# Characterising Structure-Behaviour Reasoning within a Chemical Design Challenge: ‘Green Bubble Soap’

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# Technology Education and Learning through Chemical Design

- Design is traditionally a part of Technology Education
  - Particularly in England and Wales: Design and Technology

- Most of the design challenges are of an ‘industrial design’ or ‘physical design’ type
  - Not many examples of chemical design in Technology Education.

- Trend towards STEM can change that when Technology Education is more related to Science Education, including Chemistry Education.

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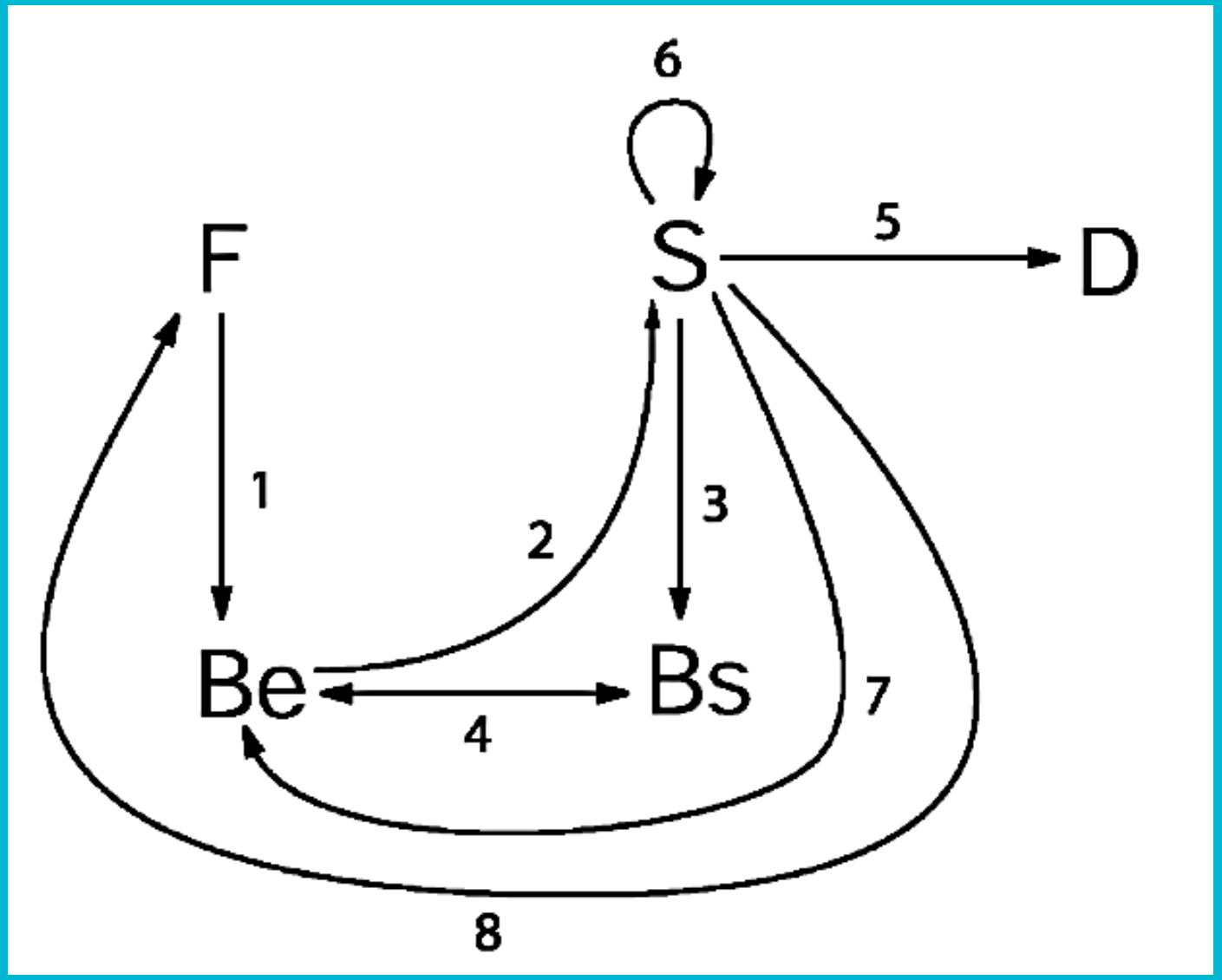
# Potential strength of STEM: design-based learning

- Design challenges can support the learning of both scientific and technological concepts
- In both domains the function-structure relation is an important one (NGSS, 2013)
- Both pupils and teachers have difficulties with this concept (see several research studies)
- Chemical Technology: design and synthesis of molecules and materials (via novel routes), analysis and optimisation of processes, all for people to extend their abilities and satisfy their needs and wants (Talanquer, 2013).
- This study: try out a chemical design challenge to see if learning function-structure thinking can be enhanced
  - Context: Chemistry Education, but in principle could also have been done in Technology Education

## Function-Behaviour-Structure framework

1. Formulation
2. Synthesis
3. Analysis
4. Evaluation
5. Documentation
6. Reformulation type 1
7. Reformulation type 2
8. Reformulation type 3

(Gero & Kannengiesser, 2004)

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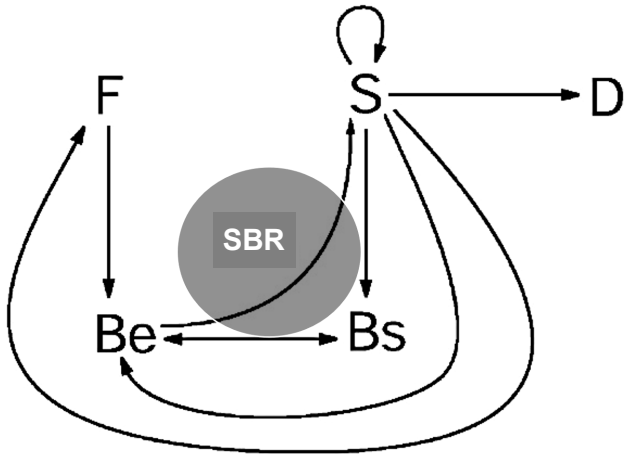
# Perspective for Structure-Behaviour Reasoning


- (adapted from: M.-J. den Otter et al., 2021)

Research Questions:

1. What types of students' structure-behaviour reasoning occurs during design activities?

2. What relationships can be identified between students' reasoning and the different stages of the design process?

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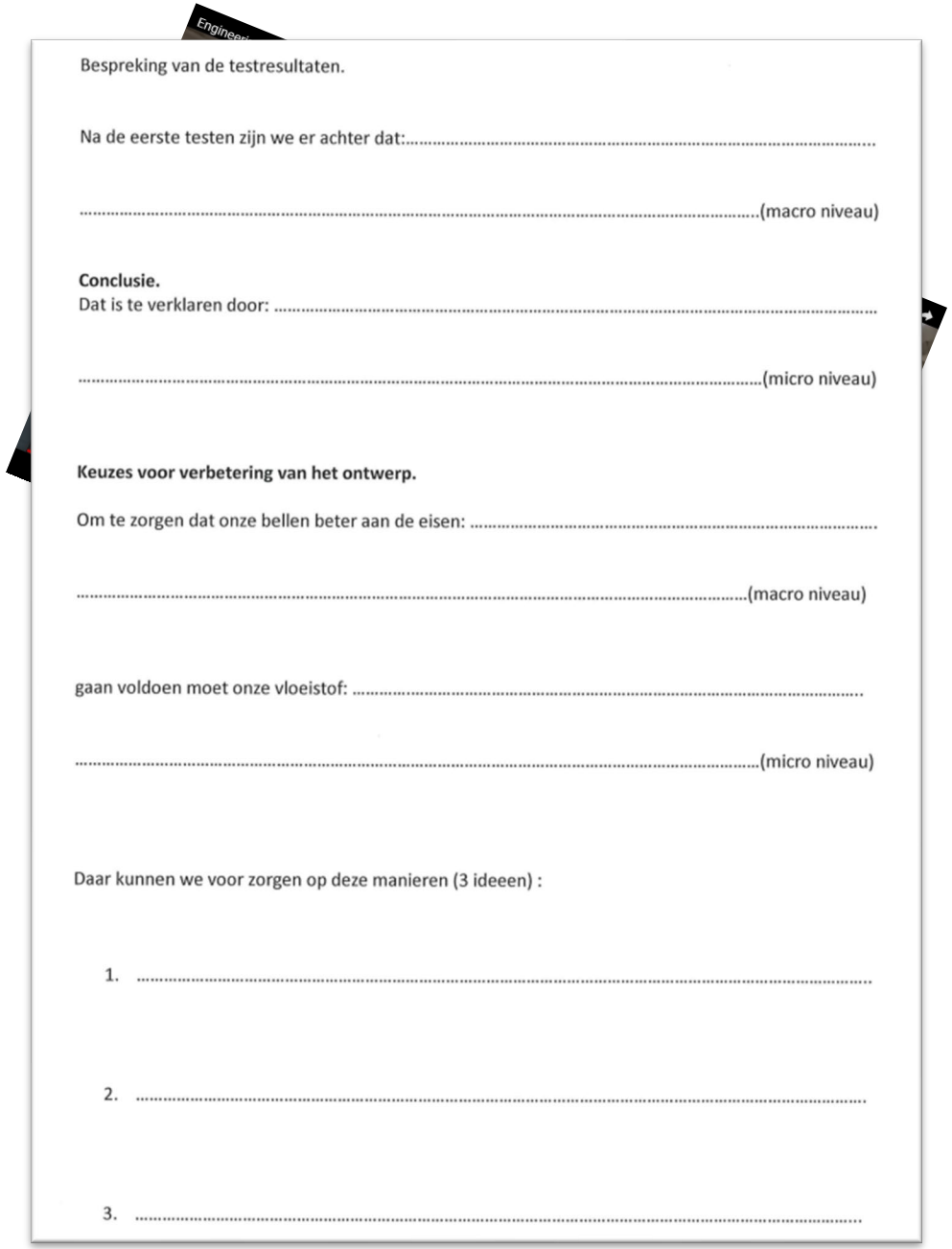
# The case: ‘green bubble soap’

- Introduction about chemical technology and design.
- 10th grade secondary students design the perfect bubble soap to blow bubbles that live the longest.
- They were only allowed to use sustainable ingredients.
- Working in teams consisting of 2 students per team.
- While generating ideas or evaluating test results students were encouraged to explain their decisions by using Structure-Behaviour Reasoning.


Bespreking van de testresultaten.

Na de eerste testen zijn we er achter dat:.....

.....(macro niveau)

**Conclusie.**
Dat is te verklaren door: .....

.....(micro niveau)

**Keuzes voor verbetering van het ontwerp.**

Om te zorgen dat onze bellen beter aan de eisen: .....

.....(macro niveau)

gaan voldoen moet onze vloeistof: .....

.....(micro niveau)

Daar kunnen we voor zorgen op deze manieren (3 ideeen) :

1. .....
2. .....
3. .....

# Methodology

- Data gathering during student-centred practical work.
- Datasources:
  1. Transcripts of the audio recordings of 2 groups students' talk during the design.
  2. Annotations and drawings on the worksheets.
- Analysis using ATLAS.ti:
- First transcripts and worksheets were divided into sections and then marked according to the stage of the design process.
- Deductive coding of students' expressions using the perspective for SBR as an analytical lens.
- Subsequent grouping and axial coding of all the quotes with the applied code "SBR" uncovered themes and yielded characterisation of the expressed type of reasoning.
- The code co-occurrence tool in ATLAS.ti provided insight in SBR themes per stage of the design process.

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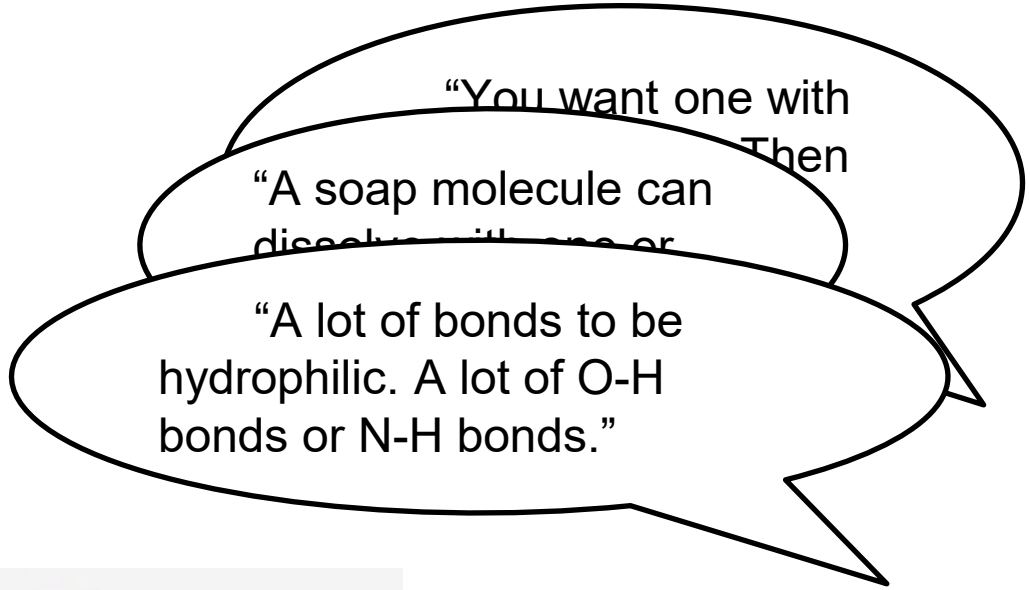
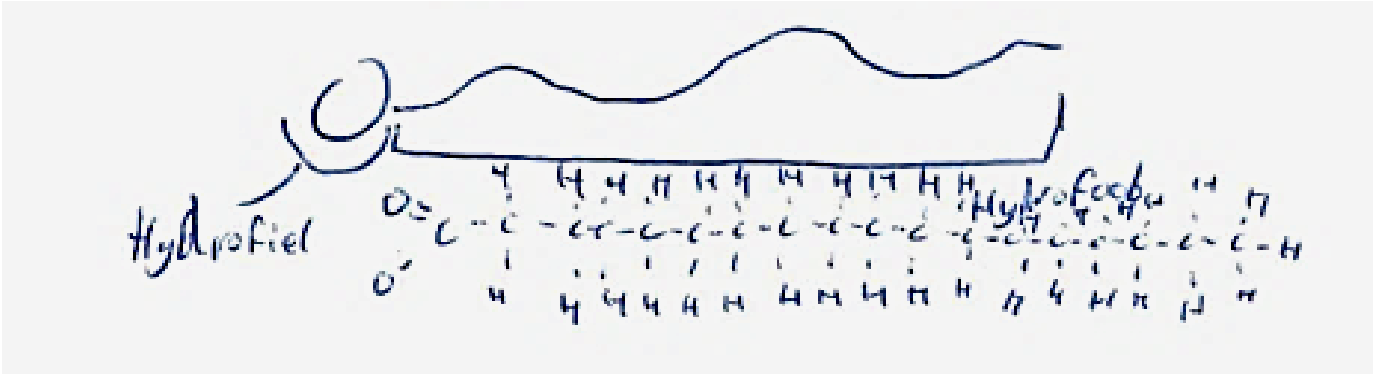
# Types of Structure – Behaviour reasoning

- A link between substances and their structural features:
  - Example:
- A link between the term '…molecule' and behaviour.
  - Example:
- A direct link between structural features and behaviour.
  - Example:

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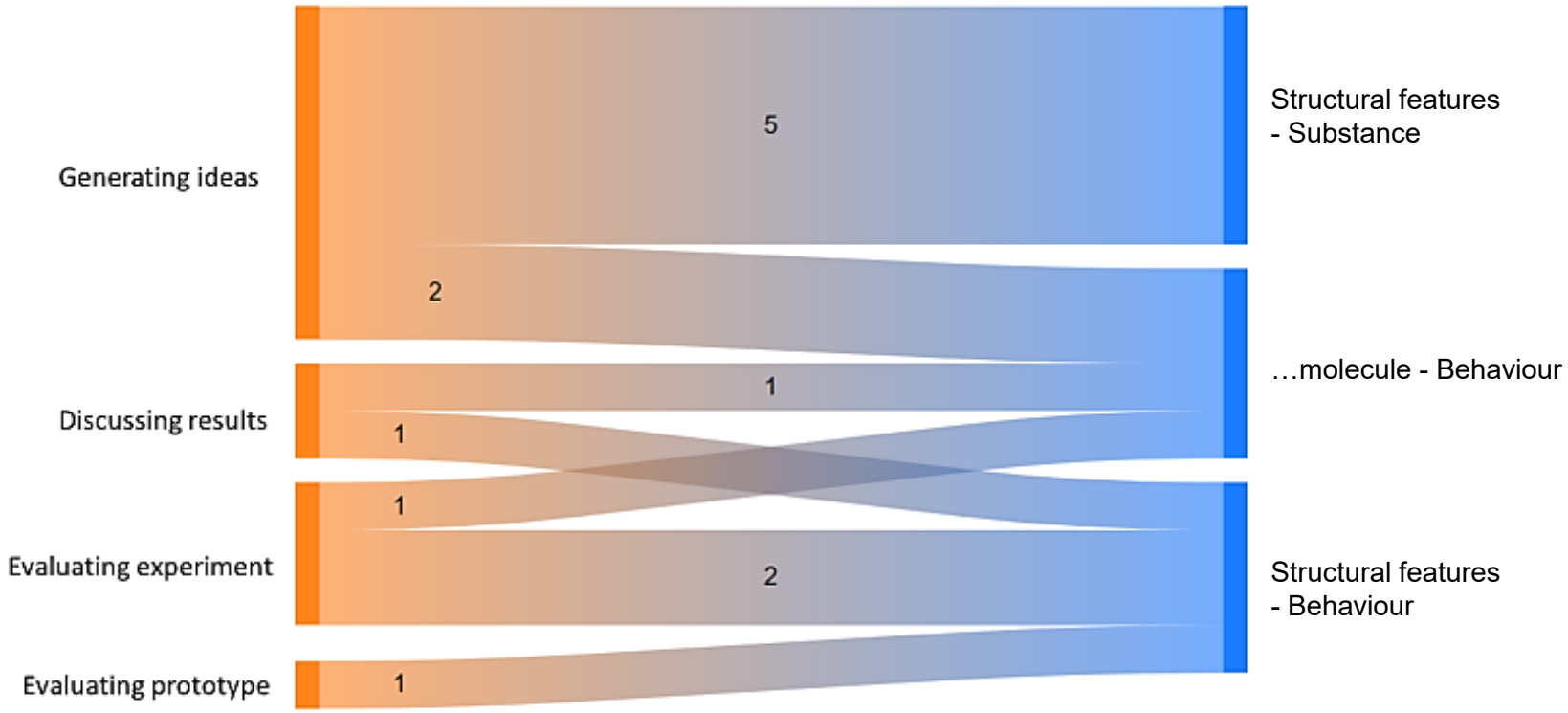
# Stages of the design proces in which SBR was identified

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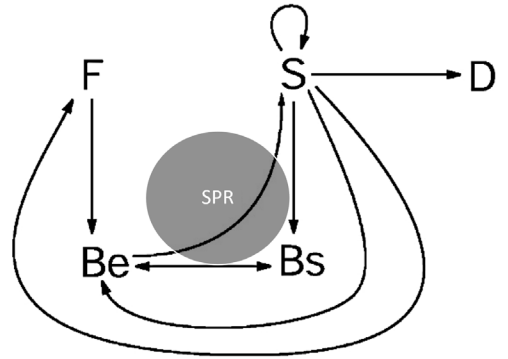
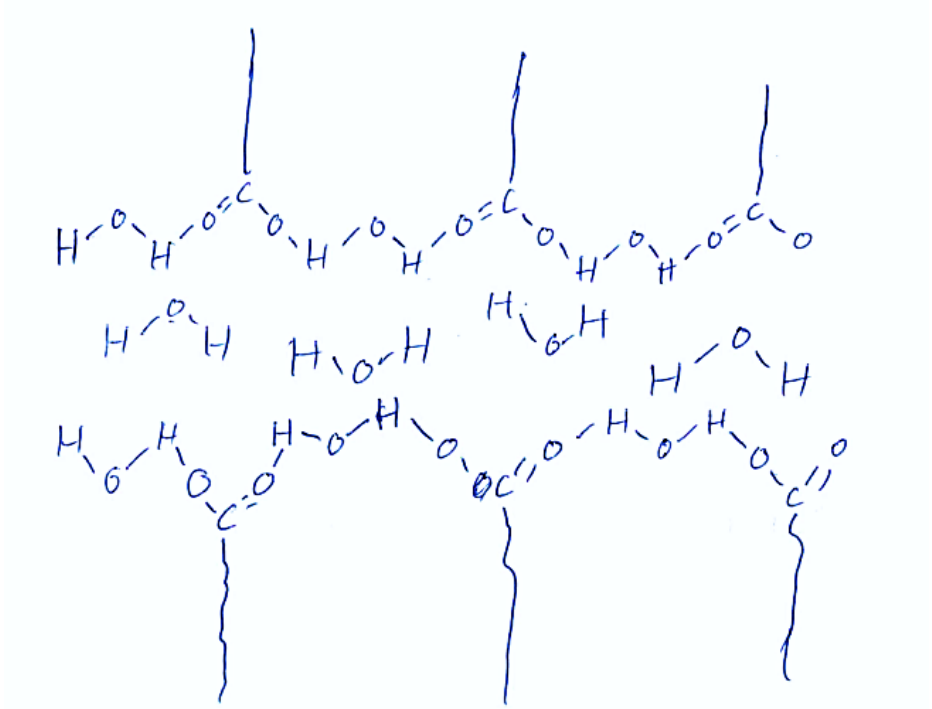
# SBR during evaluation and ideation

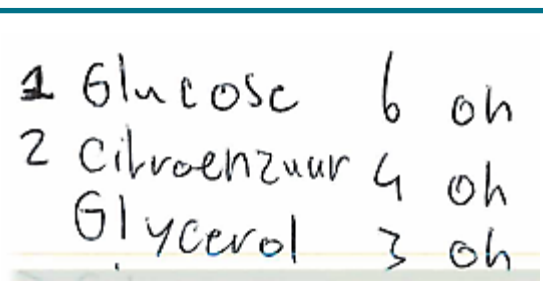


*A hydrofobic compound, a hydrophilic compound I mean.*

*A hydrophilic compound, So you are looking for a molecule that...What requirements does such a molecule have to meet, when it is hydrophilic?*

*A lot of bonds to be hydrophilic, a lot of O-H bonds, or N-H"*

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# Concluding remarks

- RQ 1: What types of structure-behaviour reasoning occurred during design?
- Structure-Behaviour reasoning was found in 3 following ways:
  - As link between structural features and substances
  - As link between the term “…molecule” and behaviour of a substance
  - As a link between structures or characteristic moieties and behaviour of a substance

- RQ 2: What relationships can be identified between students’ reasoning and the different stages of the design process.
- Students’ reasoning was found during evaluation, discussion of results and ideation: stages in which students gave meaning to their observations.

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# Future work

- Perform the study on larger scale (minimum of 6 classrooms, 12 groups) to gain more in-depth analysis of types of reasoning within the FBS framework processes and how it can guide design thinking and thinking of complex systems.

- Focus on teacher interventions during processes of evaluation, ideation and reformulation type 1 (changes in terms of the structure variables or ranges of values for them). How do teacher interventions influence students' structure-behaviour reasoning during design activities.

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# Thank you for your attention

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