# SKILLS DEVELOPMENT FOR ENGINEERING EDUCATION

**Workshop for UT Week of Education**
10 June 2024

Leonie Krab, programme director
Linlin Pei, educational specialist
**Chemical Science & Engineering**

UNIVERSITY OF TWENTE.

# WHAT ARE "ESSENTIAL SKILLS"?

- Essential skills are transferable skills that are essential in a future career (of an engineer)
  - maybe intellectual, practical, personal, professional…
  - transferable!

- At CSE, we teach and assess skills both implicitly and explicitly

  Explicit workshops are connected to content (most often to the project)

# WHY WOULD WE TEACH ESSENTIAL SKILLS?

- We see:
  - ✓ challenges in (project) group work
  - ✓ cultural / diversity challenges in the international classroom
  - ✓ lingering communicative skills (written and oral)
  - ✓ a lack of critical thinking (and quantitative literacy, inquiry and analysis, …)
- We intend:
  - ✓ to promote the quality of our education
  - ✓ to demonstrate the value of discovery, innovation, and (critical) reflection
  - ✓ to improve the embedding of essential skills

# HOW TO TEACH AND ASSESS THESE SKILLS?
## THE CSE APPROACH

- Exercise
- Essential skills at CSE: an overview
- Examples of how we work
- Exploration of a useful tool

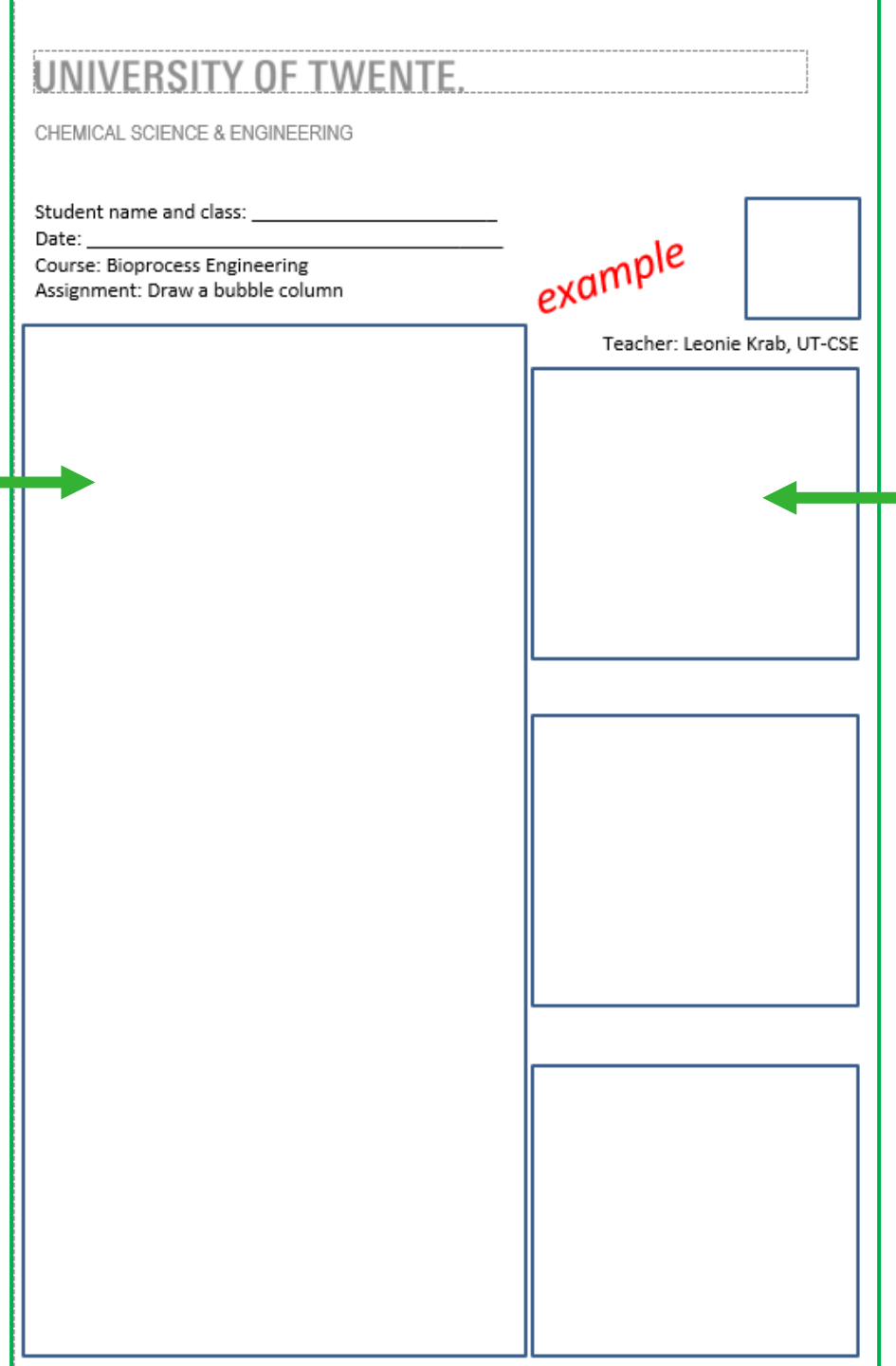
# AN EXERCISE

***Bioprocess engineering***
***Your assignment:***
***draw a bubble column***

**Learning goal:**
show what a bubble column in process industry could look like

**Requirements:**

- clear, schematic picture
- single words are allowed
- dimensions are free
- column must sustain growth of algae




You can write requests for specific feedback in the three boxes on the right.



UNIVERSITY OF TWENTE.

# FEEDBACK AND GRADE

**Learning goal:**
show what a bubble column in process industry could look like
**Requirements:**
- clear, schematic picture
- single words are allowed
- dimensions are free
- column must sustain growth of algae

1. Give your drawing to the neighbour on your left
2. Have a good look at the drawing you get
3. Assess it

   (consider learning goal and requirements. Think about clarity, functionality, practicality, and attractiveness of the design)

Without showing it to the “artist”:

3. Write your feedback in the upper box on the back; write tips (“feedforward”) in the lower box on the back
4. Decide about the grade you would give (0-10, 10 is highest, ≥ 5.5 is a pass) and write the grade in the small square on the top right (front of the paper). Leave the paper with the grade visible (front side up).

# LEARNING FROM YOUR GRADE

Please give the assignment back to its owner and show the grade (front side), but not the feedback!

Knowing your grade: do you know how to improve your design? What will you do differently in the final test? Does the grade help you with your uncertainties or specific questions?

How helpful is a grade?

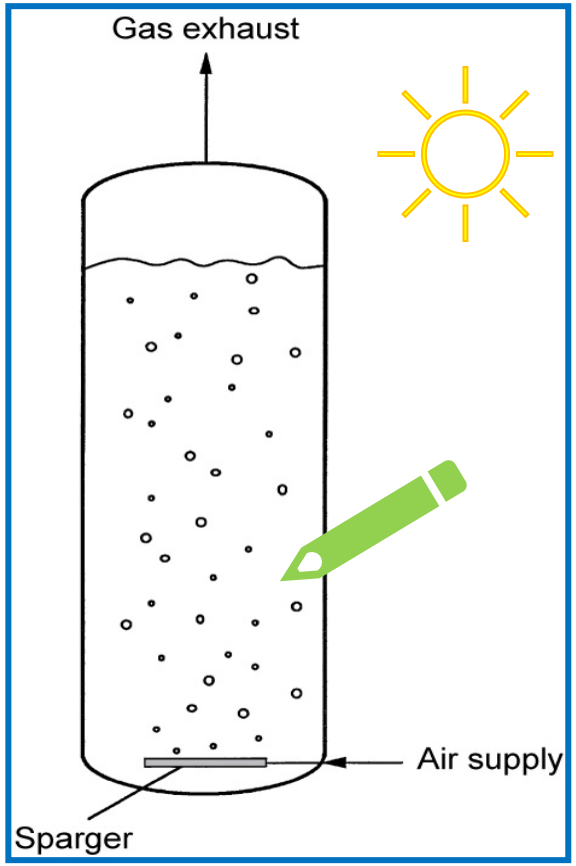
# LEARNING FROM YOUR FEEDBACK

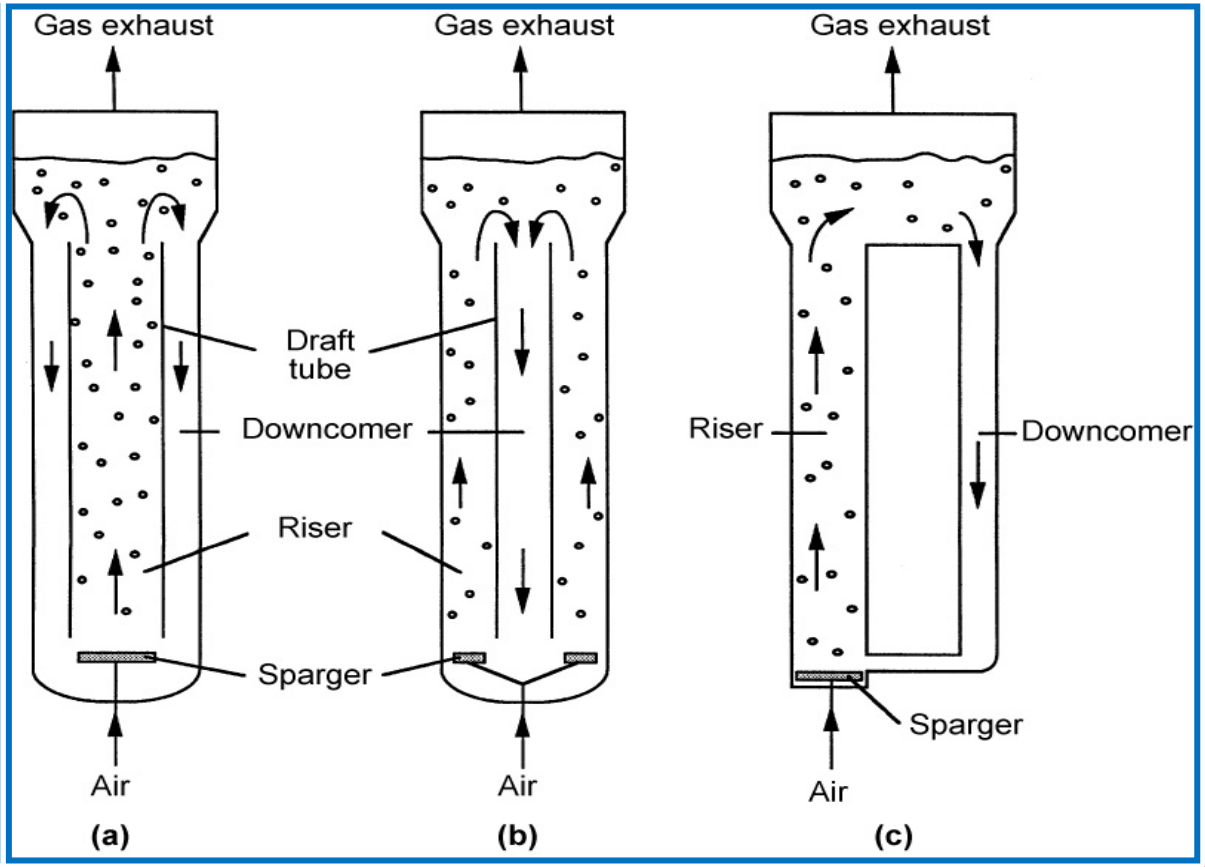
Now turn your paper to look at the feedback.

Having read your feedback: do you know how to improve your design? What will you do differently in the final test? Does the feedback help you with your uncertainties or specific questions?

How helpful is feedback?

# BIOPROCESS ENGINEERING:
# DRAW A BUBBLE COLUMN




ScienceDirect
https://www.sciencedirect.com/science/article/pii/S2211926417300917





UNIVERSITY OF TWENTE.

# GIVING FEEDBACK

… is not always easy:

- ✓It costs teachers more time (in short term)
- ✓A pass-or-fail conclusion is not always obvious from the feedback alone
- ✓Some students are motivated primarily by grades

Yet, its benefits are evident:

- ✓Students learn much more, and deeper
- ✓*Learning* is central, instead of passing an exam
- ✓We want to attract students that want to develop academically, not students that just want to pass tests

# ESSENTIAL SKILLS IN THE BSc-CSE

1. Inquiry and analysis
2. Critical thinking (incl. Listening)
3. Creative thinking
4. Written communication
5. Oral communication
6. Reading
7. Quantitative literacy
8. Information literacy
9. Teamwork
10. Problem solving (incl. Design & Modelling)
11. Civic engagement – local and global (incl. Sustainability awareness)
12. Intercultural knowledge and competence
13. Ethical reasoning
14. Integrative learning & conceptual modelling

*Skills and rubrics based on AACU Value rubrics*

ITY
ITE.

# HOW DID WE IMPLEMENT ESSENTIAL-SKILLS TEACHING AND ASSESSMENT AT CSE?

- Examples from BSc CSE M2 and M6, and from MSc CSE

1. Inquiry and analysis
2. Critical thinking (incl. Listening)
3. Creative thinking
4. Written communication
5. Oral communication
6. Reading
7. Quantitative literacy (M6)
8. Information literacy
9. Teamwork (M1, M2)
10. Problem solving (incl. Design & Modelling)
11. Civic engagement – local and global (incl. Sustainability awareness)
12. Intercultural knowledge and competence (M2)
13. Ethical reasoning
14. Integrative learning

# CHEMICAL SCIENCE & ENGINEERING

## EXAMPLE M2 WORKSHOP ON INTERCULTURAL TEAMWORK

The aims (and learning goals) for the workshop are:

1. to become more aware of expectations;
2. to identify differences in (prior) education;
3. to explore ways to get the most out of your education here;
4. to work in a (project) group of diverse people

# CONTENTS OF CSE M2 WORKSHOP

## EXAMPLE M2 INTERCULTURAL TEAMWORK

1. Introduction: what are we going to do today, and why?
2. Exercise A: identify yourself to your project group (“name game”)
3. Exercise B: universal, vs. cultural, vs. personal characteristics
4. Exercise C: define together “what is culture?”
5. Theory: interculturalism and intercultural communication
6. Exercise D: your current “position” in time & communication
7. Expectations: in NL, at UT and at CSE; do they match with yours?

   Exercise E (optional): discussion of cases

---

Reflection per group: assignment, including peer feedback and discussion

Outlook workshops M2

# CULTURAL DIFFERENCES

## EXAMPLE M2 INTERCULTURAL TEAMWORK

| | | |
|---|---|---|
| **Communication** | High context (indirect) | Low context (direct) |
| **Time** | Synchronic (flexible) | Sequential (more strict) |
| **Emotions** | Affective (show feelings) | Neutral (controlled) |
| **Business** | Relationship-oriented | Deal-oriented |
| **Management** | Hierarchical | Egalitarian |

Teamwork:

Tuckman: stages of development (team performance & effectiveness)
DIY: self-perception inventory (Belbin)
Belbin: team-role definition
Belbin: your team roles

# OUR APPROACH FOR REFLECTION

- AACU Value system[β], using rubrics for all essential skills
- Rubrics articulate fundamental criteria per learning outcome
- Performance descriptors demonstrate progressively more sophisticated levels of attainment
- Where applicable, adjusted to programme's specific needs

[β] VALUE Rubrics | AAC&U (aacu.org)

# EXPLORATION OF A USEFUL TOOL: SELF-ASSESSMENT, REFLECTIONS, FEEDBACK

PebblePad

Contents | Home | M1: Teamwork | M2: Intercultural Knowledge... | M3: Written Communication | M4: Inquiry & Analysis | M4: Critical Thinking | M5: Civic Engagement | M6: Oral Communication | M6: Quantitative Literacy

M1: Teamwork | M2: Interc

- Getting Started with M1 TW
- Upload Evidence
- End M1 TW Reflection
- Later reflections M1 TW

## Academic Skills Portfolio

Welcome to your very own academic skills portfolio for the Chemical Science and Engineering Programme.

**Development**

Through various activities such as project groups, the CSE programme provides numerous opportunities to develop Essential Skills. As a student, you should also intentionally work through a process of self-assessment, practice, receiving feedback and reflection.

FEEDBACK | COMMENTS

I want to...

Keyword search

November 2023

Leonie Krab-Hüsken
at 18:08, 13-Nov-2023 on End of the M5 CE Reflection

Feedback for Civic Engagement (including sustainability), e
you linked your development clearly to the rubric and sho
during Module 5. You experienced the importance of ope
to other people and their perspectives, in order to get mo
amongst people, and better or more efficient progress for
learning very nicely to specific parts of the project. Being s
when you look back at this skill and want to make the nex
also discuss this skill with your peers? What did that teach
structures", committee work in Alembic, or being a learnir
year students, could also be considered evidence.

Reply

August 2023

Arnoud Onnink



UNIVERSITY OF TWENTE.

# WHAT DOES IT LOOK LIKE FOR STUDENTS?

M1: Teamwork | M2: Intercultural Knowledge... | M3: Written Communication | M4: Inquiry & Analysis | M4: Critical Thinking | M5: Civic

**Workshop Essential Skills (deadline: Friday in week 1 of M1)**

Rubric + reflection!

## First Self-assessment

Success begins with self-awareness. To make a conscious decision on possible actions to achieve your goal, you must first understand what you want and what you are capable of doing. The teamwork rubric can provide more information about your current level of certain skills. We anticipate that our students will complete their programme at level 4, "End of Bachelor's." You are, however, perfectly fine starting with level 1, "Emerging."

Please evaluate your teamwork skills using the table below:

**Deadline: M1, Friday in week 1**

| | **Emerging (1)** 1 pts | **Developing (2)** 2pts | **Developing (3)** 3pts | **End of Bachelor's (4)** 4pts |
|---|---|---|---|---|
| **Contributes to Team Meetings** | Shares ideas but does not advance the work of the group. | Offers new suggestions to advance the work of the group. | Offers alternative solutions or courses of action that build on the ideas of others. | Helps the team move forward by articulating the merits of alternative ideas or proposals. |
| **Facilitates the Contributions of Team Members** | Engages team members by taking turns and listening to others without interrupting. | Engages team members in ways that facilitate their contributions to meetings by restating the views of other team members and/or asking questions for clarification. | Engages team members in ways that facilitate their contributions to meetings by constructively building upon or synthesizing the contributions of others. | Engages team members in ways that facilitate their contributions to meetings by both constructively building upon or synthesizing the contributions of others as well as noticing when someone is not participating and inviting them to engage. |
| **Individual Contributions Outside of Team Meetings** | Completes all assigned tasks by deadline. | Completes all assigned tasks by deadline; work accomplished advances the project. | Completes all assigned tasks by deadline; work accomplished is thorough, comprehensive, and | Completes all assigned tasks by deadline; work accomplished is thorough, comprehensive, and |

Feedback

FEEDBACK | COMMENTS | PROGRESS

I want to... | Close

Keyword search

End of CSE M4 feedback, Inquiry & Analysis. It is good to see that you recognise the importance of practice and focus. You will of course develop all essential skills during all the modules, but at times it can be more productive to focus more on specific sets that you are interested in improving. In the case you describe, you will have more time later to focus more on the research skills. It is especially important that you got significant practice in developing sub-topics. The development of sub-research questions later on is an incredibly important skill for a researcher

Reply

February 2023

Leonie Krab-Hüsken
at 09:26, 20-Feb-2023
Released

End of M2 feedback: Well done for understanding the difference between low- and high-context cultures and putting your intercultural skills to use in your project. It's impressive that you uncovered surprising cultural practices, such as arranged marriage. Your project has certainly helped you build intercultural understanding and teamwork skills. Regarding time management differences, it's great that you have proactively planned for potential challenges in the future. We're curious about your reflections on the feedback from your peers through BuddyCheck. Well done, keep up the great work!

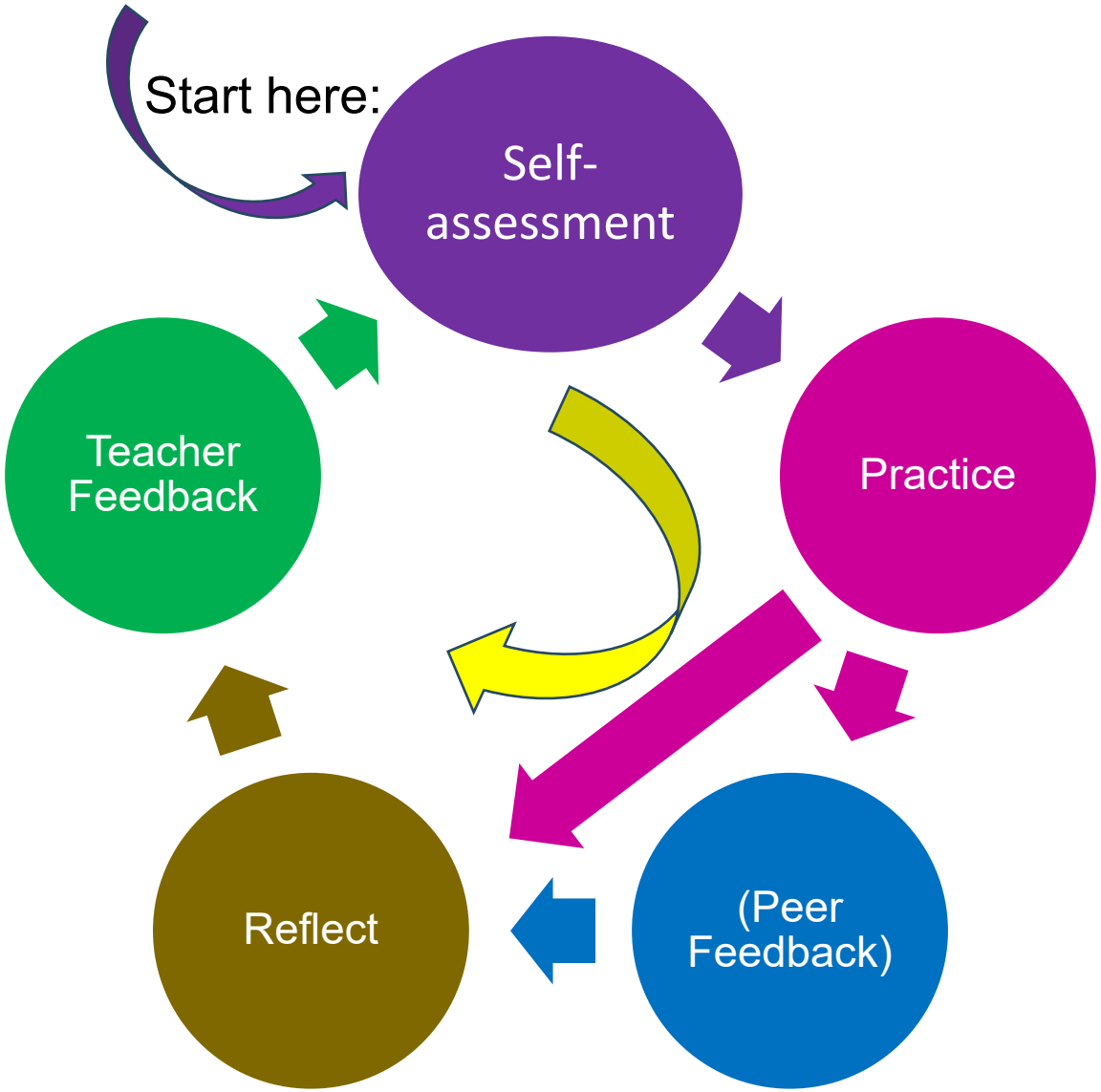
Reply

November 2022

Linlin Pei
at 13:14, 21-Nov-2022
Released

End of M1 feedback: In general, we recognize and agree with your self-evaluation. We clearly see how your evidence proves your development in *Contributes to Team Meetings* and *Facilitates the Contributions of Team Members*. We clearly see how

# ESSENTIAL SKILLS: LEARNING PROCESS






UNIVERSITY OF TWENTE.

# EXAMPLE M6: GUESSTIMATION CASES

- How much $CO_2$ does an oak tree in the Netherlands store in 1 year?
- How big of a water tank would you need, to store enough heat in liquid water over the summer, so that you can heat your house the whole wi
- Estimate how many pipette tips the entire UT uses per day.
- How many apples should you eat to have enough energy to climb the Mount Everest?
- If you had to wash all the clothing worn today at the UT, how many rou with a washing machine would you need?
- How many sugar molecules are on your face after a direct hit with a cake?
- How much cleaning solution is needed to clean all the desks and tables in Carré once?

EXAMPLE exercises M6 Quantitative literacy



SITY NTE.

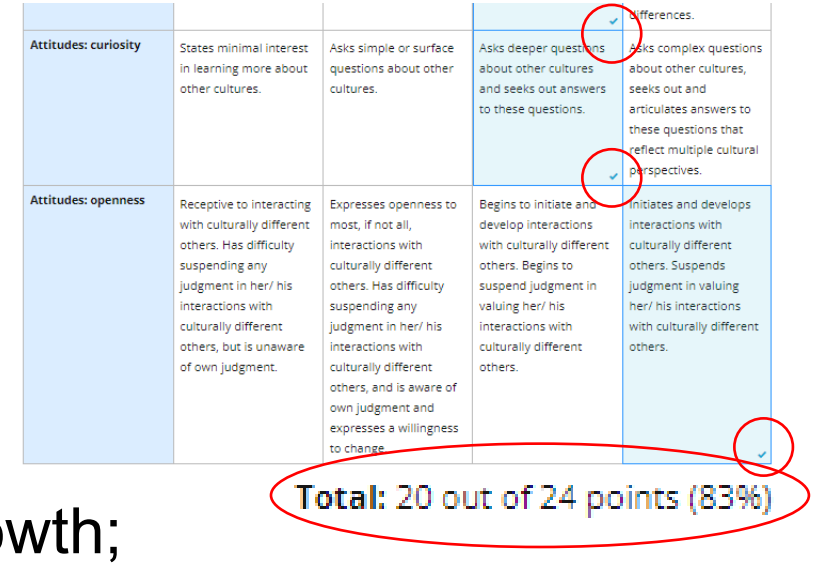
# FINAL EXAMPLE: QUANTITATIVE LITERACY @CSE

Characteristics:
Interpretation; Representation; Calculation; Application/Analysis; Assumptions; Communication

| CSE Essential skill # 7: Quantitative Literacy | Emerging 1 | Developing 2 | Developing 3 | Bachelor's 4 |
|---|---|---|---|---|
| **Interpretation** *Ability to explain information presented in mathematical forms (e.g., equations, graphs, diagrams, tables, words)* | Attempts to explain information presented in mathematical forms, but draws incorrect conclusions about what the information means. *For example, attempts to explain the trend data shown in a graph, but will frequently misinterpret the nature of that trend, perhaps by confusing p… negative trends.* | Provides somewhat accurate explanations of information presented in mathematical forms, but occasionally makes mino… related to computation… *instance…* | Provides accur… inf… …plains …a graph. | …te explanations of …rmation presented in mathematical forms. Makes appropriate inferences based on that information. *For example, accurately explains the trend data shown in a graph and makes reasonable predictions regarding what the data suggest about future events.* |
| **Representation** *Ability to convert relevant information into va… mathematical form…* | Com… …. | …pletes conversion of information but resulting mathematical portrayal is only partially appropriate or accurate. | Competently converts relevant information into an appropriate and desired mathematical portrayal. | Skillfully converts relevant information into an insightful mathematical portrayal in a way that contributes to a further or deeper understanding. |
| **Calculation** | …alculations are attempted but are both unsuccessful and are not comprehensive. *For example, units are missing or incorrect.* | Calculations attempted are either unsuccessful or represent only a portion of the calculations required to comprehensively solve the problem. Units are correctly used. | Calculations attempted are essentially all successful and sufficiently comprehensive to solve the problem. Units are correctly used. | Calculations attempted are essentially all successful and sufficiently comprehensive to solve the problem. Calculations are also presented clearly. Units are correctly used. |
| **Application / Analysis** *Ability to make judgments and draw appropriate conclusions based on quantitative analysis* | Uses the quantitative analysis of data as the basis for tentative, basic judgments, although is hesitant or uncertain about drawing conclusions from this work. | Uses the quantitative analysis of data as the basis for workmanlike (without inspiration or nuance, ordinary) judgments, drawing plausible conclusions from this work. | Uses the quantitative analysis of data as the basis for competent judgments, drawing reasonable and appropriately qualified conclusions from this work. | Uses the quantitative analysis of data as the basis for deep and thoughtful judgments, drawing insightful, carefully qualified conclusions from this work. |
| **Assumptions** *Ability to make & evaluate important assumptions in estimation, modeling, and data analysis* | Attempts to describe assumptions. | Explicitly describes assumptions. | Explicitly describes assumptions and provides compelling rationale for why assumptions are appropriate. | Explicitly describes assumptions and provides compelling rationale for why each assumption is appropriate. Shows awareness that confidence in final conclusions is limited by the accuracy of the assumptions. |

Students were hardly aware of this skill;
The rubric gave them a **language** to express their competencies and development

# WHY THIS APPROACH?



| | | | | |
|---|---|---|---|---|
| | | | | differences. |
| **Attitudes: curiosity** | States minimal interest in learning more about other cultures. | Asks simple or surface questions about other cultures. | Asks deeper questions about other cultures and seeks out answers to these questions. | Asks complex questions about other cultures, seeks out and articulates answers to these questions that reflect multiple cultural perspectives. |
| **Attitudes: openness** | Receptive to interacting with culturally different others. Has difficulty suspending any judgment in her/ his interactions with culturally different others, but is unaware of own judgment. | Expresses openness to most, if not all, interactions with culturally different others. Has difficulty suspending any judgment in her/ his interactions with culturally different others, and is aware of own judgment and expresses a willingness to change. | Begins to initiate and develop interactions with culturally different others. Begins to suspend judgment in valuing her/ his interactions with culturally different others. | Initiates and develops interactions with culturally different others. Suspends judgment in valuing her/ his interactions with culturally different others. |

**Total:** 20 out of 24 points (83%)

- Stimulate reflection and growth
- PebblePad is a very practical tool
  - **Rubrics** help students to **find words** for their growth;
  - **Checking boxes** in rubrics and counting these scores gives quick **overview** for students and facilitates assessment;
  - **Feedback very visible** (good overview);
  - Tool to reflect and to steer students' learning;
  - Feedback from small group of teachers and/or hand-picked peers
- GDPR (AVG)
  - Privacy of students guaranteed; very limited access (separate from Canvas)
- LLL (LLO)
  - Students keep access after graduating