Teaching Systems Engineering to Undergraduates

A Complex Issue?

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Teaching Systems Engineering

Cognitive Levels

- Know (recognize, name, describe, ...): remember or retrieve previously learned material
- Understand (summarise, explain, compare, ...): make sense of given information/ situations
- Apply (create, implement, develop, ...): apply knowledge and skills in given situations

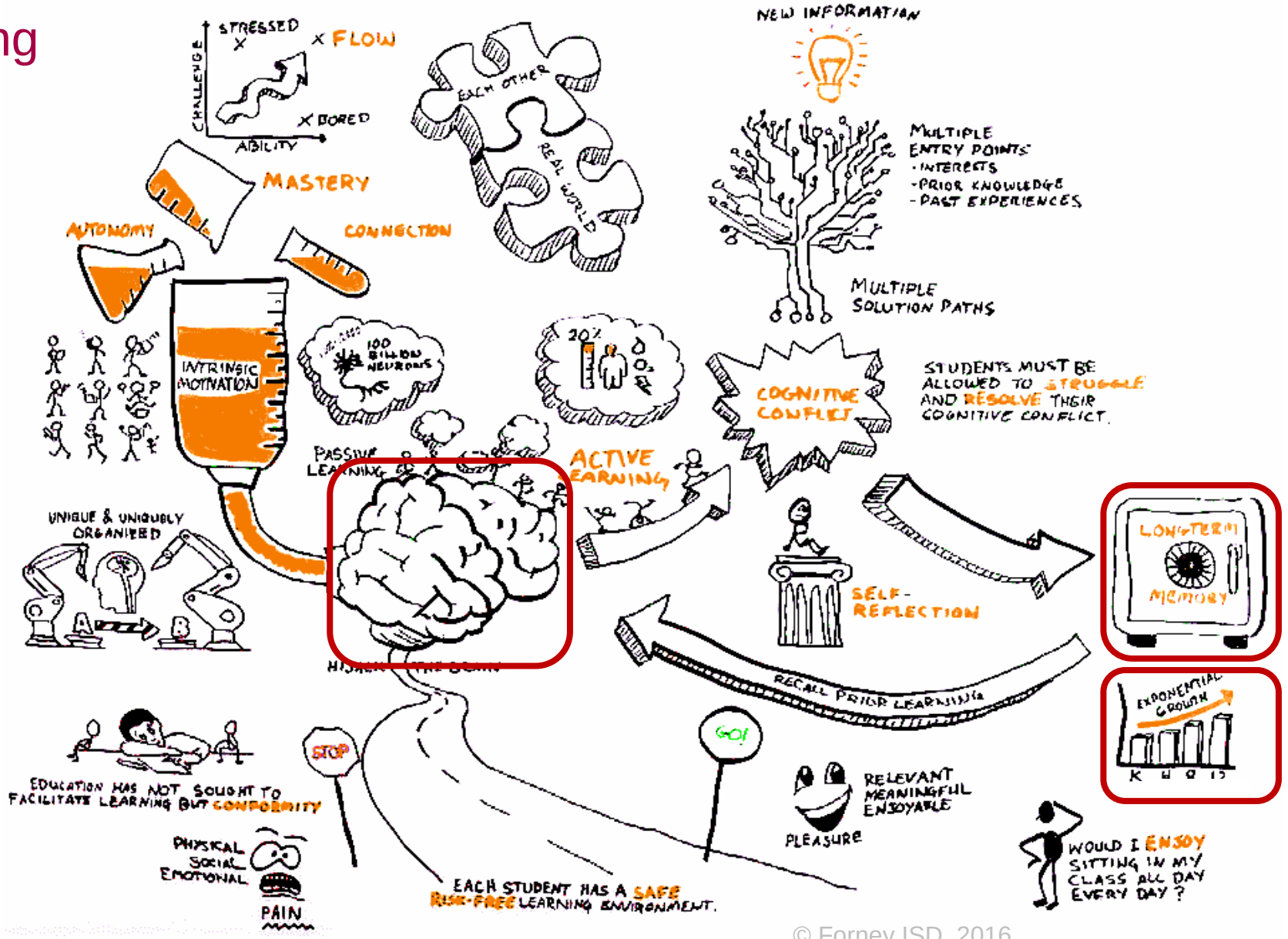
We wanted to enable the students to apply their new skills and knowledge.

Boundary Conditions

- Students from mixed background
- No prior SE-exposure or -knowledge
- No or little product development experience
- Some led towards non-SE ideas (“unlearn”)
- 4h SE Elective & 4h Project, 1 Semester each
- Modern Learning Platform (Moodle)

Enabling students to confidently apply SE concepts requires enabling them to learn it!

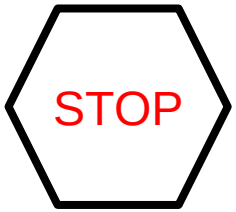
Learning



Basics

We must engage the students' brains

- Physical
- Social
- Emotional

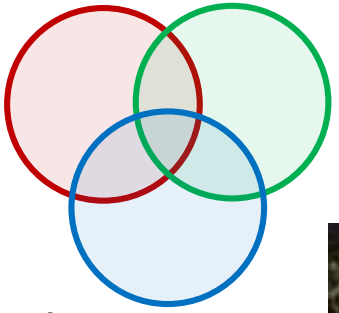


- Relevant
- Meaningful
- Enjoyable

- Pain is the strongest emotion to aid learning
- However, pleasure is easier to achieve (legally)

→ We must provide a light-hearted, safe, and - if possible - fun environment!

Implementation



- Send out light, inviting, friendly pre-course information
- Always friendly, allow jokes, ..."call me Marco"
- Start with a video on exciting feats of Systems Engineering
- Spend 1st session just on getting to know one another (incl. us)
- Introduce "Gamification" early on in the course (...the winner gets...)

Learning Process

Increasing our knowledge by adding and connecting new information

Reconciling new information with prior learning, thus forming new connections

Shield → Avoid students' frustration

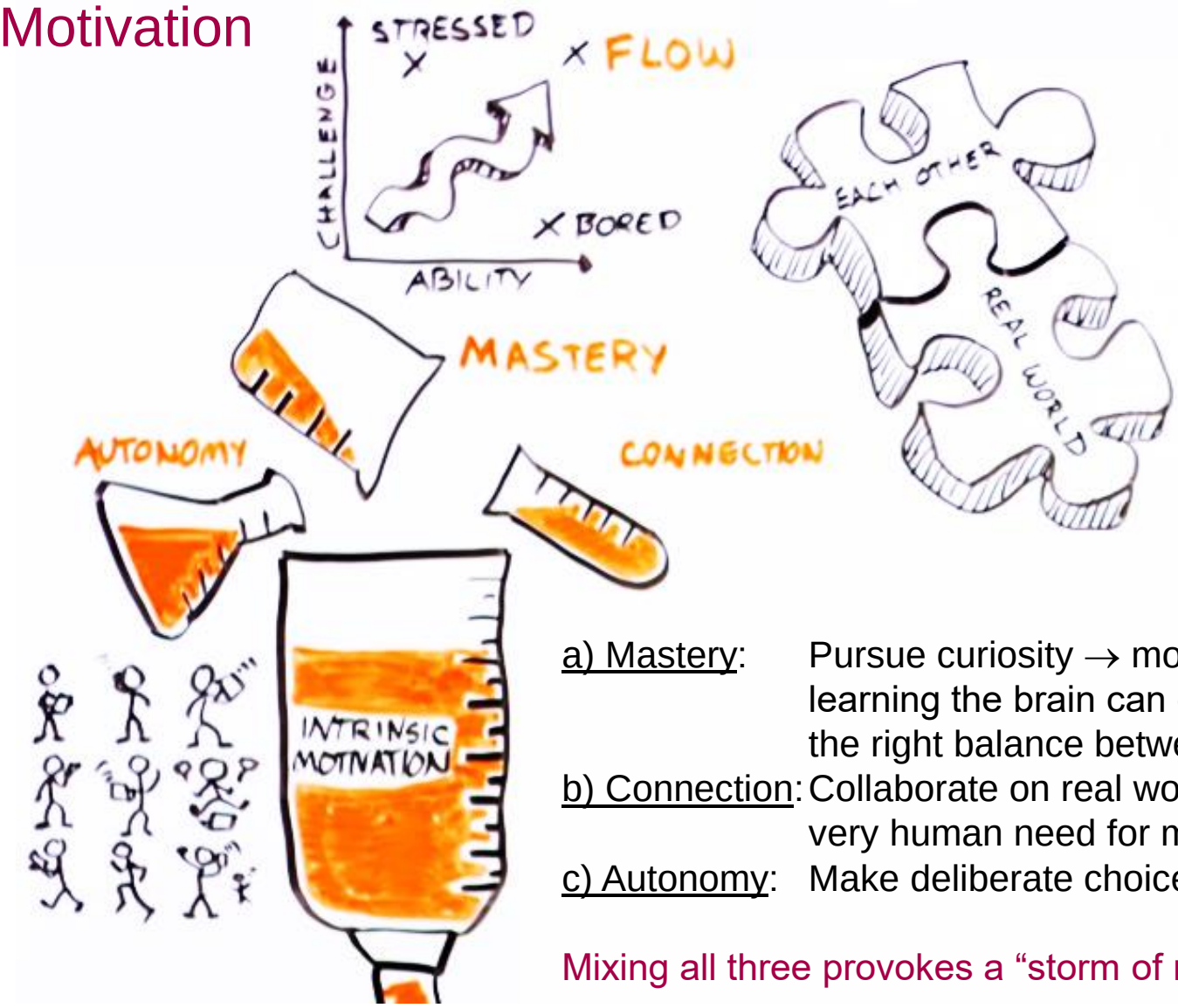
Expose → Allow students to struggle and resolve the conflict

But the students need to "buy-in" to this process!

For this, they must

1. be intrinsically motivated
2. become actively involved
3. get enough time to self- or peer-reflect

1. Motivation



WOULD I ENJOY SITTING IN MY CLASS ALL DAY EVERY DAY?

a) Mastery: Pursue curiosity → most intense enjoyment of learning the brain can experience ("Flow", requires the right balance between Ability and Challenge)

b) Connection: Collaborate on real world challenges → satisfies the very human need for meaningful relationships

c) Autonomy: Make deliberate choices → sense of empowerment

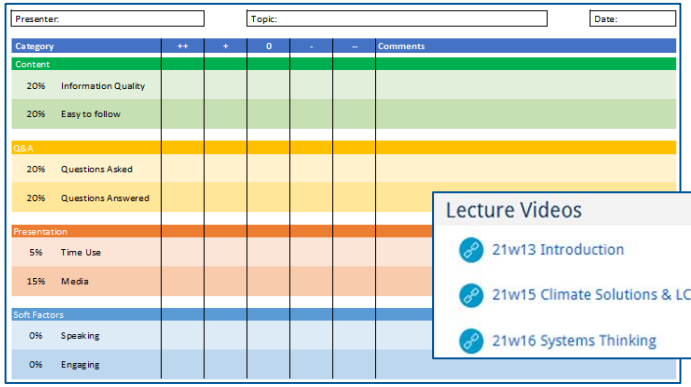
Mixing all three provokes a "storm of motivation" in your students!

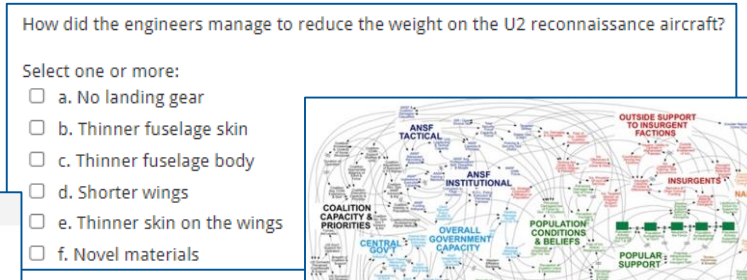
1a: Mastery

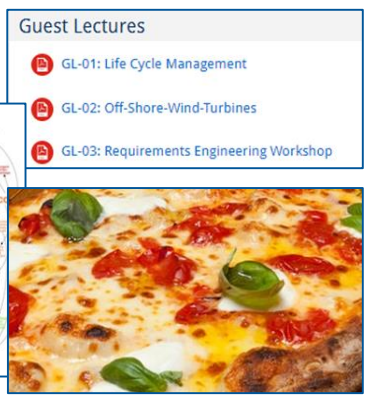
Pursue curiosity to reach “Flow”, most intense enjoyment of learning the brain can experience

Implementation

- Clear Goal: students are informed about course structure & exam (presentation) grading
- Just-in-Time-Teaching (JiTT): students prepare the theory at home, which is tested & graded (bonus) before → deeper discussions and better learning during the session
- Notebook: students encouraged to keep an SE diary (that they can bring to the tests)
- Assignments: students present SE topics in exam-like setting → increase confidence
- Guest Lectures: experts are invited to contribute → multiple view- and entry-points
- Start from Existing Knowledge: students develop the V-Model for a well known product
- Record Sessions: students can relive the discussions and watch their own presentations







1b: Connection

Collaborate on real world challenges to satisfy the need for relationships

Implementation

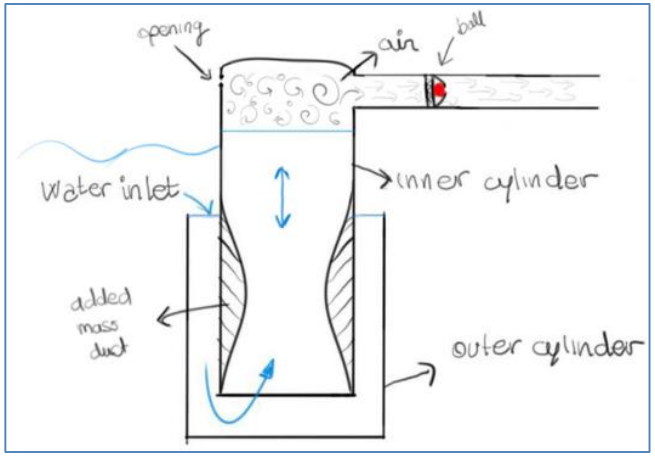
- Problem Based: the theory is applied in a real project → real responsibility
- Good Cause: working to help the disadvantaged or save the planet → meaningful
- Team Work: all project work is done in a team → increase joy and mixing talents
- Team Building: a full session incl. the “Marshmallow Challenge” → active, entry level, fun
- Expert Support: team artefacts are reviewed by industry experts → up-the-game
- Presentation: teams present work to ext. partner together → fun, excitement, and support
- High Visibility: projects discussed in the regional press → proud of their work

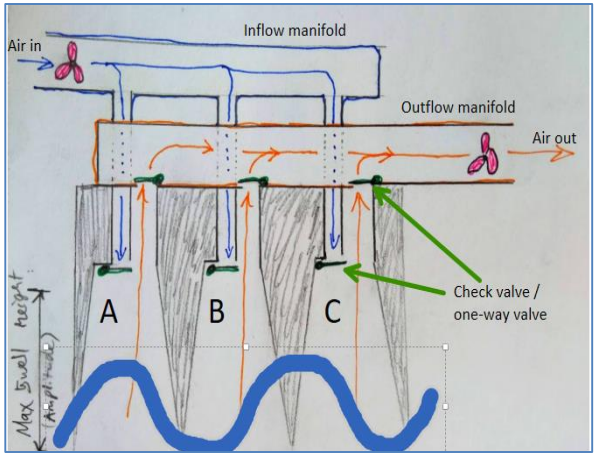
1c: Autonomy

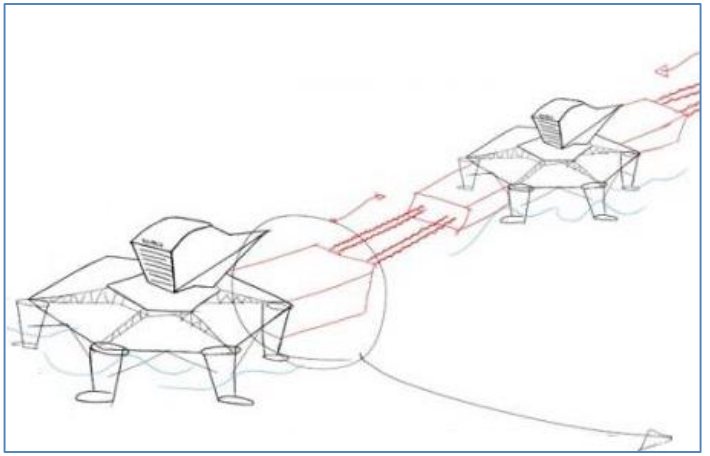
Allowing the students to make meaningful choices to achieve a sense of empowerment

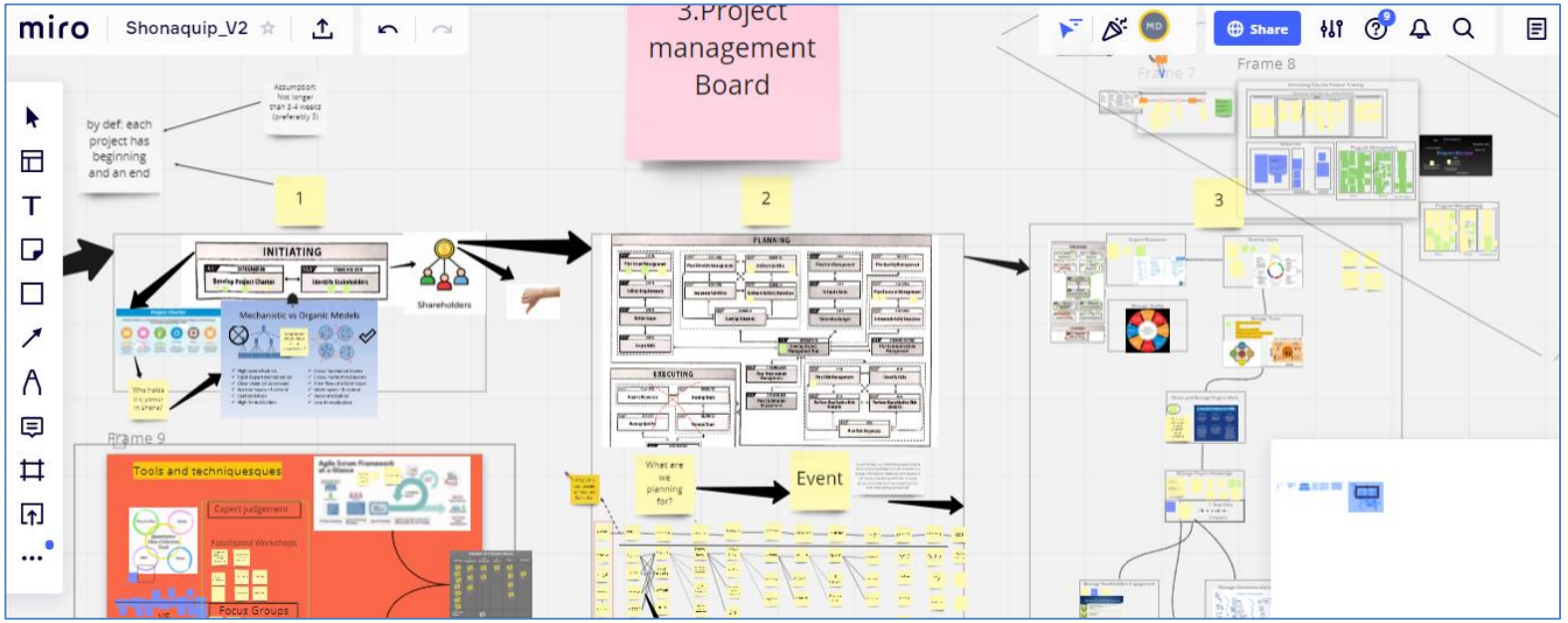
Implementation

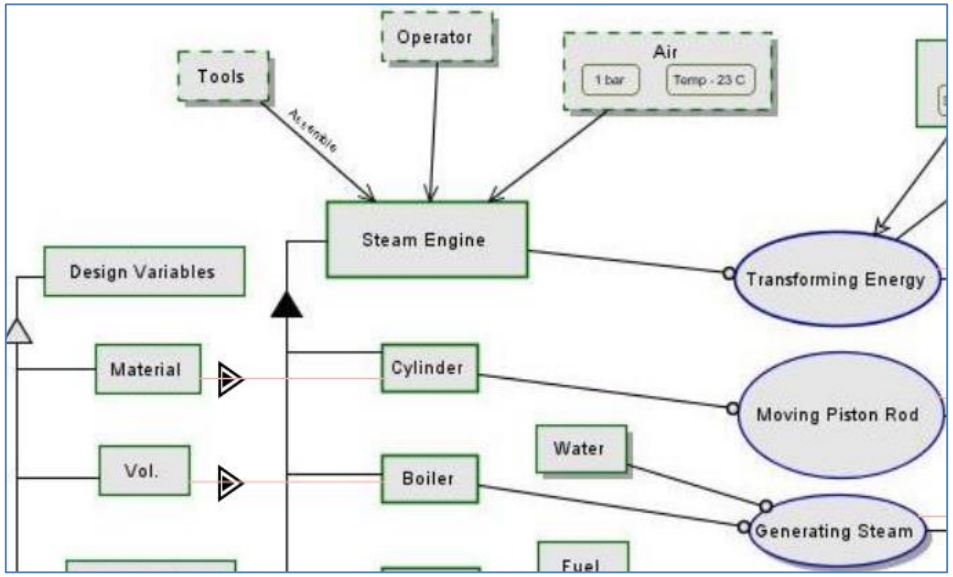
- Self-Organizing Teams: students pick teams → improved motivation & communication
- Problem Based Learning: teams are given the problem→ fact & solution finding
- Weekly Assignments: teams must apply SE-Learning (JiTT) → feedback during session
- Trial-and-Error: teams choose their own collaboration tools → we learned a lot!
- Act-Plan-Do-Study: teams try many different approaches → “failure” is encouraged
- Large Variety: teams can freely decide path → typically many interesting concepts (TRIZ)
- Great Diversity: teams use workshops unsupervised → great “paper-prototypes”

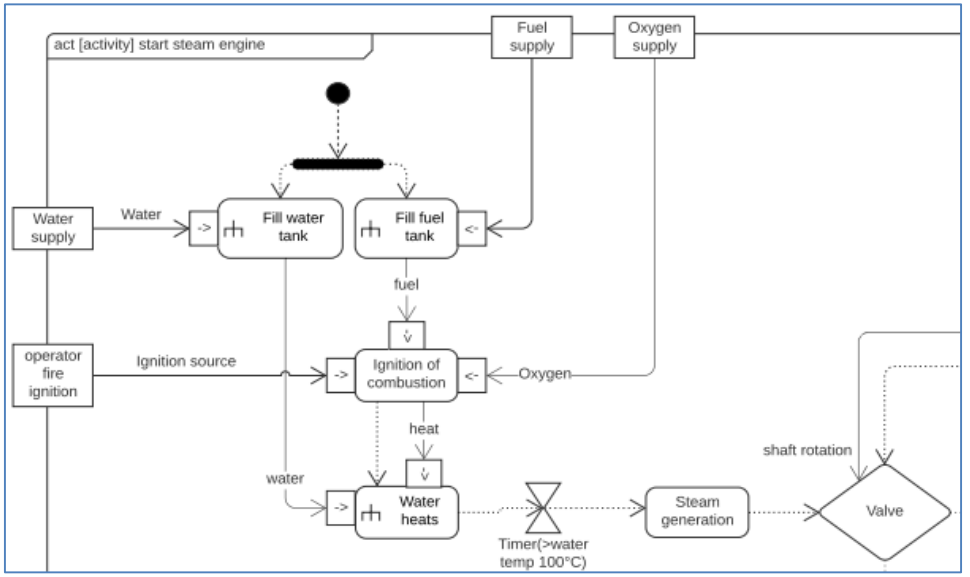


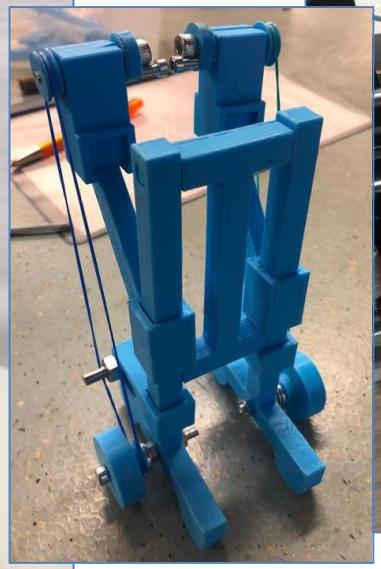


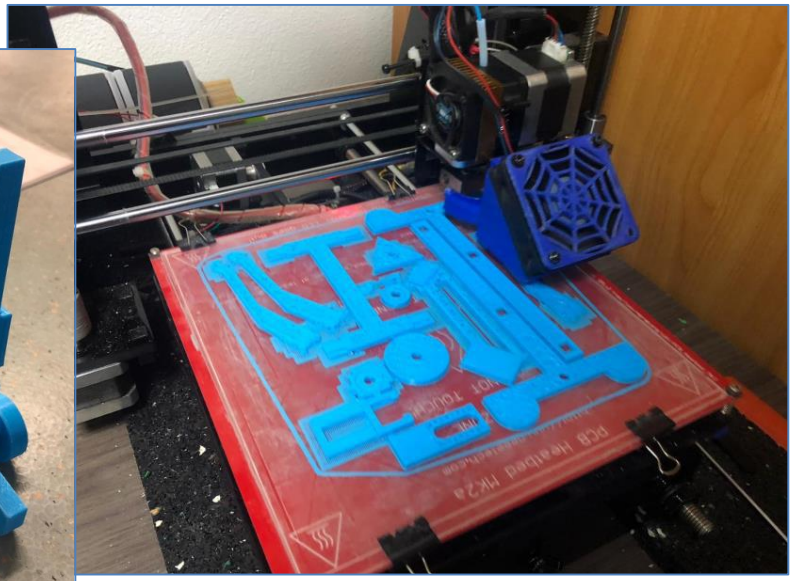


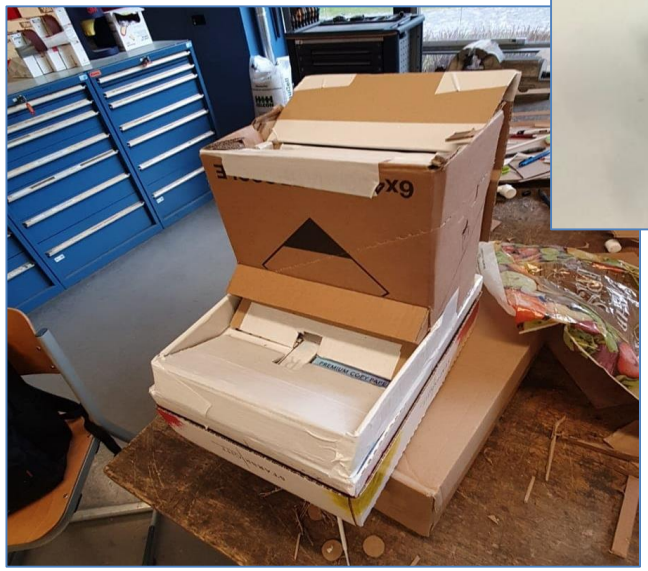


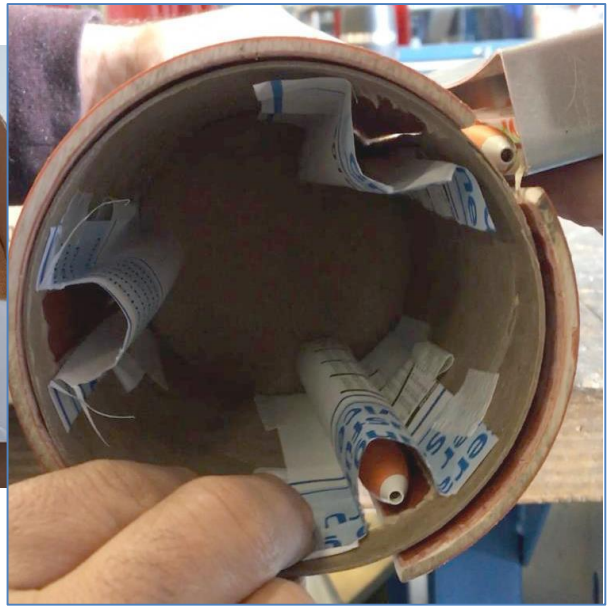












2. Active Learning (As if they're note active already*)

Implementation

- Workshop Experience: the students create real prototypes
- Work in THI's "Learning Lab": safe space for exploration
- Active Needs Elicitation: go out and speak to potential users → schools, nursing homes

3. (Self-) Reflection

The pillar that sustains student through the struggle of cognitive conflict.

Implementation

- Weekly Feedback: all teams receive individual feedback → typically discussed in teams
- Assignment Feedback: every student gets individual feedback → prepare for exam
- Peer-Review: one complete session → they learn to give and receive feedback

• 4s → 5s, 6s, 7s	• 6s → 7s, 8s, 9s	• 8s → 9s, 4s, 5s
• 5s → 6s, 7s, 8s	• 7s → 8s, 9s, 4s	• 9s → 4s, 5s, 6s

- Concept-Review: present to industry expert → they're *very* ready to defend their ideas

What have we achieved?

- Successful Learning: students are motivated, active, and able to self-/peer-/team/ reflect!
- Students love the course: amazing evaluation results; 100% attendance, even online
- Great Interest in SE: 5 - 8 Bachelor's Theses every term, IEEE paper, volunteering
- Better Master's Degrees and Jobs: students are getting into great unis and companies
- Recognition and Prizes: the press reports regularly - "best student project 2020"
- Student Award for best Teaching: ...and for the students the award for "Best Learning":)

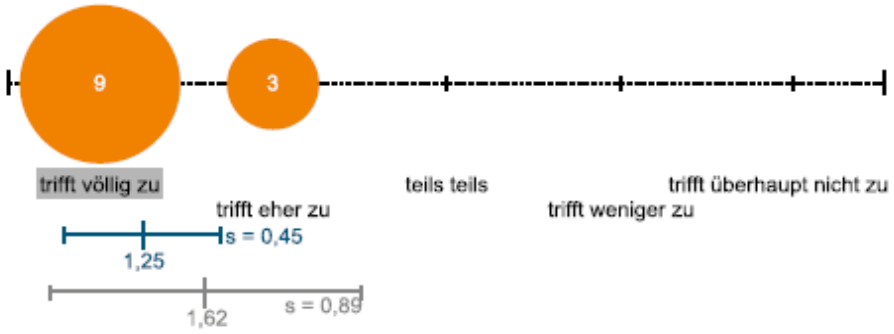
Preis für gute Lehre

Vergeben durch die Fachschaft Wirtschaftsingenieurwesen an Prof. Dr. Marco Di Maio

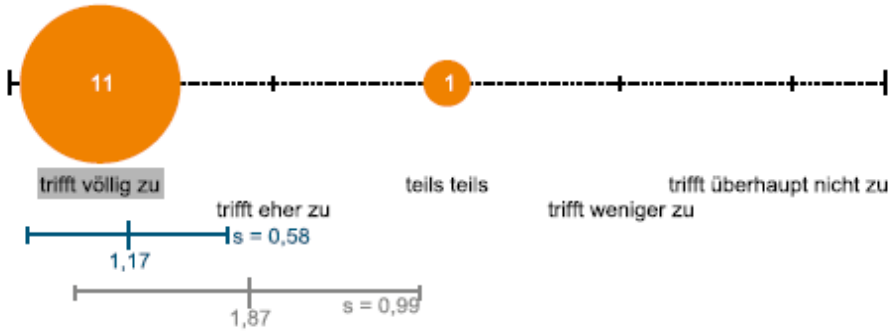
- Praktische Ausrichtung bei Vermittlung der Lehrinhalte
- Interaktive Vorlesungen mit persönlicher Begeisterung
- Individuelle Unterstützung zu jeder Zeit
- Einsatz bei Problemen der Studierenden
- Laut Studierenden: Immer mit Lächeln und sympathischem Kommentar anzutreffen

Prof. M. Di Maio, Quelle: THI

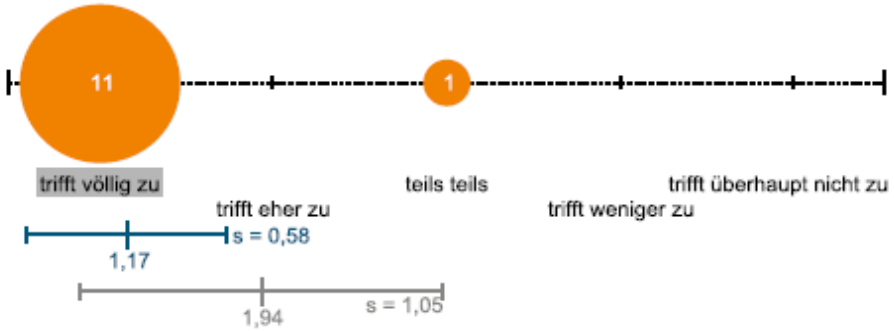
Die Veranstaltung ...



... ist gut strukturiert und verläuft nach einer klaren Gliederung.

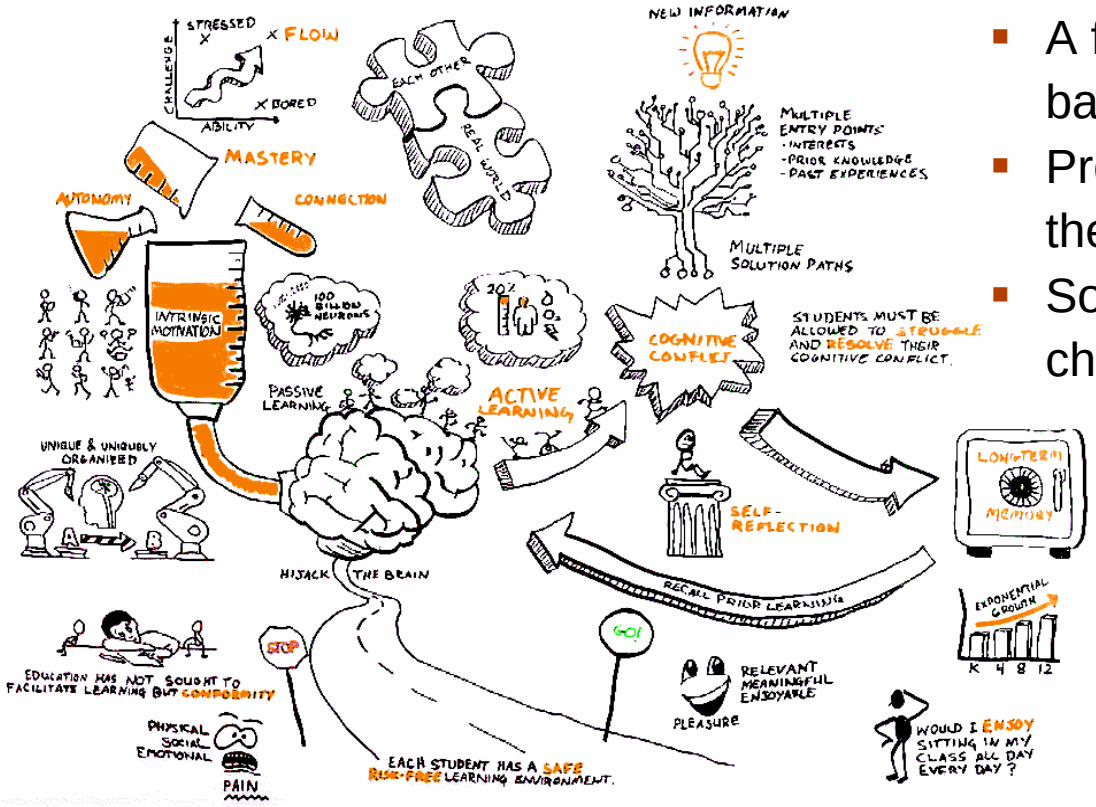


... ist durch den Einsatz verschiedener Medien oder technischer Geräte abwechslungsreich und anschaulich gestaltet.



... motiviert zur weiteren Beschäftigung mit dem Lehrthema.

Conclusion: Complex? Maybe - But Worth It!



- A fun way of teaching Systems Engineering based on *trying to understand* learning
- Proud and confident students who will take the SE mind-set to their future work
- Social impact, environmentally friendly - charities and companies amazed by results

Thank you for listening - and do ask questions!
After all, it's a great way to learn!

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Thank you for Listening!

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