Predetermination of Visual Representation Type Influences Students‘ Performance and Cognitive Load

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Open-Minded

Starting Point

Translating verbal information into visual representations is fundamental to communicating in the field of organic chemistry (Kozma et al., 2000).

Theoretical Background

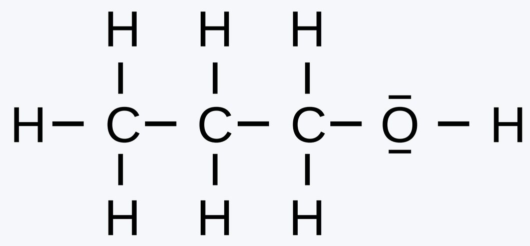
Digital tools rely on using skeletal formula – experts' standard representation type (Brecher, 2008).

Students are not sufficiently familiar with skeletal formula before they visit an organic chemistry course at university.

Representation forms

Skeletal formula

Structural formula



Systematic name propane-1-ol

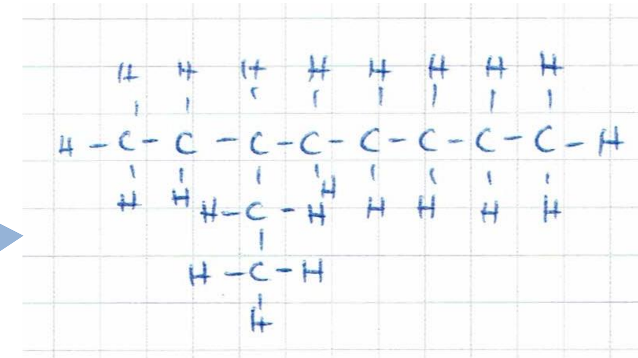
Research Questions

Which representation type do students choose when they need to translate verbal information about a molecule into a visual representation (study 1)?

To what extend does a predetermined representation type affect students' performance and cognitive load (study 2)?

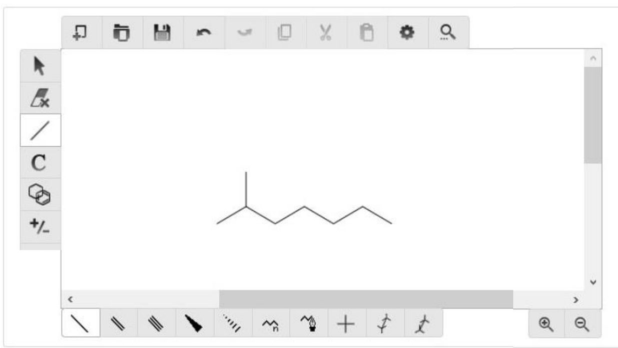
Item Pair (Study 1)

Draw a 3-ethyloctane molecule.



Paper-pencil-based task with solution

Draw a 2-methylheptane molecule.



Digital task with solution

Method

Within-subject-design with item pairs in both formats (paper-pencil, digital)

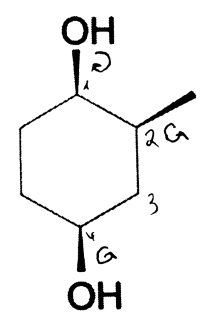
Performance and cognitive load

Sample

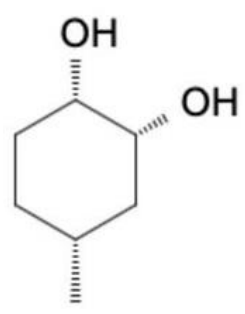
Chemistry majors and students preparing to become chemistry teachers from an introductory organic chemistry course

Item Pair (Study 2)

Determine the configuration of the following molecule.



Paper-pencil-based task with markings



Digital task

The molecule is …
- ◯ *1S, 2R, 4R*
- ◯ *1R, 2R, 4R*
- ◯ *1S, 2S, 4S*
- ◯ *1R, 2S, 4S*

… configured.

Results Study 1

Learners used less abstract representations for translating molecules' systematic names into visual representation for 22.44 % of all given responses (631).

The number of missing answers is significantly higher for the digital format (40.1 %, paper-pencil-format: 25.7 %, $t(47) = 3.80$, $p < .001$).

Reliability Study 1 (Translating)

The students' solutions were used to calculate their person abilities using the Rasch model (Winsteps version 5.2.4.0, Boone, et a., 2014).

N = 48, 14 Item pairs

Paper-and-pencil assessment:
person reliability = .85, item reliability = .87

Digital assessment:
person reliability = .83, item reliability = .89

Reliability Study 2 (Chirality)

The students' solutions were used to calculate task difficulties using the Rasch model (Winsteps version 5.2.4.0, Boone, et a., 2014).

N = 80, 19 Item Pairs (DC, MC, drawing)

Chemistry tasks:
Person reliability = .82, item reliability = .90

Invested mental effort (Paas, 1992):
Person reliability = .93, item reliability = .96

Results Study 2

47 of 80 learners used markings or notes to make implicit information explicit in the paper-pencil format (the digital format does not provide such options).

Digital format goes along with higher task difficulties, $t(18) = 2.35$, $p = .031$, $d_{RM} = 0.69$, and higher invested mental effort, $t(18) = 6.42$, $p = \leq .001$, $d_{RM} = 1.68$.

An interaction term of invested mental effort and note-taking best explains the probability of solving the tasks for those students who take notes (students who take notes generally perform better than students who do not take notes).

Interaction

Results indicate that invested mental effort, $B = -0.19$, $SE = .03$, $t = 5.99$, $p < .001$, and note taking, $B = -0.22$, $SE = .11$, $t = -2.16$, p .047, are significant predictors. The interaction term (*invested mental effort X note taking*) turned out to be another significant predictor, $B = 0.37$, $SE = .12$, $t = 3.07$, $p = .008$. Overall, the model accounted for 81 % of the variance of the probability of solving the task, with the interaction term explaining 12 % variance beyond the main-effects terms.

Discussion

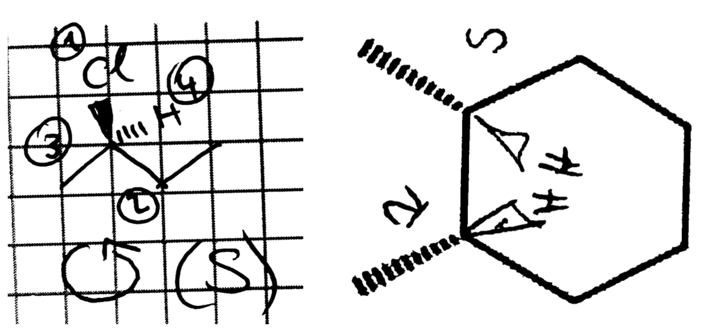
Common organic chemistry tasks are not easily adaptable to digital formats.

Digital tasks do not allow students to work in the same way as they are used to with paper-pencil formats.

Visual representations of molecules seem to be a critical factor here.

How can students be supported in learning to meaningfully work with abstract representations such as skeletal formula?

Markings Within Molecules



PI|T|CH
PRÜFUNGEN INNOVIEREN | TRANSFER SCHAFFEN | CHANCENGERECHTIGKEIT FÖRDERN

References

Example task

Scan
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EARLI
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Walpuski Group

Kontakt

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