Forming project groups – what methods are best?

What methods are you using today?

1

Prepare to debate, starting at 13.00

RED TEAMS

You will argue that students themselves should select groups.

BLUE TEAMS

You will argue that the teacher should select groups.

Preparation:

- Formulate your arguments
- Try to predict what arguments the others will use and consider how to argue back

Debate:

- One randomly selected member from your team will be debating with representatives of other tables.
- Make sure that all of you are prepared to represent the group!

2

Students should form groups

- Sometimes the course is not about learning teamwork, then let the students focus on the subject. Choosing groups can improve motivation
- It is easier (for the teacher) that the students do it so we don't have to. We can help if someone is left outside.
- They can pick people who they feel safe with, and whose calendar matches.
- They are grownups and should be able to make their choices.
- People tend to seek others who they know and like, and they have good experiences with them.
- In working life, you *can* actually choose who you work with. I have never been forced to work with anyone.
- We try to create good learning situations at university, the quality of the end product is not the most important.
- We should not assume that students will optimize comfort, but we can give them guidelines
- It may increase motivation

Teachers should form groups

- There are frameworks; structured methods. In the first year they need to get to know others socially, improving their learning.
- Easier that someone picks the groups
- You want heterogeneity in the groups
- Students are grown-ups. In working life they must be able to work with everyone.
- When the students choose, it takes endless waste of time, it is much quicker if I do it.
- Students should get used to it
- You should learn to work in teams (not just one friendship team)
- Good for the social environment in the class that they work with different people.
- There are loners who tend to be left outside
- It's all about learning, comfort and enjoyment are important, but it's all about competence

4

When we argue about the better way of doing things…

ALWAYS ask: *better for what?*

In this case: What are the intended learning outcomes?

What is the purpose of group work here? Is it…

- a learning activity to increase students' ability to work in groups (an intended learning outcome)?
- a means to reach other (disciplinary) objectives?
- only a practical arrangement (to fit # of 3D printers)?

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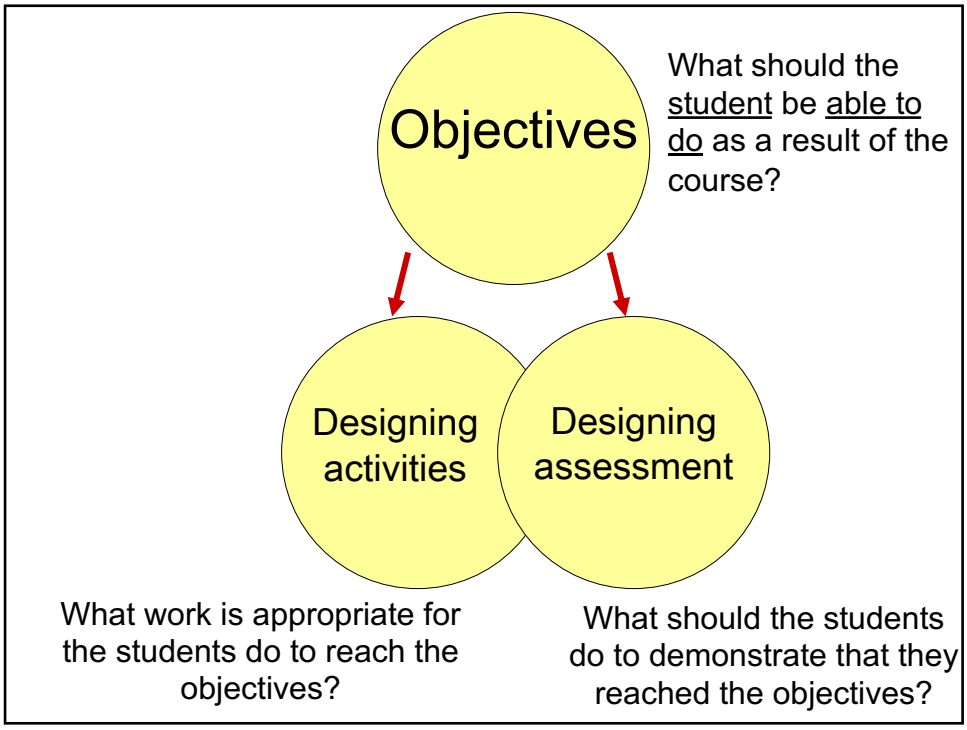

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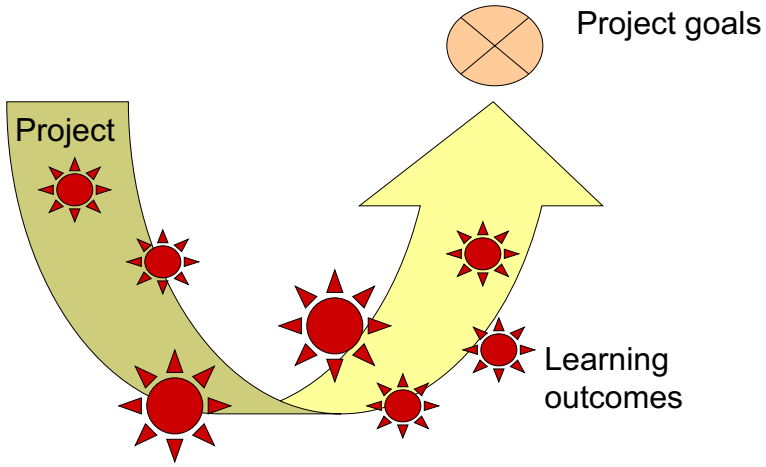
What is the purpose of project work in education anyway?



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Powerful principle 1: the purpose is student learning

Competing values:

- Task achievement
- Convenience
- Fairness of effort
- Satisfaction
- Conflict avoidance

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What algorithms can we use for forming groups?

-

-

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A long time ago in a galaxy far, far away....

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Self-selected groups – bad for learning

- Little dynamics in group constellations
  (better for learning to cooperate with different people)
- Specialisation and expert tasks
  (bad for learning the subject)
- Habitual roles and relations
  (also dependence and free riders)

- Negative social consequences, e.g. segregation, exclusion, status hierarchies

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A simple method to create random groups

- Hand out a playing card to each student
- Form groups:
  - red/black
  - suite: ♠/♣/♥/♦
  - value: A/K/D/Kn/10/9/8/7/6/5/4/3/2
  - Draw cards
  - Play cards (a trick is a group)
- Change quickly between configurations and group sizes
- If more than 52 students, use two decks with different backsides

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Why is it so common to let students self-select?

…it is a part of the tradition of **group grades**
- maybe that is the fundametal problem?

what reasons could there be not to have individual assessment in projects?

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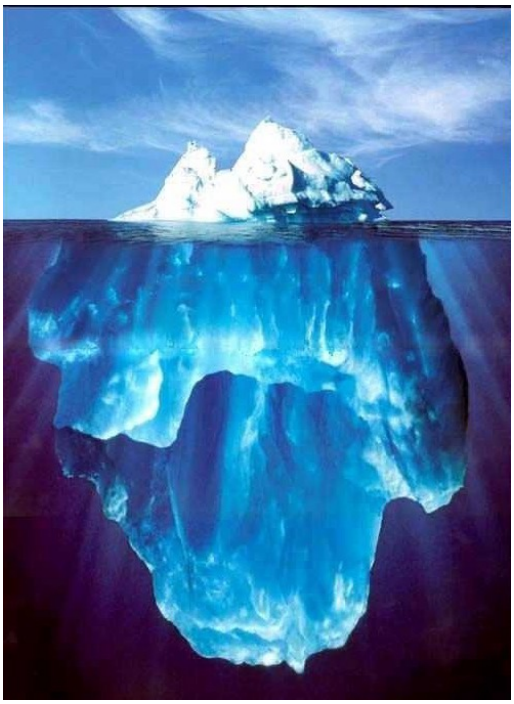

By the way:

This learning activity format (the debate) is known as fishbowl

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A critique of groupwork in education

- Students tend to divide the work according to their existing expertise
- In other words, they minimize learning!

- No problem, it is natural, we would do the same…

- **The problem is that we tend to use task achievement as a proxy for learning**
- **It is also aggregated on group level**

- **Then we have a problem – note that we created it with our poor course design!**

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Teaching and Assessment in Project-based Courses -with focus on Learning

Jakob Kuttenkeuler, Naval Architecture
Stefan Hallström, Lightweight Structures
Kristina Edström, Engineering Education Development

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Examples are illustrations of principles

A specific **example** will **illustrate** **generic principles** to **inspire** **applications** - of many different kinds.

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First day of the course, each group of 8-16 students get a challenge:

e.g.

Conceive, design, build and operate
a vehicle that can transport one person
at planing speed on water
and at low speed submerged.

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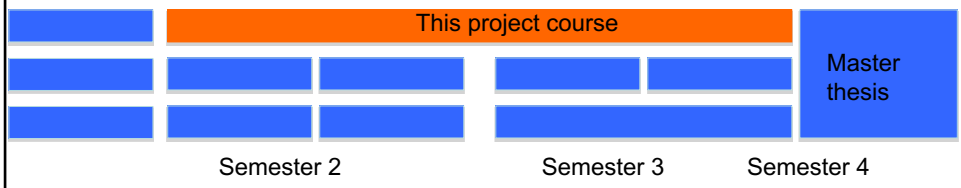
Some basic course facts



- Class of 30-40 students from mixed programs, groups of 8-16,
- 2 semesters, 20 ECTS (1/3 of students' time for a year)
- Individual grading A-F

- 2 weekly scheduled hours but most activities “on demand”
- Standard course funding (low material budget, limited teaching time)
- Access to a standard classroom “owned” by the students (24/7)
- Access to department workshops

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Different project every year

33

So that's what we typically see of project courses

But let's take a deeper look under the hood to see what is really going on

34

Different project every year,
but the learning objectives are the same!

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After the course the participant should be able to:

- take on (technical) problems with a **systems view**

Students should pay attention to:

The *actual* challenges

What really matters

Keys to success

My contribution for the best of the team/project

Interfaces & interactions

...

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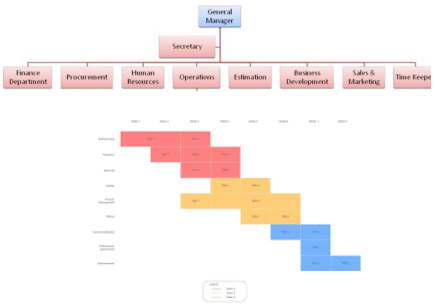
After the course the participant should be able to:

- take on technical problems in a **systems view**
- handle (technical) problems which are **incompletely stated** and subject to multiple constraints



Project management
(Easier planned than done)

The project management subdivides the work and everybody solves their part ☺

- who will "look at" propulsion?

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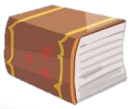
- handle technical problems which are **incompletely stated** and subject to multiple constraints
- develop strategies for **systematic choice and use of available engineering methods and tools**

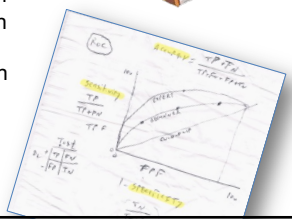
Getting the Big Picture and Paying Attention to the Details

Cultures:
French
Asian
Estonian
Swedish
German
Spanish
Italian
Mexican
...

The natural first choice



Google



Let students experience the power and beauty of initial simple models and reasoning

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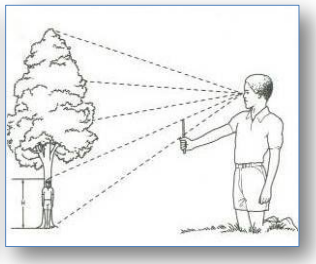
- handle technical problems which are **incompletely stated** and subject to multiple constraints
- develop strategies for **systematic choice and use of available engineering methods and tools**
- **make estimations** and appreciate their value and limitations

Everyone is always waiting for better input!



Estimations & Educated guesses

Remember to revisit and challenge

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- **make estimations** and appreciate their value and limitations
- **make decisions** based on acquired knowledge

Comfort zone

Reinforced & traceable decisions

Scary zone

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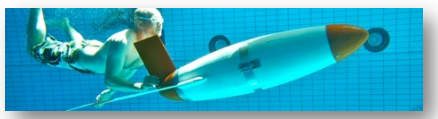
- **make estimations** and appreciate their value and limitations
- **make decisions** based on acquired knowledge
- **pursue** own ideas **and realise** them practically

- To discuss, argue, debate and stand up for your standpoint.

- Sometimes let go of darlings.



Testable state where *my effort made a difference*

Struggle with real world issues, e.g. play, friction, misalignment…

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- **assess quality of** own **work** and work by others

More on this when we talk about assessment.

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- **pursue** own ideas **and realise** them practically
- **assess quality of** own **work** and work by others
- work in a true **project setting** that effectively utilises available resources

e.g. ..time, money, lab, teachers, and other resources.

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- work in a true project setting that effectively utilises available resources
- explain **mechanisms behind progress and difficulties** in an authentic project setting

Big groups (8-16)

Deadlines
Professionalism & respect
Decision making
Keeping people busy
Traceability in decisions
Group contract
Team energy management

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After the course the participant should be able to:

- analyse technical problems in a **systems view**
- handle technical problems which are **incompletely stated** and subject to multiple constraints
- develop strategies for **systematic choice and use of available engineering methods and tools**
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- work in a true **project setting** that effectively utilises available resources
- explain **mechanisms behind progress and difficulties** in such a setting
- **communicate engineering** – orally, in writing and graphically

All possible modes of communication in authentic situations!

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After the course the participant should be able to:

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- explain **mechanisms behind progress and difficulties** in such a setting
- **communicate engineering** – orally, in writing and graphically

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The purpose is learning

Given the nature of the learning objectives, students must be exposed to:

- The logic of open-ended problems
- Validation rather than “right answers”
- Empowerment and responsibility
- Discover principles and concepts hidden in real problems

Students struggle when they encounter fundamental principles and concepts “in the wild”

Newton's laws on motion
Archimedes principle
Strength vs Stiffness
Ohms law
Equilibrium and stability
Equations of motion
Feedback control
Stability
etc.

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Powerful principle #2
The project sets the logic

- **The project** sets the logic and drives specifications, plans, needs, deadlines... **not the teachers!**
  - ➔ This makes everything students do in the course **meaningful**, reporting comes natural (for the first time).
  - ➔ This makes the course format **sustainable**

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Powerful principle #3
The students own the project

- **Teachers advise and coach**, but do not provide solutions. Students are not protected from mistakes, friction or anxiety. The project results will reflect the students' level of proficiency, not the teachers'.
  - ➔ This allows, and forces, students to think for themselves, growing into engineers
  - ➔ This makes the course format **sustainable**

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Maria Montessori:

EVERY TIME YOU TIE THE SHOES FOR YOUR CHILD, YOU HINDER HER OWN DEVELOPMENT.

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The purpose is learning – but how to assess it individually in a group environment?

Grading is individual towards the learning objectives

The **group product is not graded**, because it is aggregated and loosely coupled to learning

- **Group grades are unfair** as they don't necessarily reflect one's own achievements.
- **Group grades invite free riders** and **make low achievers a burden** to the group. This **generates conflicts** around ambition levels, taking focus from the work and learning.
- **Product grades (or end reports) are loosely coupled to learning outcomes**.
- **Product grades gives little incentive to learn,** but rather to specialise on what they already do well.

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Learning outcomes can be reached through different activities

Students do many different tasks in the project

- Conceptual analysis
- "Expert" analysis
- Project management
- Manufacturing
- …
- Presentations
- Experiments
- Planning and follow-up
- PR
- …

→ We require students to take ***individual responsibility*** for reaching all learning outcomes.

→ Students will **automagically** choose to engage in a variety of activities in order to reach all learning outcomes once they "get the course"

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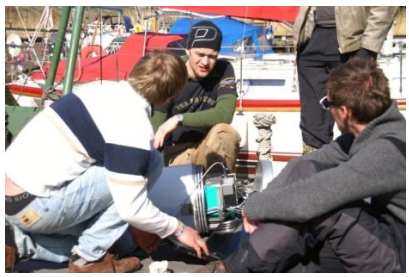
Assessment challenges

- Individual grades (A-F)
- Assessing individual performance in a group setting
- Students work on a variety of different tasks
- Teachers see only fragments of the actual performance
- Legal security / fairness



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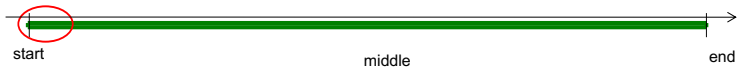
Assessment

Faculty

- Workshop on the course goals

Students

- plan their activities
- collect evidence of their progress towards the learning outcomes in individual “portfolios”



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Assessment

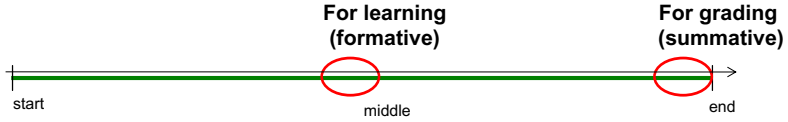
Faculty

- repeat course goals
- lead discussion on giving/receiving feedback

Students

- write summary
- read all summaries in their group
- write feedback and suggest peer grades
- read feedback & reflect

- de-briefing
- Faculty set grades



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Summary: Sample (mid course)

L7. Effectively choose and use available engineering methods

Status: Approaching. Ref: [4][5][6]

I am trying but find it hard to find the balance between rough estimates and sophisticated computerized methods. Further, the word "effectively" does not apply on me.

L5. Make estimations, appreciating their value and limitations

The propeller analysis required several estimations during its initial phase, e.g. the input power from the solar cells to the engine and the hull resistance. When working with the supporting structure for the hulls [72] the design loads acting on the craft were also approximated based on evaluation of the most critical loading conditions. These estimations were made in order to operate with some numbers and start the calculations. It was understood that having some, even rough, estimations will not let the process stop and will have only positive influence on the overall result.

References:

1. Meeting minutes from …
2. Presentation, Preliminary design at design review #1
3. Experiment 4, Planning, execution and results
4. Report A 12, Hydrostatic stability - analysis
5. Report A107, Engine, design and mounting

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Grading criteria
(agreed by the students for their use)

- For grade A you should also
  - Distinguish yourself in several of the above task areas and learning outcomes
  - Show special personal engagement, responsibility and initiative for the project and group work
- For grade B you should also
  - Work actively with analysis, practical implementation, administration and communication
  - Clearly show that you reached the learning outcomes
- For grade C you should also
  - Work in most of the fields analysis, practical implementation, administration and communication
  - Clearly show personal initiative and engagement in the course
- For grade D you should also
  - Work with several types of tasks in the project
  - To some extent take on responsibilities in the course
  - Clearly show that you approach most of the intended learning outcomes
- For grade E you should
  - Actively participate in the course seminars and project meetings
  - Actively participate in the course activities, read and answered emails from course leaders and delivered the course assignments
  - Spend time on task corresponding to 20 credits
  - Show that you approach the intended learning outcomes to a significant extent

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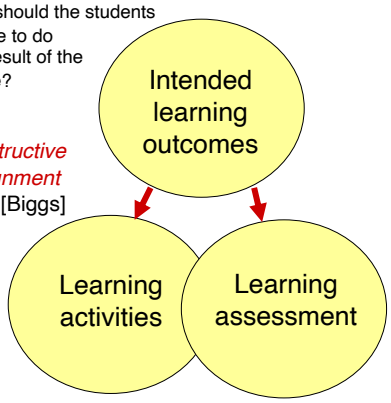
Why is the assessment system so complicated?

What should the students be able to do as a result of the course?

Constructive alignment [Biggs]



What work is appropriate for the students to do, to reach the learning outcomes?

How should the students demonstrate that they fulfil the learning outcomes?

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Powerful principle #4
Generating reflection on experience

- The course provides a firm structure for reflection, stimulated by feedback.
  - ➔ 'Learning by doing' – but doing is not sufficient for learning. **Reflection** is what **turns experience into learning.**
  - ➔ Teachers drive a process for rubbing students against each other. Faculty role is to **create and run the process** – not to give all the feedback. Note the cost-effectiveness.

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How the grades are set

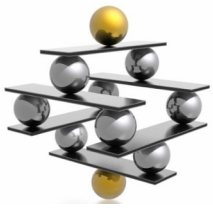
The grades are set **in relation to the intended learning outcomes** based on a holistic assessment of:

- **portfolios** (summary + references, e.g. reports, protocols, presentations, sketches, hardware, …)
- **given feedback**
- **received feedback**
- **recommended grades from peers**

- **Participation, logged time and continuous observations**

by two teachers, independently

We do it in consensus ;-)



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Powerful principle #5

Reversing the 'burden of proof'

- Each individual student is responsible for collecting and presenting evidence of their learning outcomes (in a portfolio)

  ➔ this generates reflection and directs students attention to the intended learning outcomes

  ➔ makes the course format **sustainable**

61

Key challenges – Let's hear some student voices

Interviews with students in the 2004 & 2005 cohorts
(not the students in the picture...)

62

Interviewer: So you chose not to switch project leader?

"No, it wouldn't have furthered the project. It could only have suffered. But if you completely drop [considerations for] the product – and maybe you should, actually – it might have furthered the course. It's hard to tell...you simply tend to put your focus on the product you are making."

Tension between project and learning...

64

Interviewer: How do you think this course could be improved?

In the beginning I think there should have been some technical seminars to give a faster start of the project. Technical specialists who could have given a few lectures.

To help you see possible designs for instance?

Yes, technical solutions. And whom we could have contacted later with questions.

Hmm. I wonder if you may risk the main idea of the course?

Yes... that is a risk... If they say 'this is what you should do'... Yes, you are right.

I can see that it's been painful though.

Yes, but maybe that's what is good for us.

But you think it would have been better with a more efficient start.

Yes, but that is perhaps because it had led to a better end result, I mean the boat. But maybe the learning wouldn't...

Tension between project and learning...
Conceptions of teacher's and student's roles are challenged...

65

Interviewer: How do you think this course could be improved?

They should have been more <u>like teachers</u>. We had to do all the hard work ourselves and we don't feel that we got as much help from the teachers as we could have had. [...] When we went and asked them 'does this look alright', they tried to answer as vaguely as they could. Just because they tried to make us solve things ourselves I think.

Student's views on knowledge are challenged...
Conceptions of teacher's and student's roles are challenged...

66

Quote from a mid-course evaluation

Not that these were the only calculations needed, but the only ones that could be made. All the calculations assuming kinematic equilibrium seem to give various degrees of unreasonable results. This is not just a pity and shame, but it is also terribly bad pedagogy now towards the end of an education. I would really have liked to see that the theory we have learnt was possible to use. We cannot even calculate the strength since everything is so tiny.

Students with a black-and-white view on knowledge are seriously challenged...

67

Student views must always be interpreted

- We notice that
  - students' **conceptions of learning** or **attitude towards knowledge** is challenged
  - in students' eyes, **learning is often overshadowed** by the project per se
- The teacher will often be blamed, as students think **they should have been saved** from the inconvenience.
- But these relevant challenges are not "flaws" that should be eliminated. They are **key learning opportunities** and we have no intention to protect the students from them.
- It is then not appropriate to behave in conformity with student expectations. But knowing they existed was valuable for course development.
- **Conclusion: Don't give the students what they want – give them something better!**

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Powerful principle #1 revisited
The purpose is student learning

- **NOT reaching project goals**
  (BUT the project still drives learning and creates a motivational context)
- **NOT technical sophistication**
  (BUT there must be enough complexity and technical challenges to accommodate the learning outcomes)
- **NOT teacher popularity, or giving students what they want**
  (BUT the students must still have trust in the process and the teachers)

69

The beautiful sound of students growing into engineers... (I)

The greatest thing I have learned from this course is humility. I'll approach similar tasks more humbly in the future. We thought we were better than we were. No, not better, but we have taken courses with well-defined problems, where there is an answer, the key. And that went well. But now you realised that as soon as you are confronted with reality, it's quite another story.

70

The beautiful sound of students growing into engineers... (II)

”It took some time (maybe even a month) before it felt like we really got started. We were fumbling around, doing tasks without really completing them or seeing what was the conclusion, the next step from it. We wrote reports and said ‘we do this for our own sake’ but it took some time before that was actually the case. At least that’s how it was for me. But when that coin dropped, everything became very much easier.”

71

...and more of the same...

“At the beginning of the course I was somewhat worried about finishing the education and starting to work as an engineer. Those worries are gone now. My confidence in approaching technical problems and solving them has grown a lot.”

“Feedback was exchanged on everything between napkin scribbles at lunch to things you had built. This was valuable since it both gave me, and trained me to give, critique. It also helped me to see how other people are thinking and how they solve problems.”

“One of the best things during the project was that written documentation was called for and that we in much lived up to those demands. It allows you to cross check things and check the work of yourself and others, and things are always available.”

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Frequently asked questions, or comments

	1	2	3
A	What would my chemical engineering (etc) students build?	Why don't you run proper projects, instead of toys?	What about the project budget?
B	Why not use competitions and/or industry as costumer?	**Your questions and/or comments**	What can be done in earlier and smaller courses?
C	What about parallel courses?	How do you come up with new project ideas every year?	Should future PhD-students have to waste credits on this course?

75

3-2-1 Evaluation

3 things I take with me

-
-
-

2 questions/problems/issues I have going forward

-
-

1 thing I can use right away

-

76

The chair of a chemical engineering program asks

”What would our students build – a molecule, or what?”

- The essential aim is to learn through near-authentic engineering tasks, working in modes resembling professional practice
- Projects take different forms in various engineering fields
- Think of what engineers do in your field (don’t translate the artefact, consider the learning objectives)

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Actually we do have an example from chemical engineering (1st year)

78

Why don't you run a “proper project”, why do you keep playing with the students in “toy-like” projects?

79

Projects are real even though they might look as toy-projects

80

Makes students attractive!

Betsy Pfeiffer i förrgår 23:08

To: Jakob Kuttenkeuler, Stefan Hallström Cc: Don Montague

Evolo

BP

Hello Professors Kuttenkeuler and Hallström,

I work for a small water sports R&D company in California that's been developing a kite-powered hydrofoil boat for several years. Lately, we have been working on an electric-powered hydrofoil surfboard, the Jetfoiler (videos here: https://youtu.be/fhHEefqSepI and here: https://youtu.be/aIxgIVFKuAQ).

We recently found your Evolo videos online, and it looks like we're working on something similar. I'm wondering if you or any of your former students would be interested in talking to us or potentially advising us on future developments of the Jetfoiler.

Thank you for your time,
Betsy

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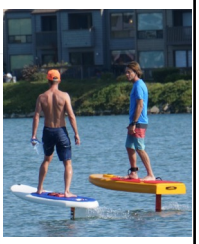
efoil .builders

The history of weight shift controlled electric hydrofoils



pacificmeister 3 Nov '17

Dear efoil community!

It is amazing to see all this innovation. We have now several hundred enthusiastic builders around the world sharing information here on this platform. This includes many companies building commercial efoil products, a lot of them are aiming for a launch in 2018. A lot of money is being invested here which is great and will help us all to move this world to sustainable, quiet, efficient and wakeless water transport.

I am writing this post because there are wrongfully issued patents to Prof. Jack W. Langelaan (1 81), (2 54). This will slow down innovation and growth of this fantastic new activity. Mr. Langelaan filed a patent about an electrically powered hydrofoil surfboard that is controlled by weight shift in 2013. Problem with that is that the claims in these patents were already well known at the time of filing, they were documented and published since Prof. Kuttenkeuler's Evolo project in 2009.

Mr. Langelaan, I ask you to please cancel your patents. That would be the honorable and right thing to do in this situation. This would avoid unnecessary legal actions and not hold up fast innovation and growth of this sport. I give you the benefit of the doubt that you didn't see the publications before filing. Many did see them. And I am sorry that the patent office didn't do their job and research state of the art. My father worked as an examiner at the patent office for over 30 years, he was known to be a very thorough examiner and often came home upset when he noticed superficial research work by one of his colleagues. Oversight happens, but it doesn't make it right.

The pioneers and real inventors are Team Evolo under Prof. Jakob Kuttenkeuler. I have been talking with Jakob and he gave me a lot of interesting background on this amazing work and he confirmed all the publications and dates. He is even considering a follow up project (Evolo 2) next year and I am already looking forward to that.

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Students do create

Jetfoiler 2022

Evolo 2008

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Another relevant “toy-like project”

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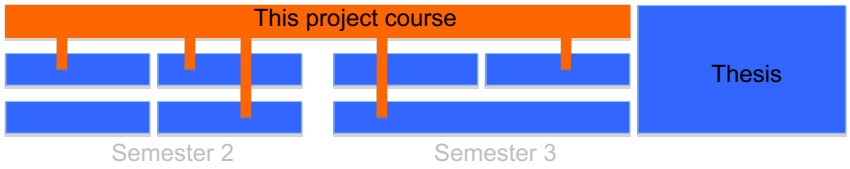
The Relation to Other Courses



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Ok, tell us which of these learning objectives are irrelevant for preparing PhD students?

- analyse technical problems in a **systems view**
- handle technical problems which are **incompletely stated** and subject to multiple constraints
- develop strategies for **systematic choice and use of available engineering methods and tools**
- **make estimations** and appreciate their value and limitations
- **make decisions** based on acquired knowledge
- **pursue** own ideas **and realise** them practically
- **assess quality of** own **work** and work by others
- work in a true **project setting** that effectively utilises available resources
- explain **mechanisms behind progress and difficulties** in such a setting
- **communicate engineering** – orally, in writing and graphically

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What can be done in earlier and smaller courses?

Progression in several dimensions:

- engineering knowledge (breadth and depth)
- size of student teams
- length of project
- increasingly complex and open-ended problems
- tensions, contextual factors
- student and facilitator roles

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What about the project budget?

- We give each group ≈ €2000 per project
- Students "hunt" sponsoring very effectively
  (This is actually a part of the course)

- **Bigger budget does not obviously lead to better learning**

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Why not use competitions and/or industry as customer?

These *may* be very good ideas! However, there are risks...

- **Trying to beat records** often lead to highly optimized, delicate and "risky" solutions that realistically need several iterations to work properly. This takes time - which we do not have in a course.

- **Competitions** sometimes impose constraints that interfere with learning objectives. Collaborating parallel teams with same objectives has worked surprisingly well ☺
(In competitions, most contenders actually loose!)

- **Industry costumers** are often valuable faculty relations that we do not want to disappoint. Thus, both students and faculty may feel a pressure to sacrifice learning just to "deliver". Realistically... research level results should not be expected in a course like this.

- **Student engagement** does not seem to rely on competitions, records and/or industry costumers – which is actually extremely good news!

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How do you come up with new project ideas every year?

There is no scientific way... but:

- **Faculty only need to come up with a "one-liner"** framing the big picture. Then, let the students take lead in forming the detailed spec which is iterated with faculty.

- **Key words:**
  - **Inspiring** challenge
  - **Relevant** technical challenges
  - **Realistic** goals with respect to time & money budgets

- Be creative over **a beer with faculty colleagues** ☺
- Why not engage students also in this phase?!

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REFERENCES

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- Hallström, Kuttenkeuler and Edström (2007). The route towards a sustainable design-implement course, *Proceedings of the 3rd CDIO Conference*, Cambridge, MA.

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