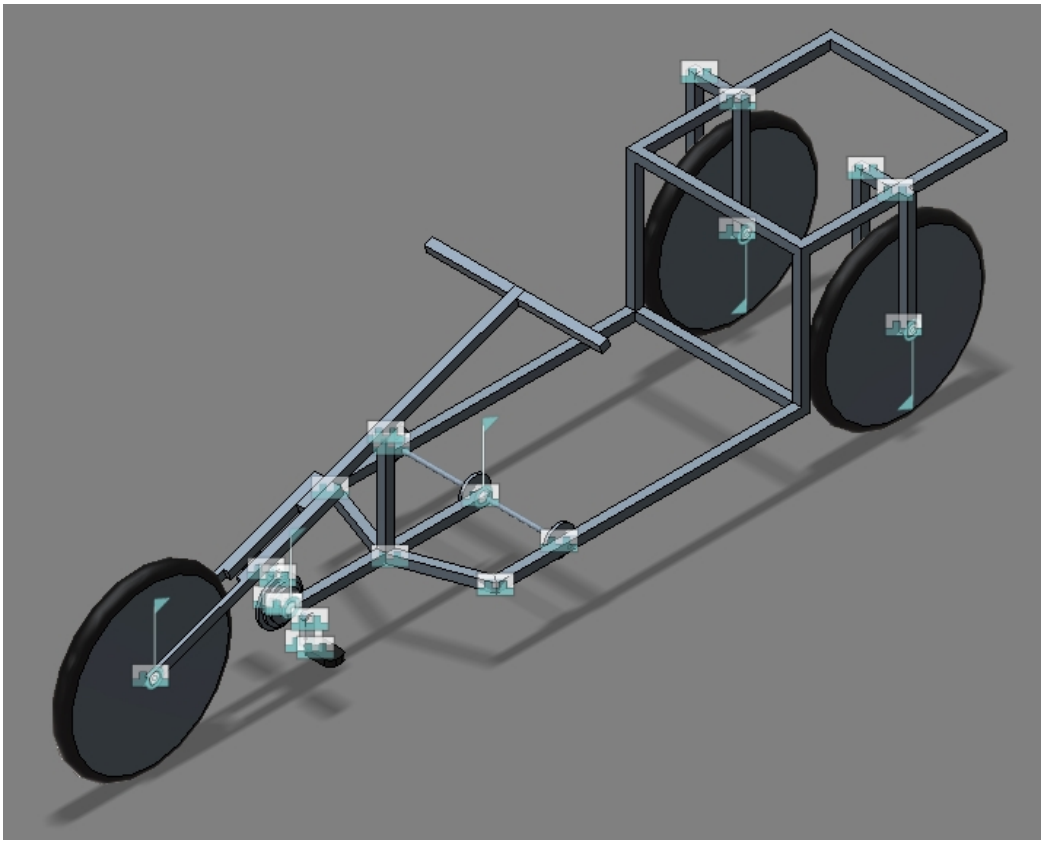
The management team returned with a highly ambitious, goal oriented time-plan, structuring the project through deadlines and working towards a concrete goal.
Unfortunately, most participants seemed to find the plan rather too ambitious. Upon presenting their proposal, the management team was rewarded with a good-natured, but very final, round of laughs.
And the result was, that the plan was never really even decided upon, and certainly didn't appear to be taken very seriously. The project never really ran according to this, or any other 'big plan'.

**goals and milestones** suggested on 30th of April were:

- Finalisation of construction-plan
- Acquisition of materials by wit-holidays (17th Mai)
- Construction of hpv by Friday 26th Juli at latest, because:
- Presentation of completed project at school-summer-fête on 29th Juli
    - Ideas: setting up a stall to introduce, advertise and explain the project
    - Offering rides on the hpv to pupils and visitors
    - In the event of still going with the idea of sponsors: advertising

- **Technicians:**



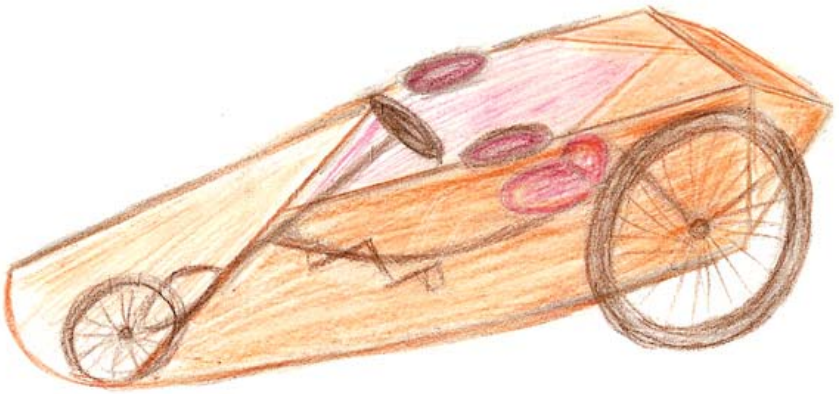


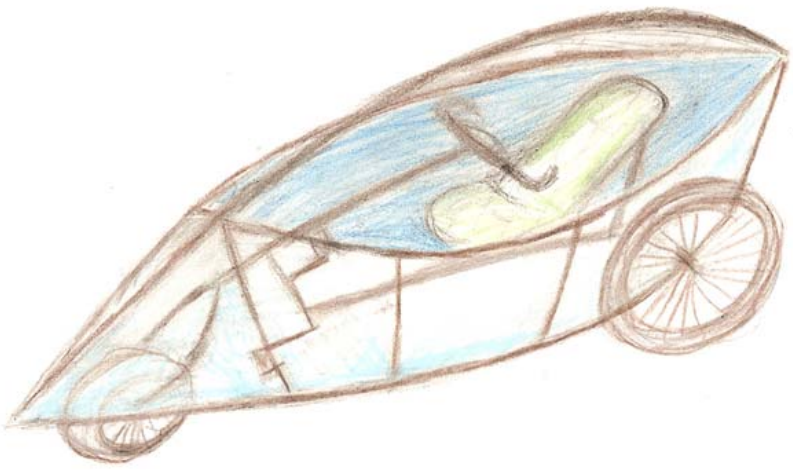
Although they had gone to great lengths to present a possible and theoretically fully functional design, they encountered several difficulties:

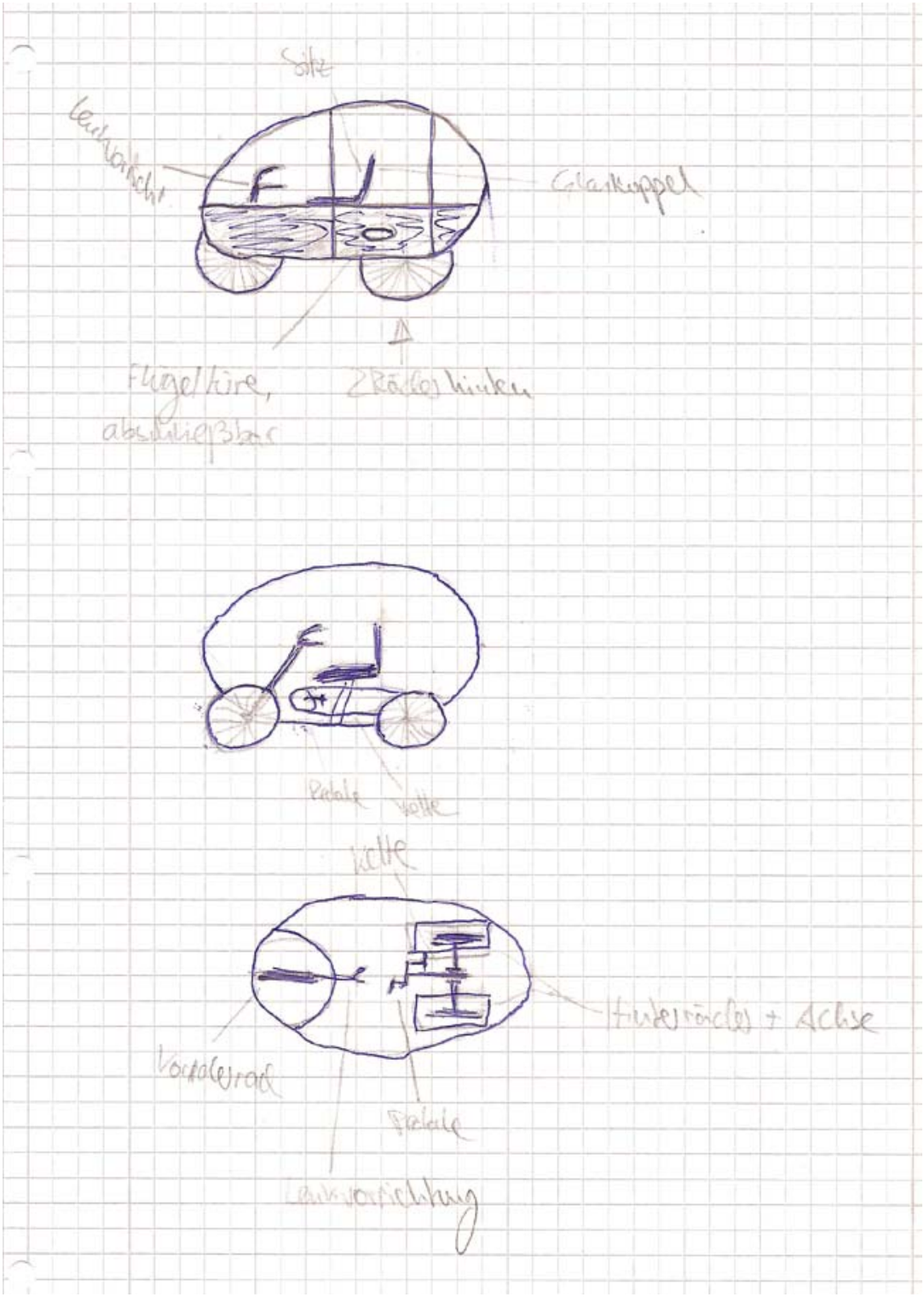
- By driving the two back wheels, two chains would be necessary. This system had been complexly worked out, but was, well, complex + added a lot of weight.
- The result was the change of plan in favour of placing to wheels at the front and one at the back.
- A further advantage of this set up was the more aerodynamic shape resulting from it.
- Aerodynamics turned out to be a big issue, as the information was supplied by Mr Sanwald, that on a bicycle, at a speed greater than about 20 km/h, around 80% of the force invested by the rider goes into overcoming air-friction
- **=> a new criterion for the designers became the orientation of the body around the ideal aerodynamic shape: a drop, petering out to the back, or cutting off sharply**

- **Designers**

The approaches to creating possible designs were very varied.
While some started with what they knew about aerodynamic design, others focused on concrete ideas of how a body could be constructed and modelled the sketches around the technical possibilities. Others again, the ‘true designer’, as Mr Sanwald affectionately titled them, completely freed themselves from any materialist constraints and gave the seminar-motivation a boost by drawing up the smartest, flashiest bodies they’re imaginations had been able to supply them with.






Sitz
Lenkstange
Glaskuppel
Flügeltüre, abschließbar
2 Räder hinten
Pedale
Kette
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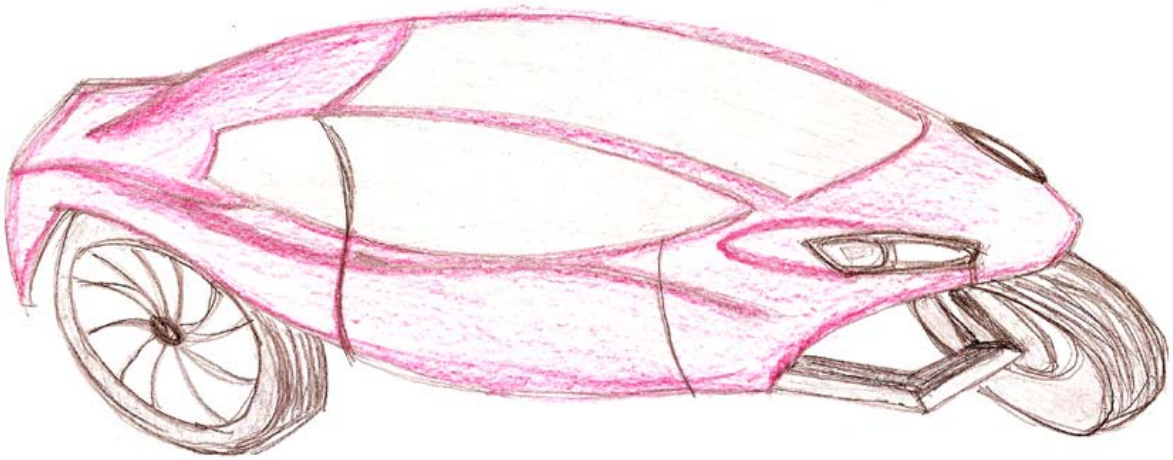
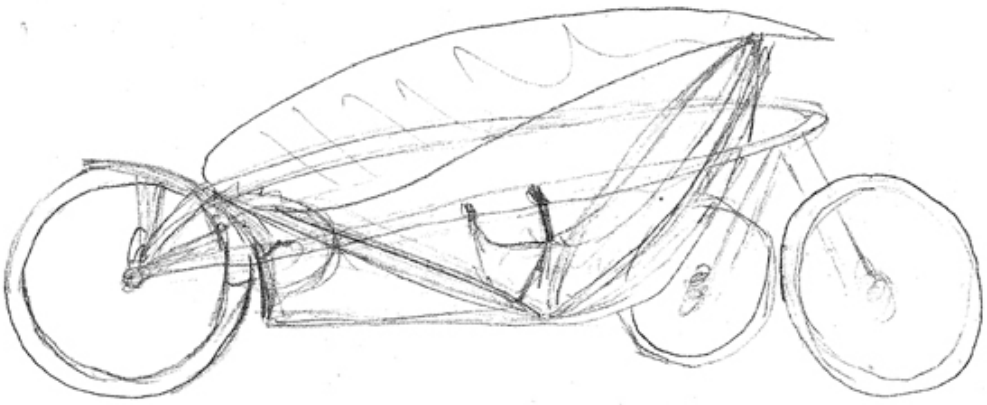
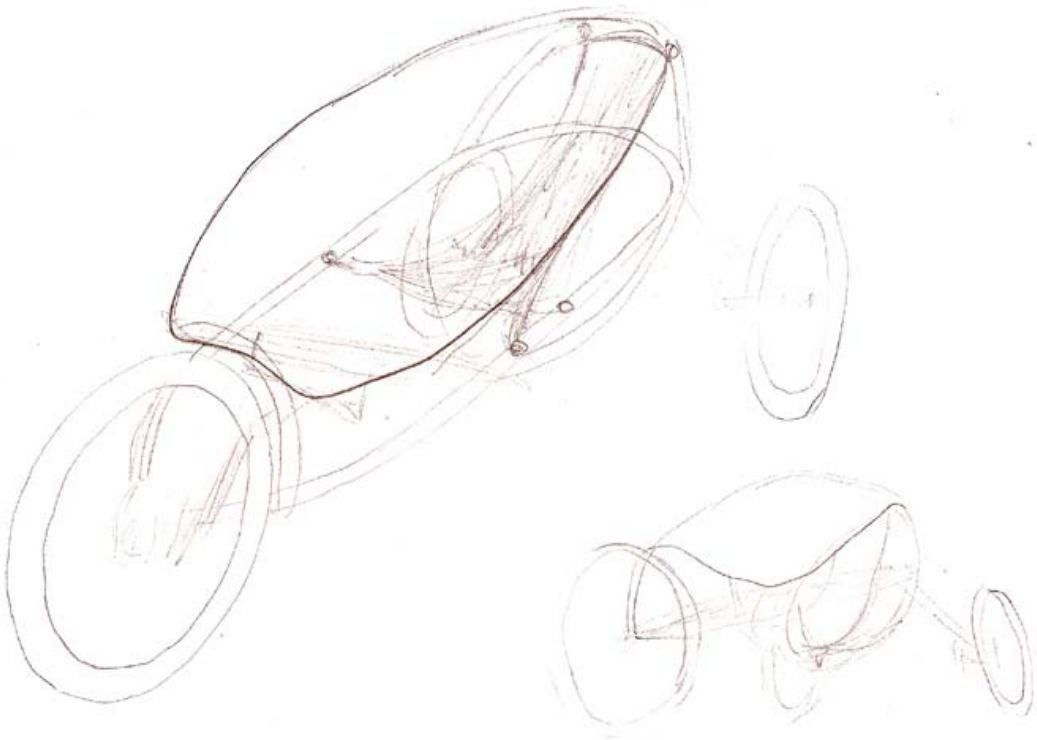
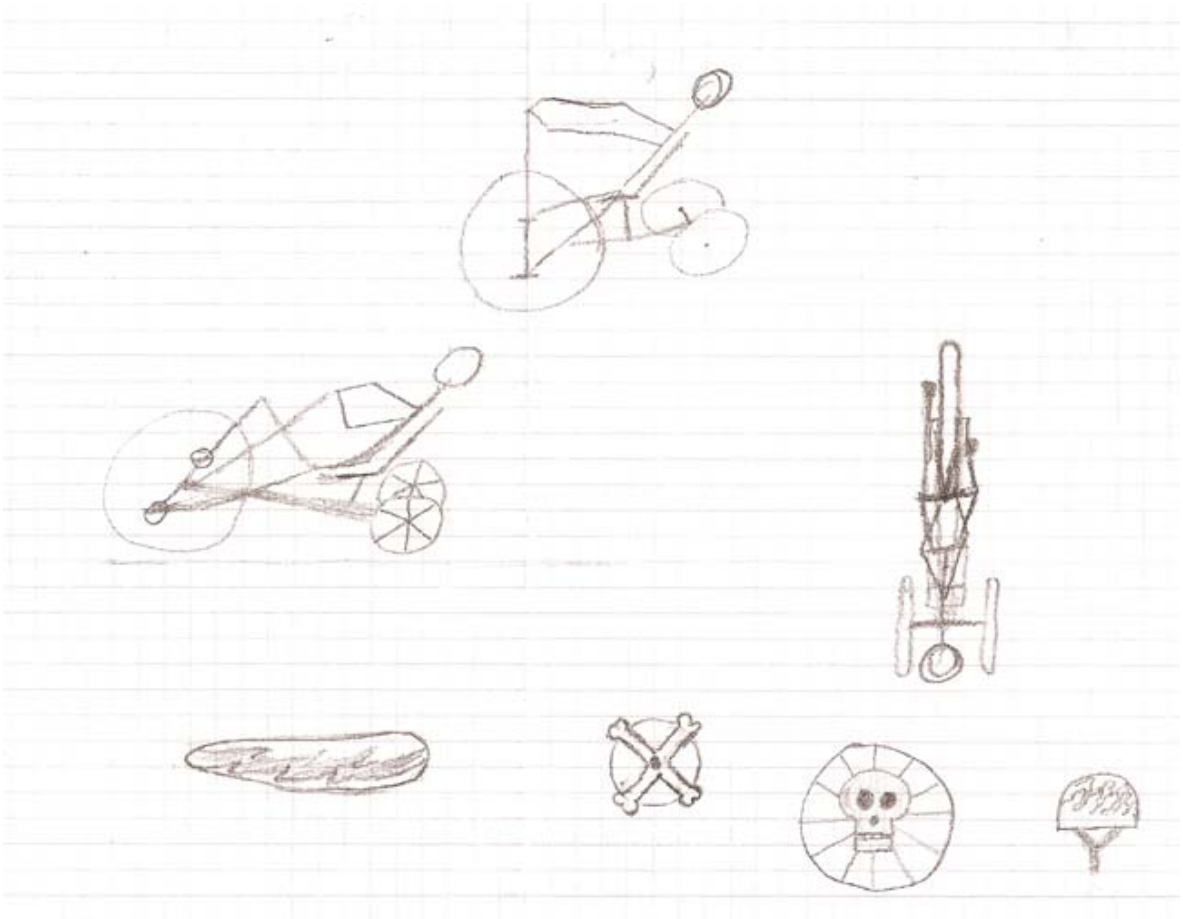
Hinterrad + Achse
Vorderrad
Pedale
Lenkvorrichtung









Although the motivational factor was much appreciated, after the presentation of each design, the discussion did forcibly turn to the achievability of each of the presented goals. A big issue the (naturally constructive!) criticism boiled down to in most cases was the material with which the groups were to work. While the technicians were expecting to use mainly old bicycle parts, complemented were necessary by aluminium, screws, a board or two, or similar, from building centres, the body could be constructed from any number of quite different materials. Any material held a number of disadvantages and, usually, various advantages, too. Several suggestions were:

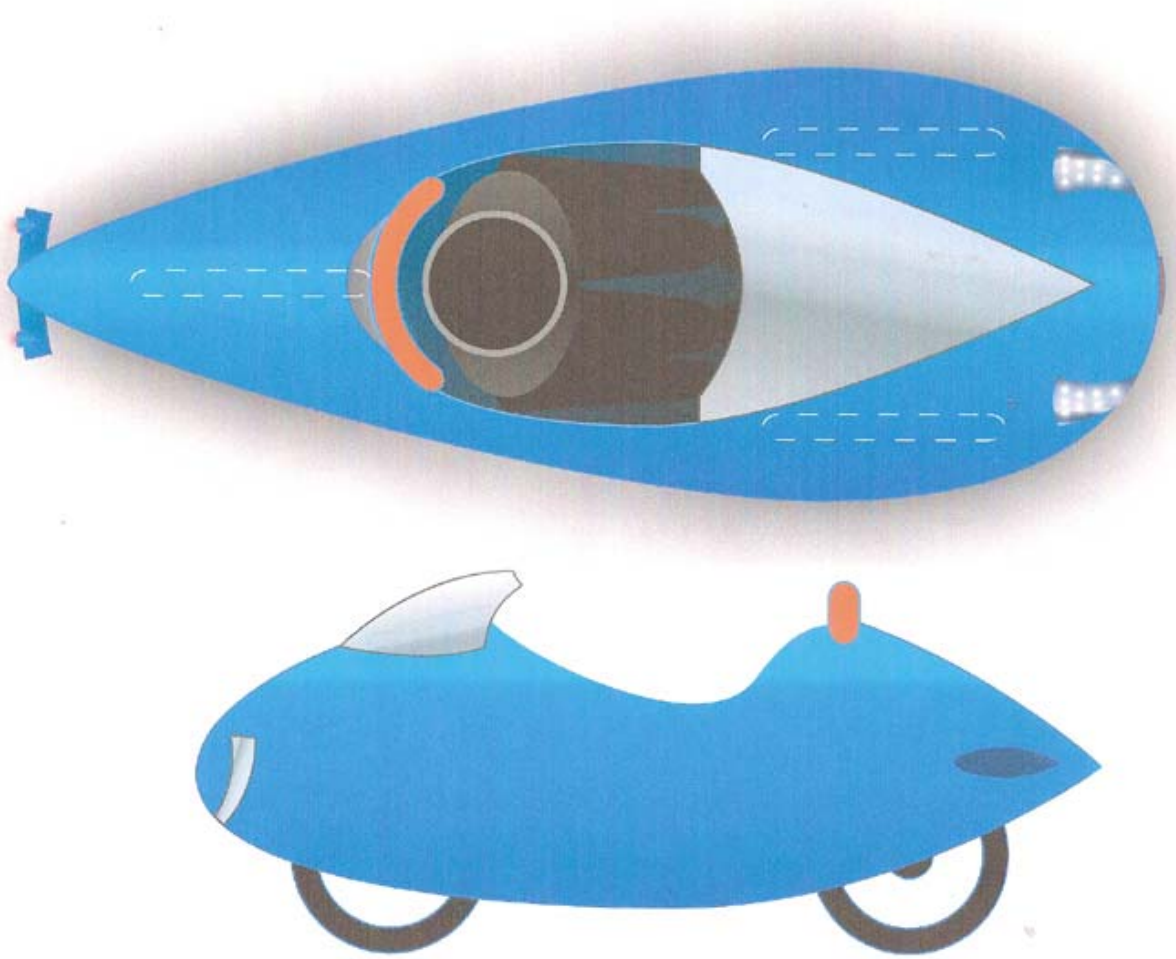
| Material | Pros | Cons |
|---|---|---|
| Wood | • Stable, resilient<br>• Easy to work, shape<br>• Fairly inexpensive (e.g. plywood) | • Very heavy<br>• Hard to bend |
| Metal | • Stable, flexible<br>• Possible to bend | • Very heavy and/or very expensive<br>• Special equipment required for work |
| Papier mâshé | • Very easy to shape (in any way)<br>• Very cheep | • Vey heavy<br>• Requires a 'mould' |
| Styrophoam | • Fairly uncomplicated to shape<br>• Can form any shape<br>• light | • unstable<br>• Leonie hates it |
| 'Tent': Willow frame + textile cover | • light<br>• Easy to shape<br>• Cheap material | • Not too sturdy<br>• 'unprofessional' appearance |
| Epoxide resin | • In compination with styrophoam, any shape possible<br>• Light<br>• Sturdy<br>• Very professional | • Very expensive<br>• Fairly work-intensive |

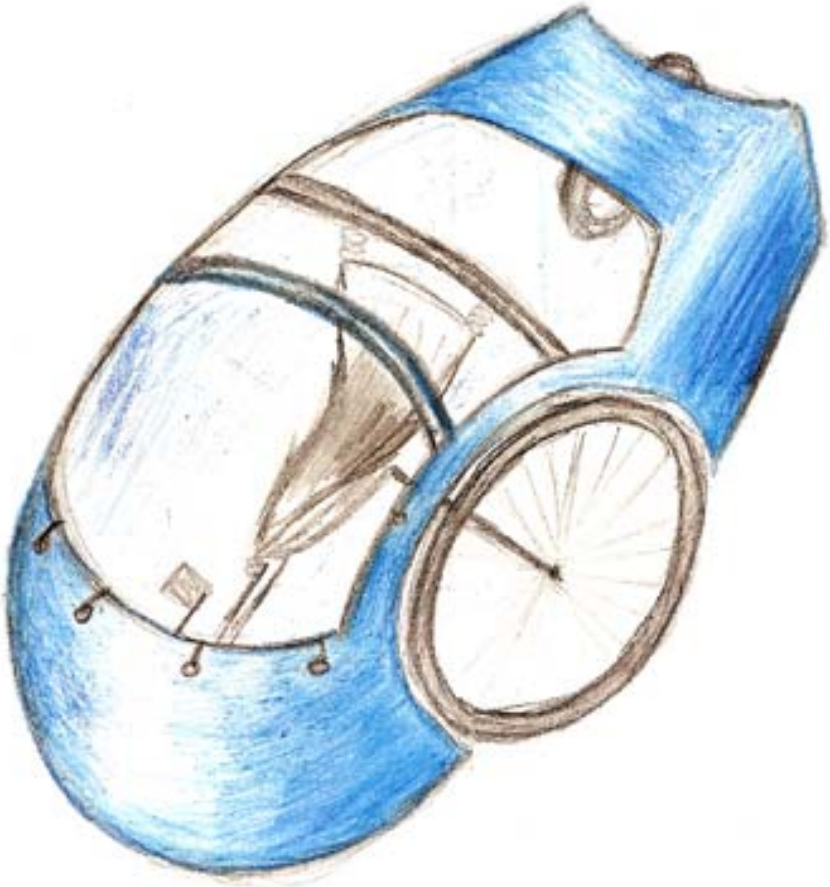
## Next fundamental decisions:

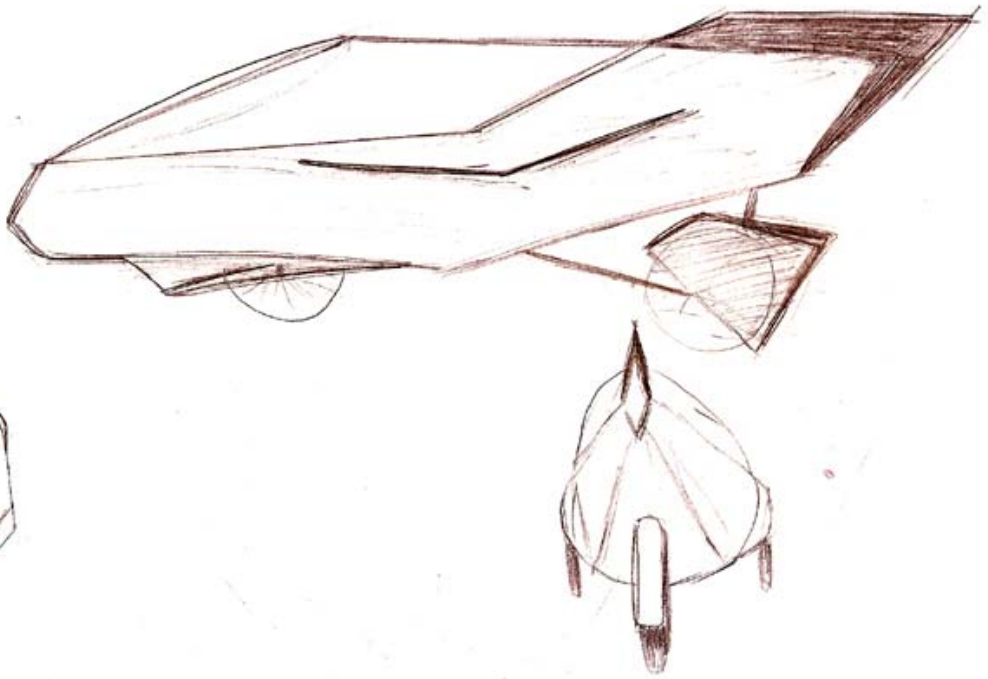
So the new criterions for future designs were:

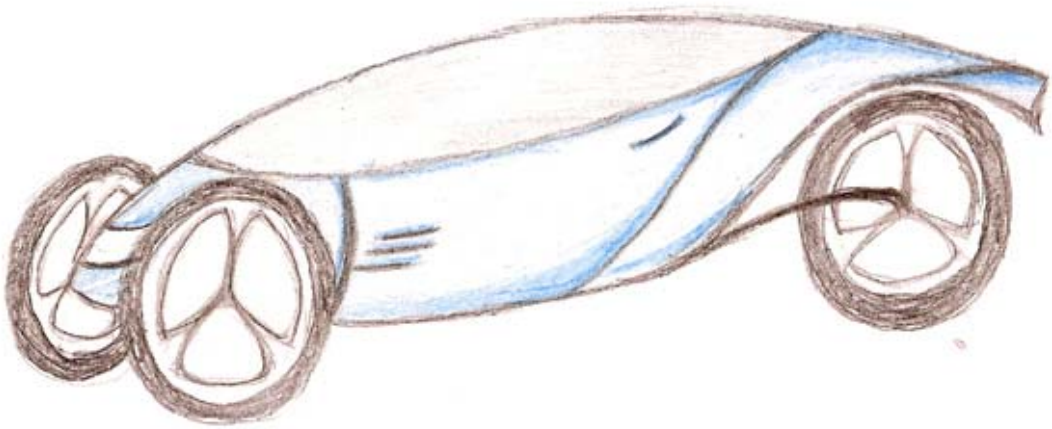
- Two wheels at front, one at back
- => a single chain
- steering of double wheels at front
- aerodynamic droplet-shape

After another prolonged period of inspiration, these designs followed:

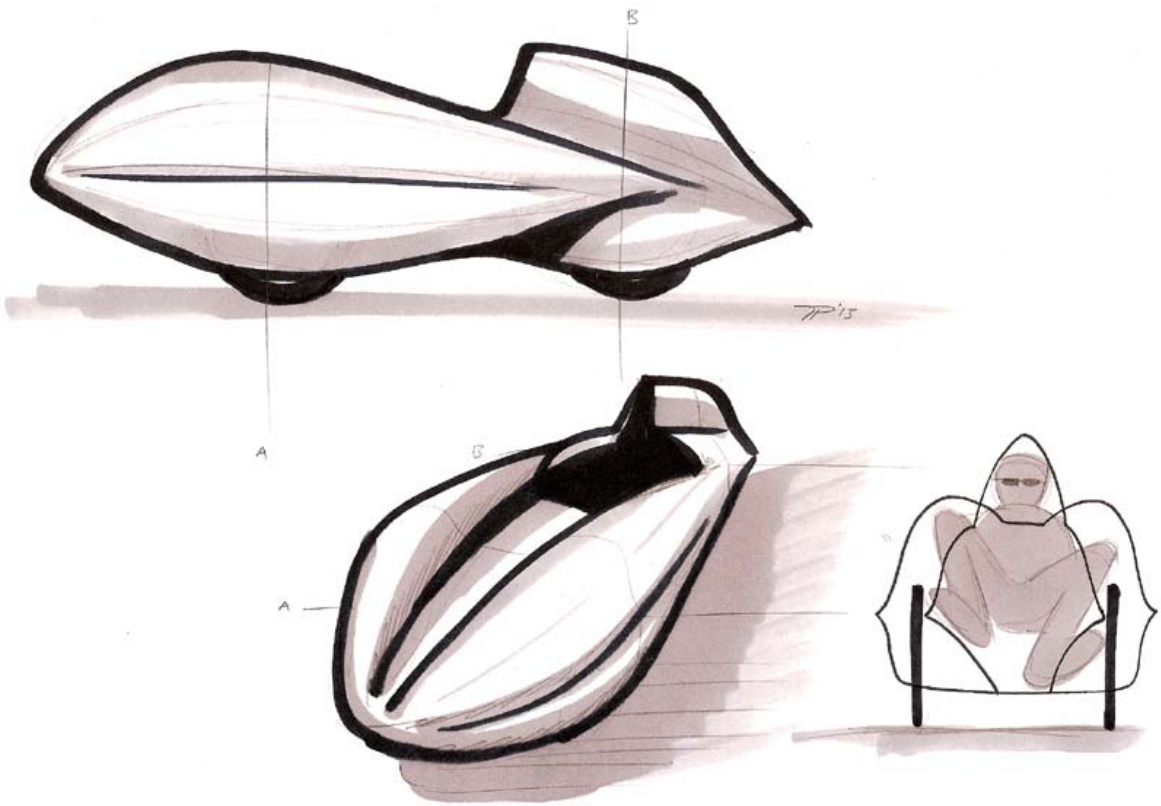








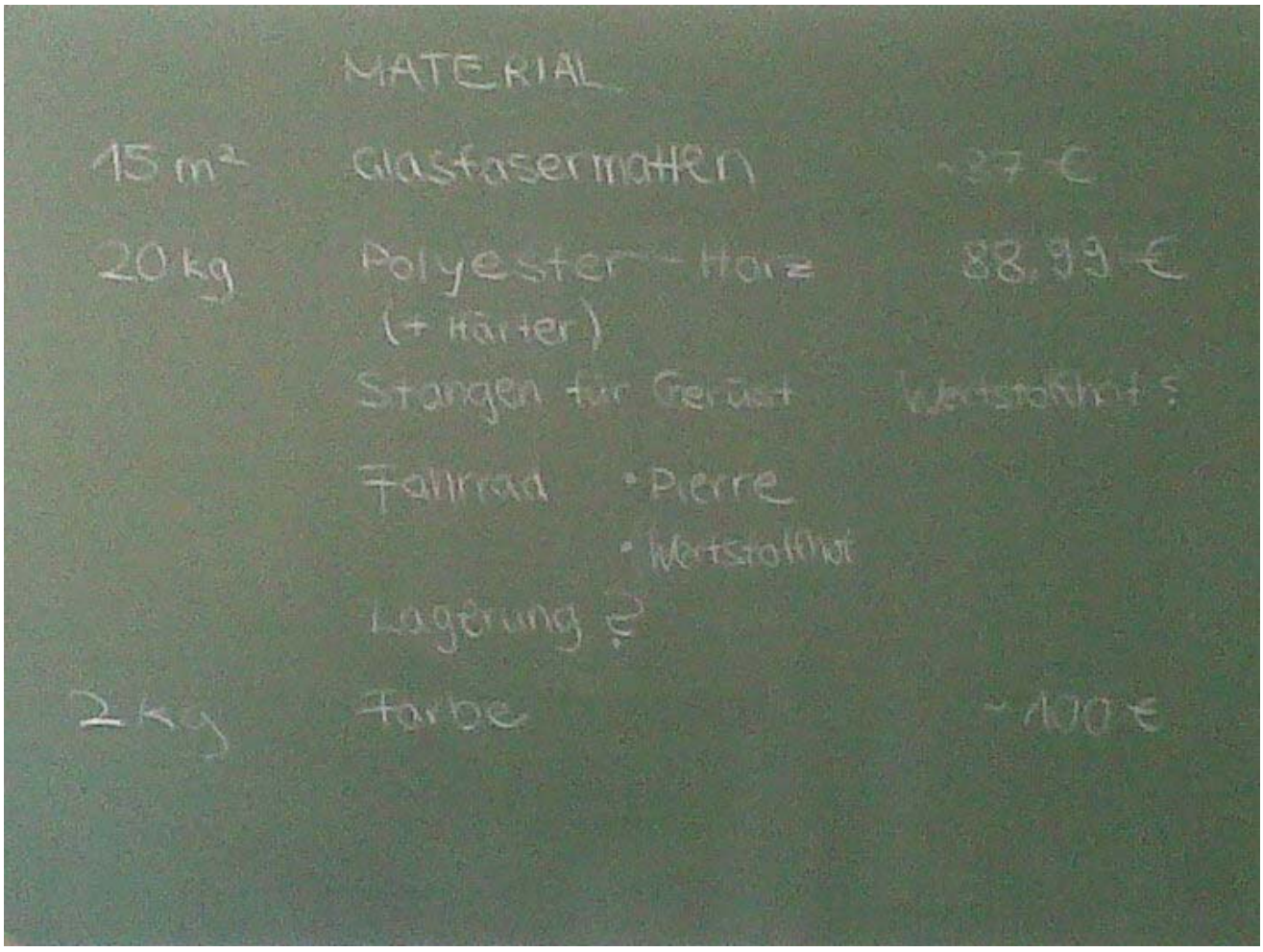
Lea Bauchrowitz



the final design being the one drawn up by Mr Sanwald himself

## Material

Finally having progressed far enough in the planning process, the next step was to decide on what materials would be required and calculating the cost.



**Frame:**

- made of two old bicycles (supplied by Pierre)
- additional bars provided by Mr Sanwald

**Other Parts from old bikes:**

- brakes
- chain(s) (adapted in length)
- wheels

**Body:**

- shaped out of styrophoam
- coated in epoxide resin
- either coloured resin
- or varnish to paint
- all bought
- => cost of around 200 Euros just for body

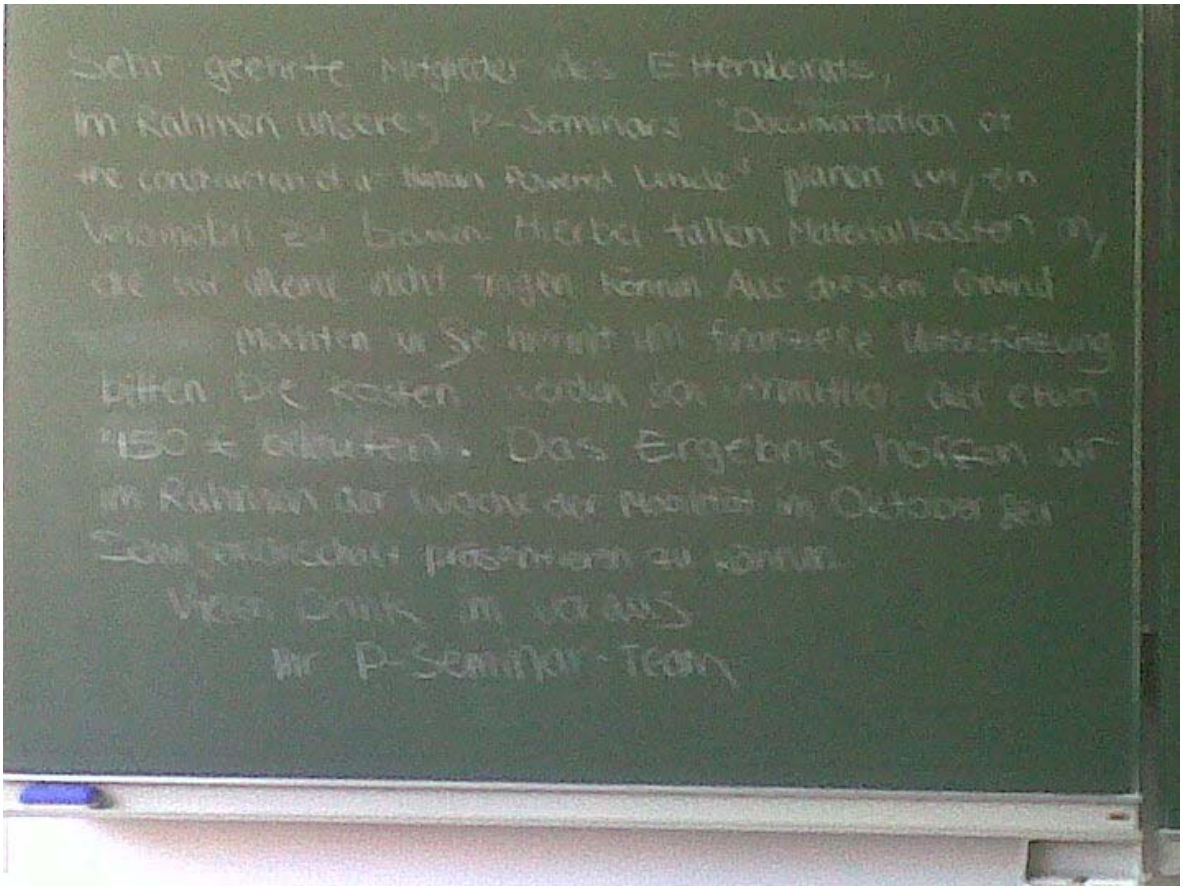
**Seat:**

- Either ‘sling’ for good cushioning, woven from old bicycle tires
- Or cushioned wooden boards
    - Slung by old tires for feathering

**=>Money required**

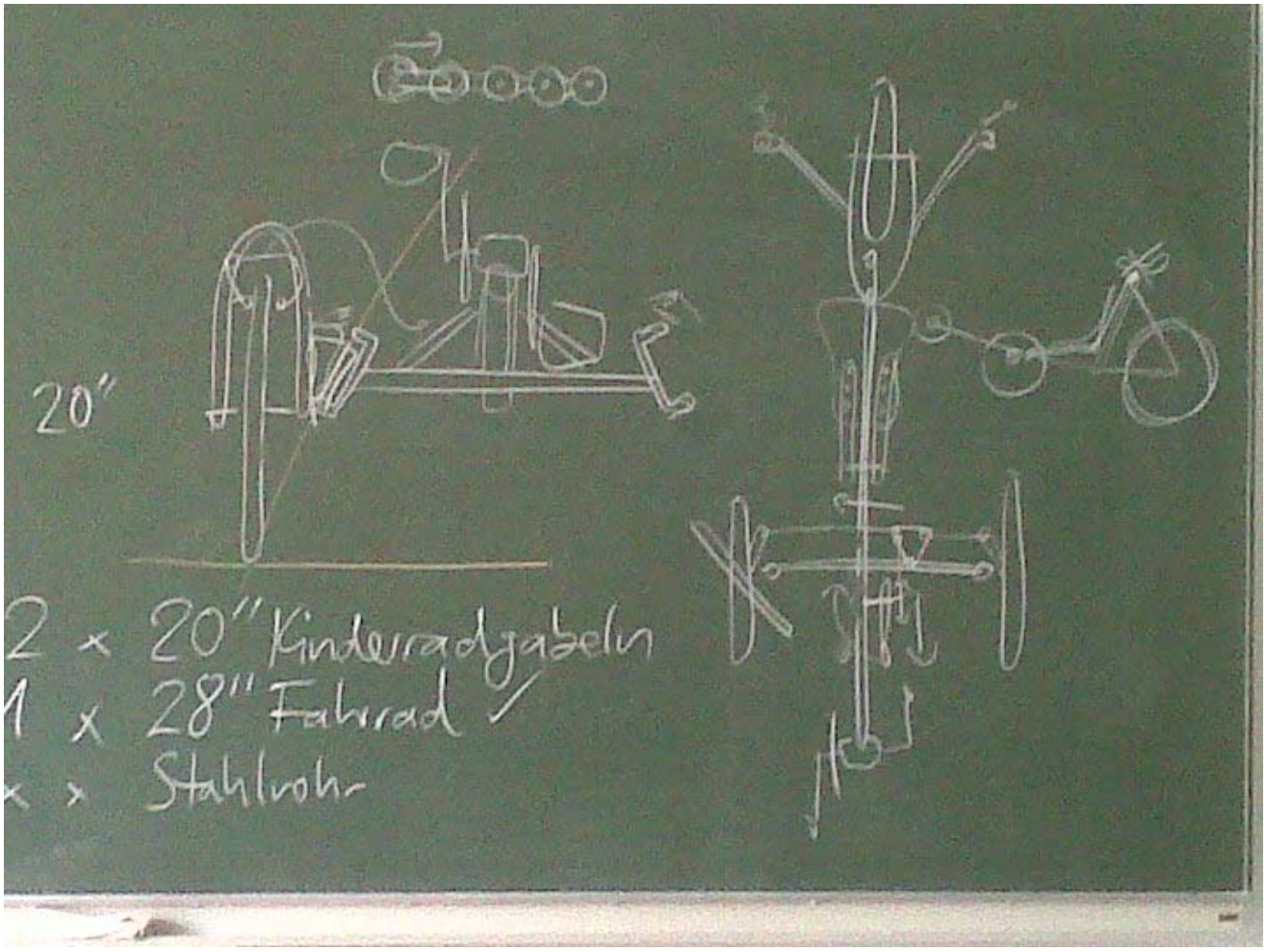
Suggestion: Application for budget from parents’ committee

⇨ **Application sent**



As can be read in this draft of the letter later sent to the parents committee, Mr Sanwald had, by then come up with a new form of presenting the project:

A week of mobility was to take place at the Dom-Gymnasium from 7th to 11th of October 2013. This would, of course fit in perfectly with the project goal. So there was, in fact, a new goal.



rough sketch of the planned hpv by Mr Sanwald

Then however, another rather passive phase in the project-work followed, during which the work was, once again, more or less set on hold by other priorities, perceived by most team-members to be more urgent, and extended by the summer holidays, followed by the entire year's final school-trip during the first week back.

**There was some progress however:**

The main task during this period was the acquisition of material. So while waiting to hear from the parents committee about a possible donation, many team members took to frequenting rubbish-sites to find spare parts. Pierre supplied two old bicycles, which were enough to supply the frame, back wheel, brakes and chain. The main problem was, that the technicians had calculated, that the difference in radius between front and back wheels should be as large as possible, the front ones having to be smaller. This meant finding two child-sized bicycles, as the joint was also required, so the back wheels were useless. These turned out to pose enormous difficulties. In particular, since both wheels still had to have identical sizes.

- 1. Children's-bike: supplied by David (or rather his sister)
    - 16'' diameter

After the summer holidays, although too late for the week of mobility, things suddenly got started:

- The parents' committee, having first declined, now granted a limited budget
- A suitable second children's-bike was acquired via e-bay

And it was decided to just start building.

Division into new areas of responsibility for construction:

- Frame
- Brakes
- Chain
- steering
- Seat
- Body

Mr Sanwald took on the task of constructing the frame, which also involved the wheels and encompassed the steering-mechanism:

- Each small wheel kept its outer handlebar
- => steering like a bicycle,
    - but due to recumbent position
        - Chosen for aerodynamics
    - Handlebars on either side of body, at waist-level

For further construction, David provided his father's company-workshop, enabling:

- Use of tools
- Space for meeting for construction
- Storage space during construction-process

The team met in small groups. Each team encountered difficulties and had to be flexible and inventive to solve them.

But they were making headway.

# SHOCKING NEWS: MR SANWALD DECLARES PROJECT FAILURE

SCHULE

## THE END

### How it came about

In the end, it transpired that either too many project members were unavailable during the Christmas holidays for a meeting to make sense, or in some cases an error of communication occurred. So, unable as the pupils had been to work on their hpv for such a long time, all returned to school eager to complete the work they had begun. Upon their return however, they were met with some terrible news: the date on which their project was to have been marked by was only a few weeks away. Now under such unexpected time-pressure, the group was forced to make some hard decisions and set some tough priorities. Although what everybody had set their heart and soul upon was the actual hpv they had all grown so fond of, the task set in the seminar had been deliberately chosen to be the documentation rather than the successful construction. Faced with the reality of having time only to finish either the documentation or the construction, the team nobly accepted defeat and set about finalising their work journals for publication.

'I WOULD LIKE TO NOTE AT THIS POINT: THE SEAT WAS IN PLACE!'

### FAILURE?

The devotion to their common goal each team member had developed became intensely apparent during the heated debate, as to whether it was justified to pronounce the project a failure.

Many members felt this undervalued the hard work they had invested. ,was only one of many dismayed outcries. And quite apart from hurt pride, it was felt that more important values, such as team-spirit, self-organisation and devotion had been…well, perhaps not entirely acquired, but at least tasted.

Which, it was decided, was a success of far greater value…

## Final evaluation:

- frame: complete
- brakes: complete
  - Levers attached to handlebars
  - two wheels possible to brake
- chain: theoretically complete
  - had posed some problems due to wrong screw-thickness
  - correct screws were acquired, but not built in yet
- steering: complete
- seat: complete
  - Two boards, connected by hinges
  - Attached by old bike-tires
  - Cushioned with foamed plastic
- body: completely virtual
  - theory and first calculations of cost and size had been developed
  - however, dependent on completion of remainder of hpv
  - => only group without any concrete results
  - => parents' budget almost untouched

## Presentation

Not having an hpv to show, this presented some difficulty. However, Mr Sanwald is planning to present some documentations on the school website.