ULg Spectra

Interactive Digital Learning Tools

Enhancing Critical Thinking and Problem-Solving Skills in First-Year Undergraduate Life Sciences Students

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EUROPEAN FYE FIRST YEAR EXPERIENCE KU LEUVEN 600

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Outline

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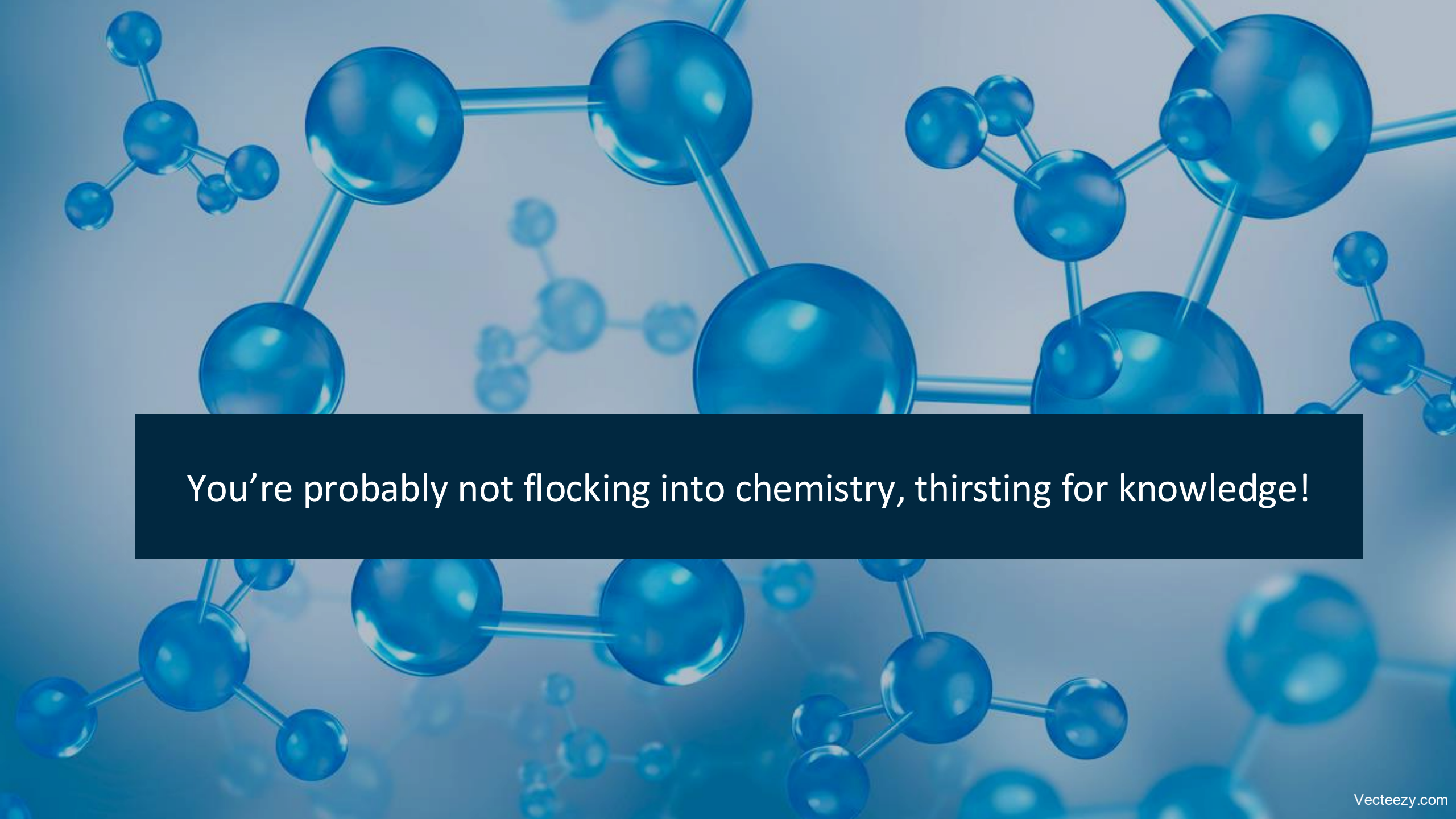
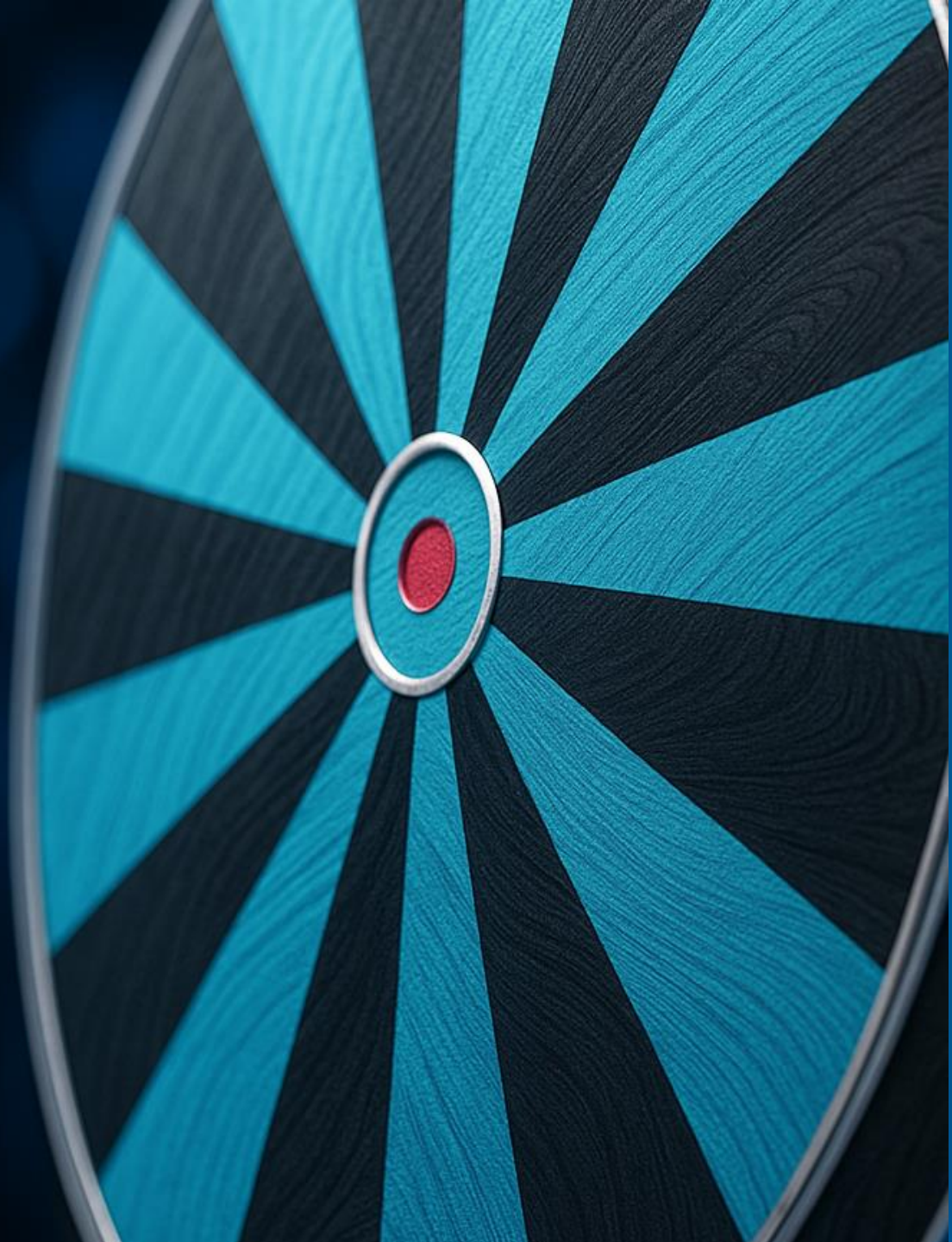
Imagine you are a first-year veterinary student …
What would you think about your organic chemistry course?


You’re probably not flocking into chemistry, thirsting for knowledge!
Vecteezy.com

Background

Engaging students is challenging!

- Chemistry is difficult, less relevant
- A mandatory hurdle
- Thought to be unrelated to future healthcare careers



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However …

Analytical thinking, critical thinking, and problem-solving skills are crucial!

- ⇨ Train students with a chemistry-based subject that mimics diagnostic process.
- ⇨ Digital technologies can help enhance students' learning experiences, motivation, and soft skills

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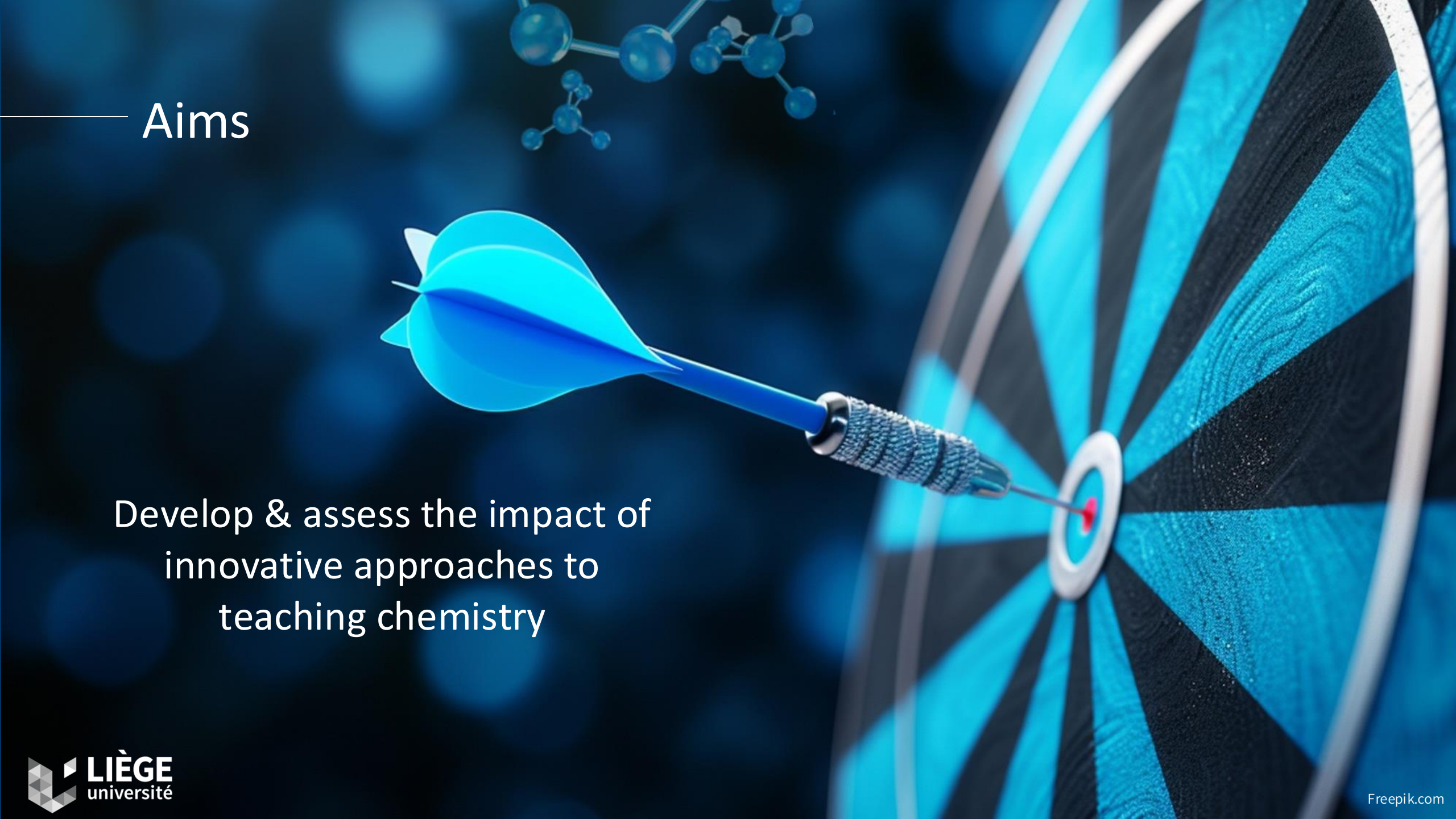
Aims



Develop & assess the impact of innovative approaches to teaching chemistry

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Enhance ...

Motivation & autonomy

Make chemistry more engaging and relevant to students' future careers

Critical thinking & argumentation skills

Use interactive problem-solving tasks designed to promote deep procedural knowledge through more productive practice

Adaptability

Explore the role of digital tools in diversifying learning and assessment methods

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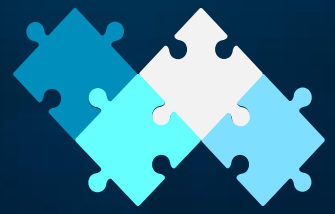
Methods

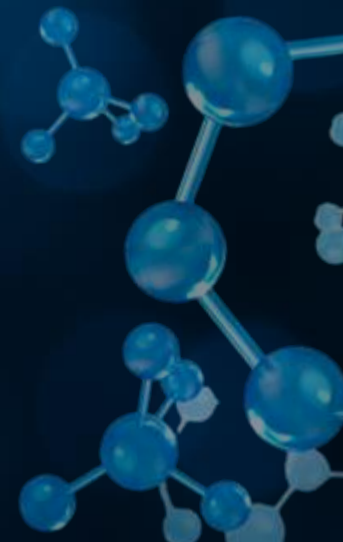
Diagnosis

Construction of a claim based on interpreting signs (symptoms) and evidence (e.g., blood test, electrocardiograms, imaging)



Molecular Structural Analysis

Construction of a claim based on interpretating relevant information from spectroscopic data



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Replace traditional textbooks

- Static images
- Need to highlight some clues

Interactivity

- Zoom in on data
- Explore clues independently

Benefits

- Asynchronous
- Self-paced
- Flexibility
- Adaptability

⇨ Student can then focus on the entire reflexive process

Made by students … For students …

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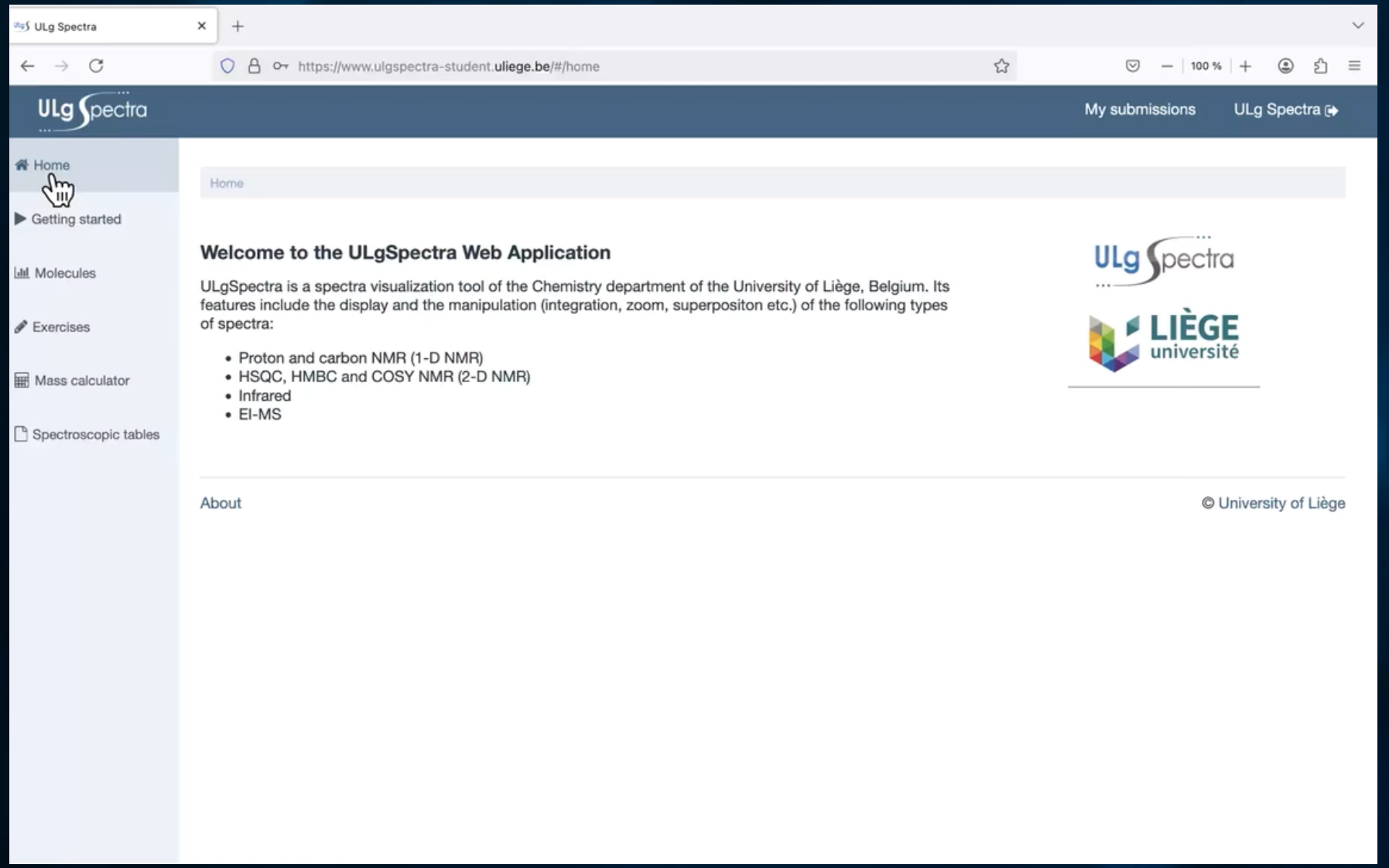

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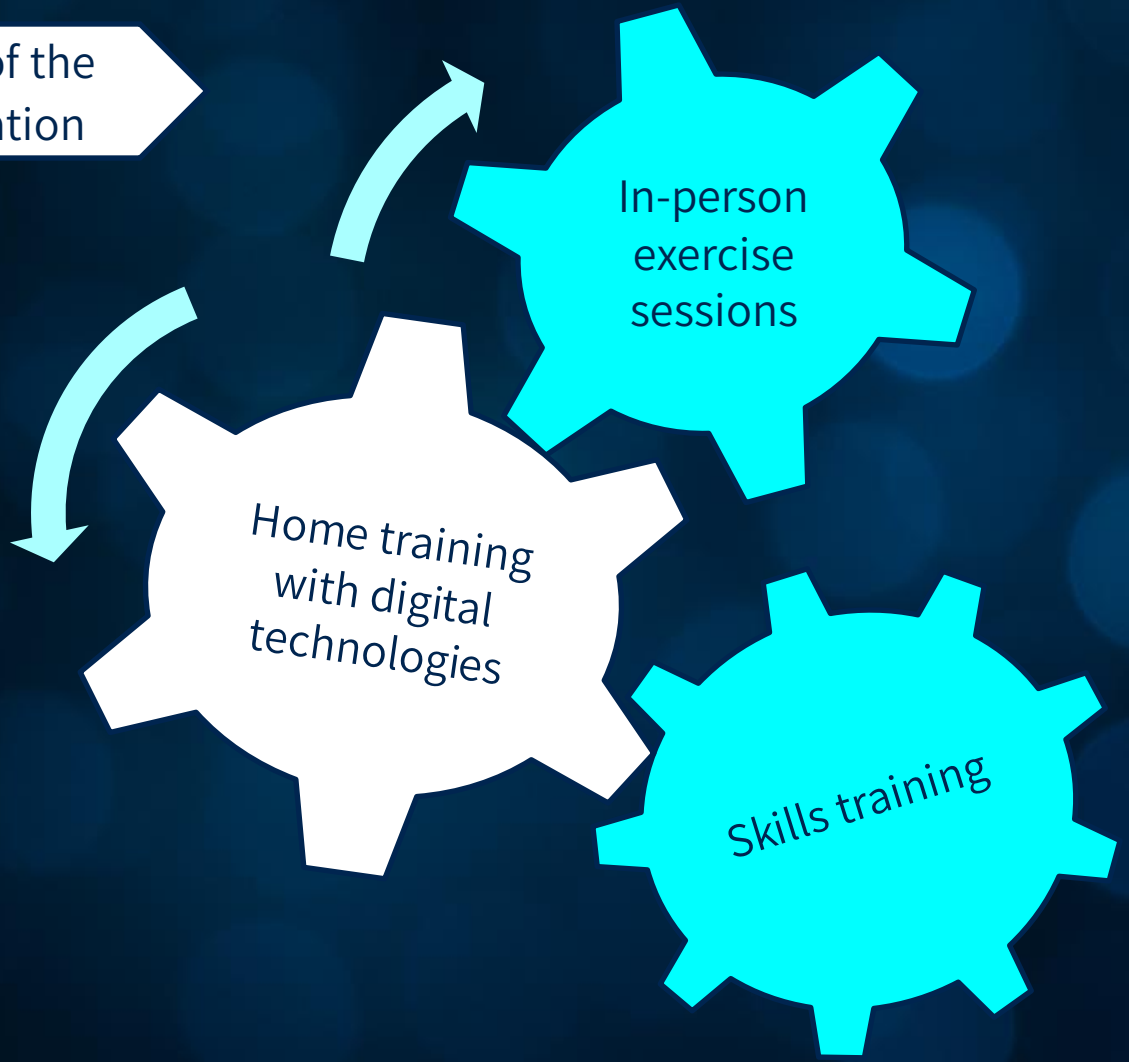
New pedagogical engineering

Theoretical concepts → Demo of the application



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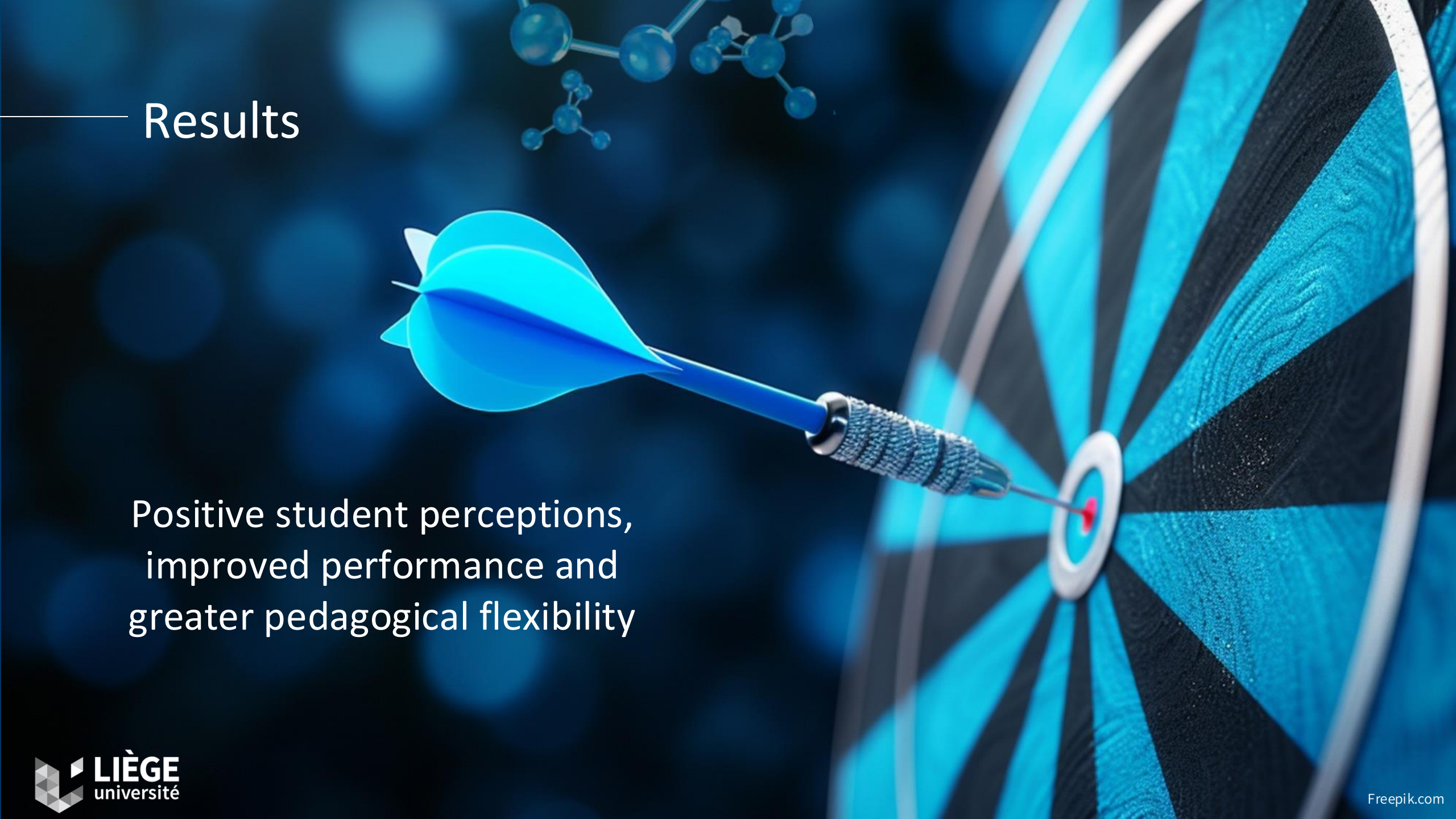
Results



Positive student perceptions, improved performance and greater pedagogical flexibility

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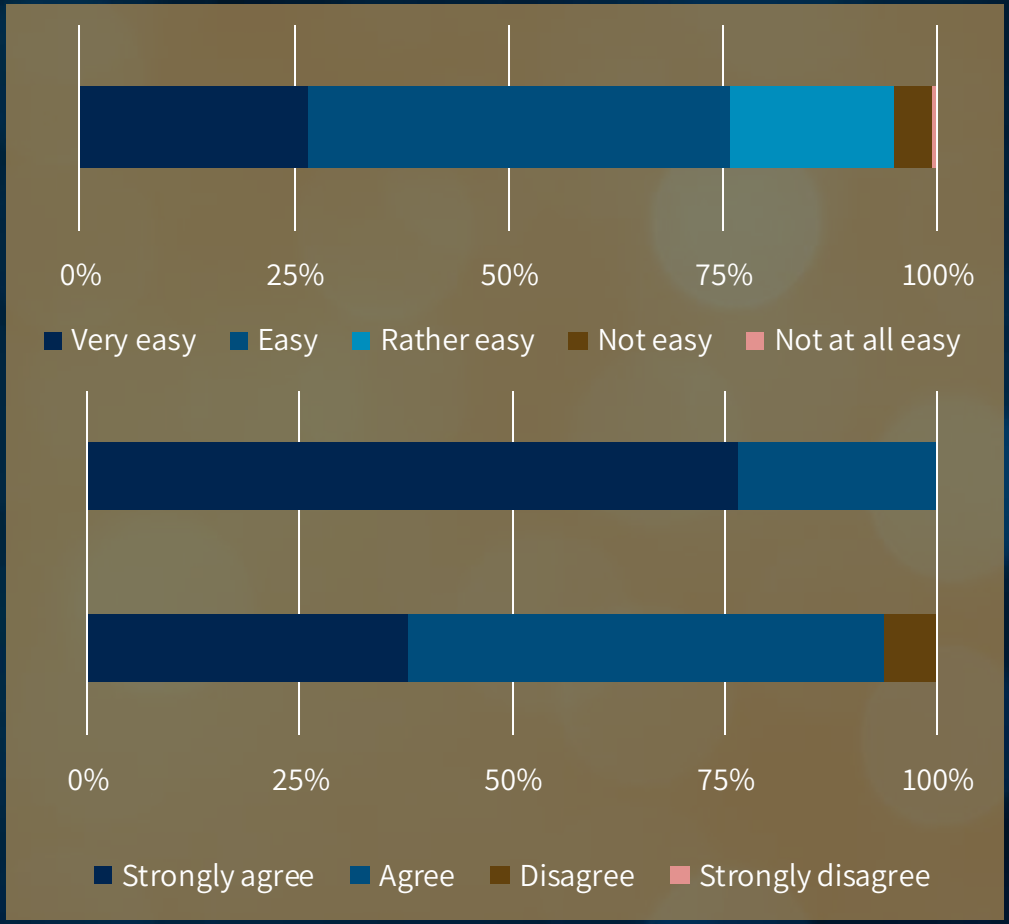
Positive students' perceptions

Is the interactive Web Application easy to use ?

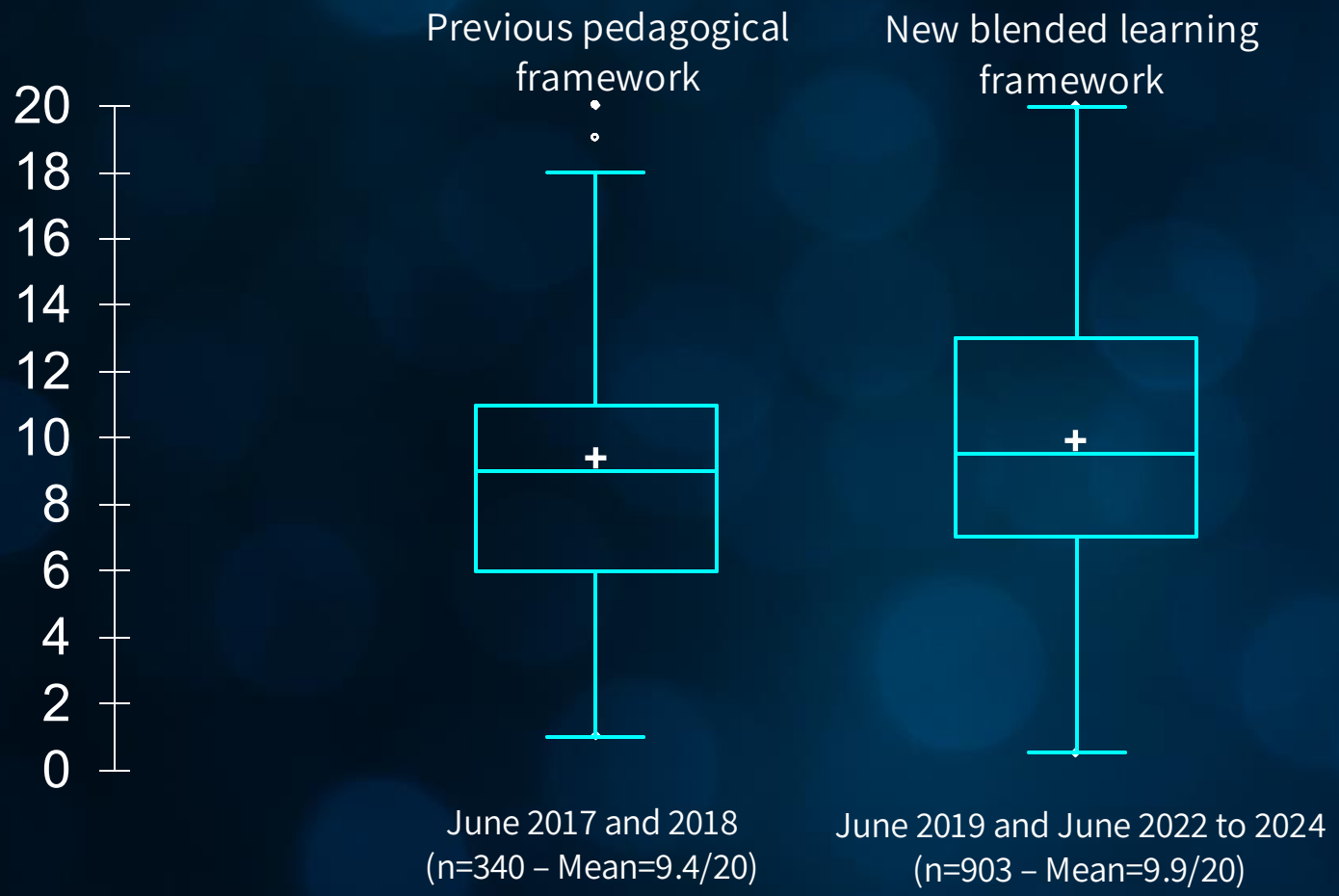
I think that online exercises are useful

ULg Spectra application help me read and handle the spectra



(n = 162)

Students' performance



Statistically significant increase of performance (Mann-Whitney U test, p = 0,040)

Box plot of students' exams performance illustrating mean grades (+) and first and third quartiles

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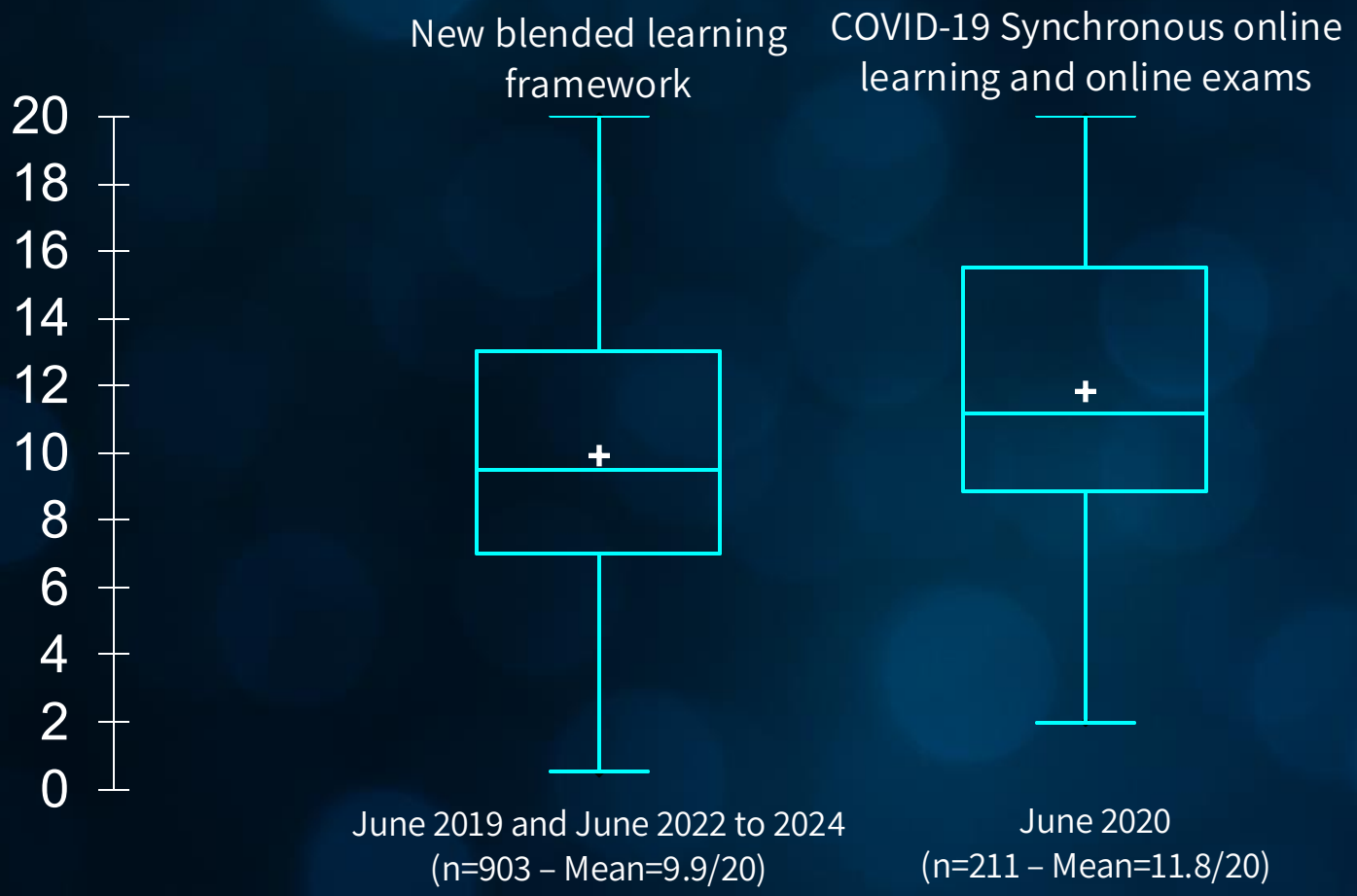
Students' performance and pedagogical flexibility



Statistically significant increase of performance (Mann-Whitney U test, $p < 0{,}0001$)

Box plot of students' exams performance illustrating mean grades (+) and first and third quartiles

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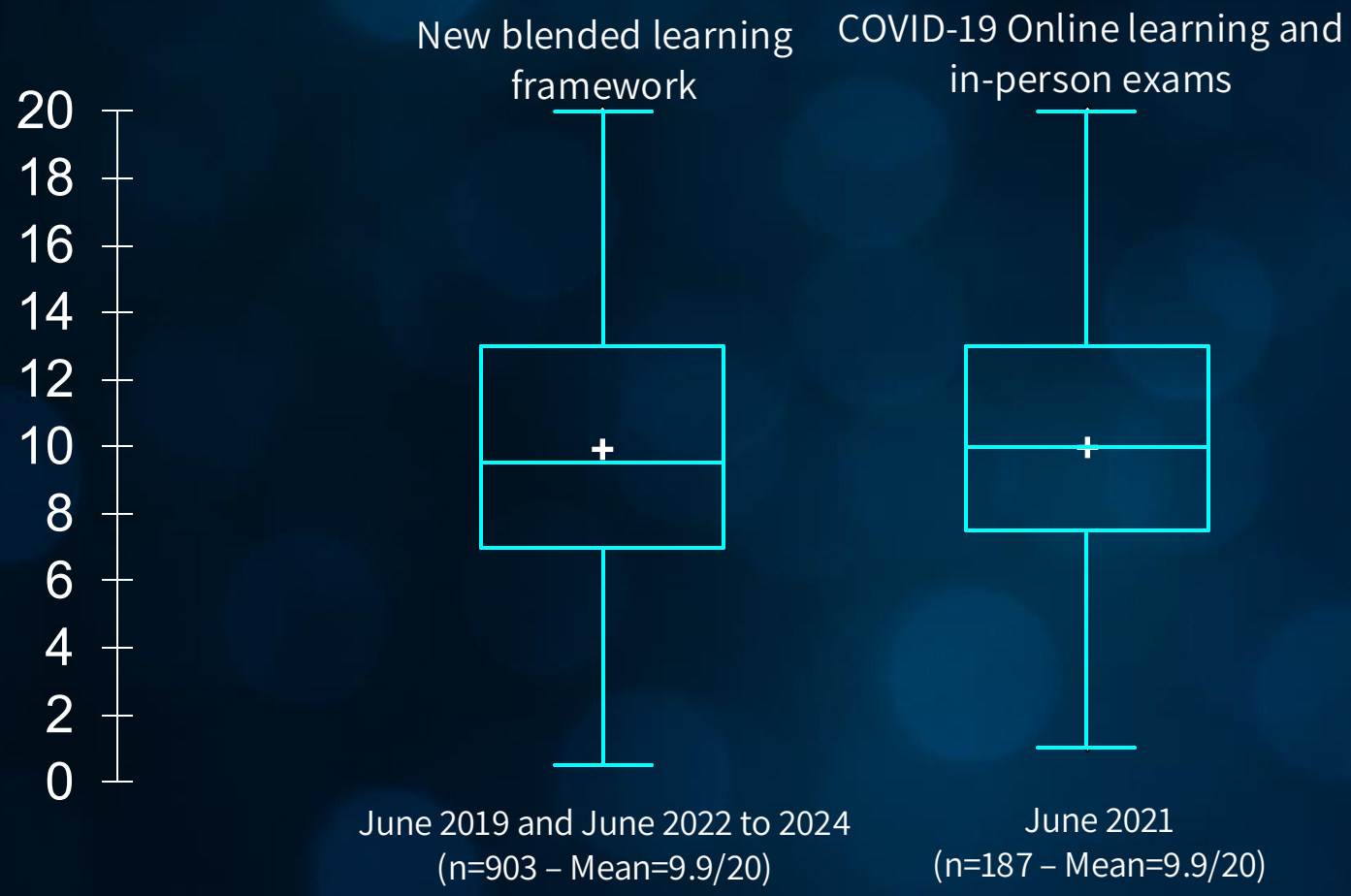
Students' performance and pedagogical flexibility



Successful adaptation to a synchronous online format

Box plot of students' exams performance illustrating mean grades (+) and first and third quartiles

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Future perspectives

Clarify and emphasize chemistry's relevance to real-life healthcare tasks

More meaningful feedback for students

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Reasoning Across Disciplines

Diagnosis

Molecular Structural Analysis

I brought a veterinarian into the classroom to help students draw clear parallels between diagnosing a patient and analyzing molecular structures.

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Simone the dog is sick. How do you figure out what’s wrong?

It’s tricky — so many possible explanations.

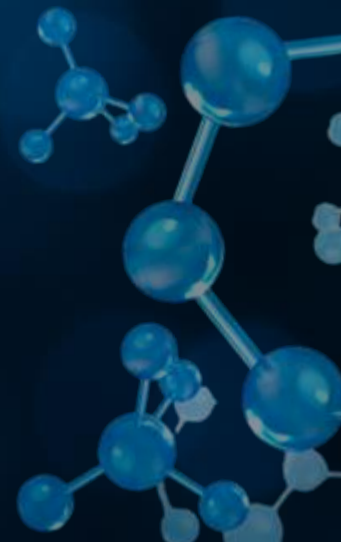
Luckily, a vet is here to guide us through it in class.

Reasoning Across Disciplines

Diagnosis

Molecular Structural Analysis

Both require careful interpretation of evidence – a shared logic, reflected like a mirror



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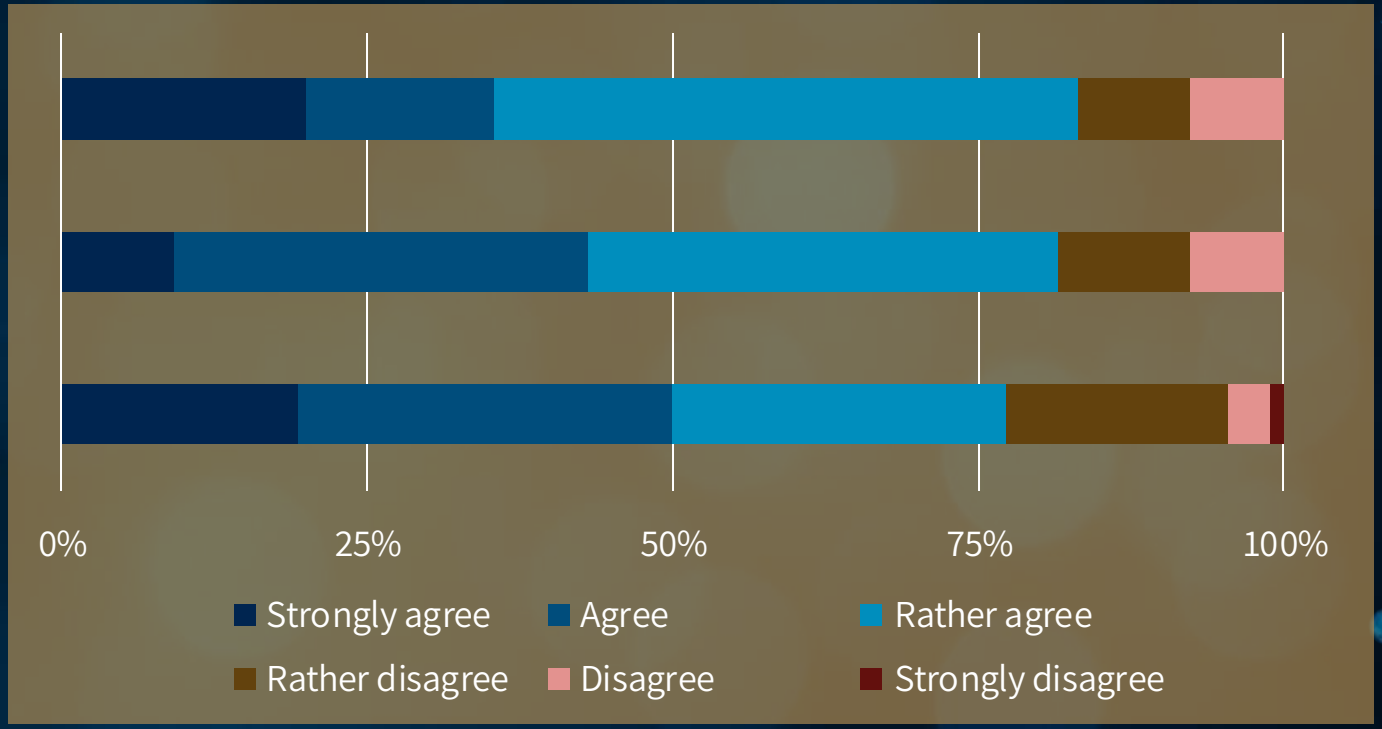
Positive students’ perceptions

I think the veterinary surgeon's contribution to the organic chemistry course was useful

This contribution increased my motivation

I think that the reasoning skills developed in structural analysis will be useful to me



(n = 88)

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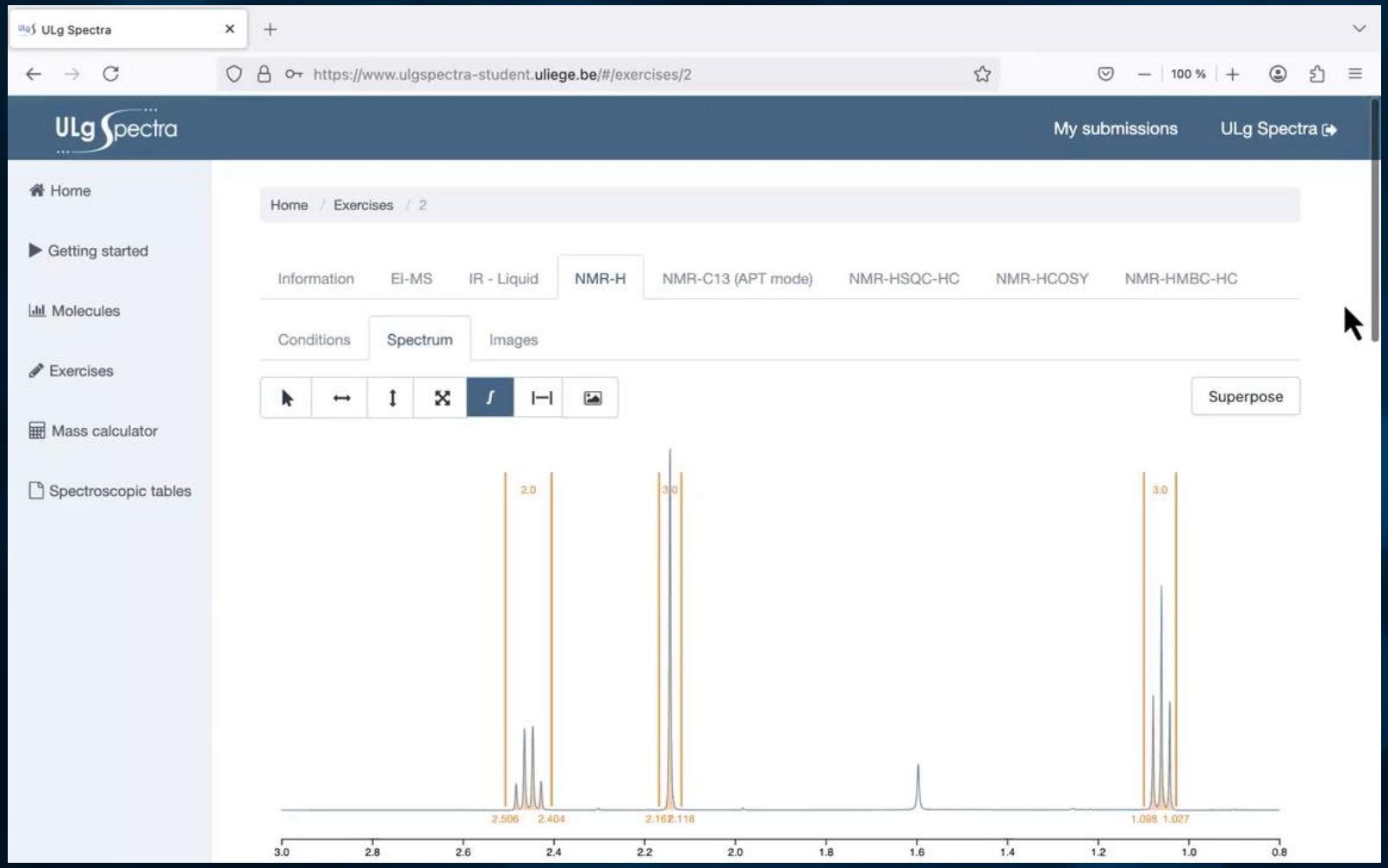
More meaningful feedback for students

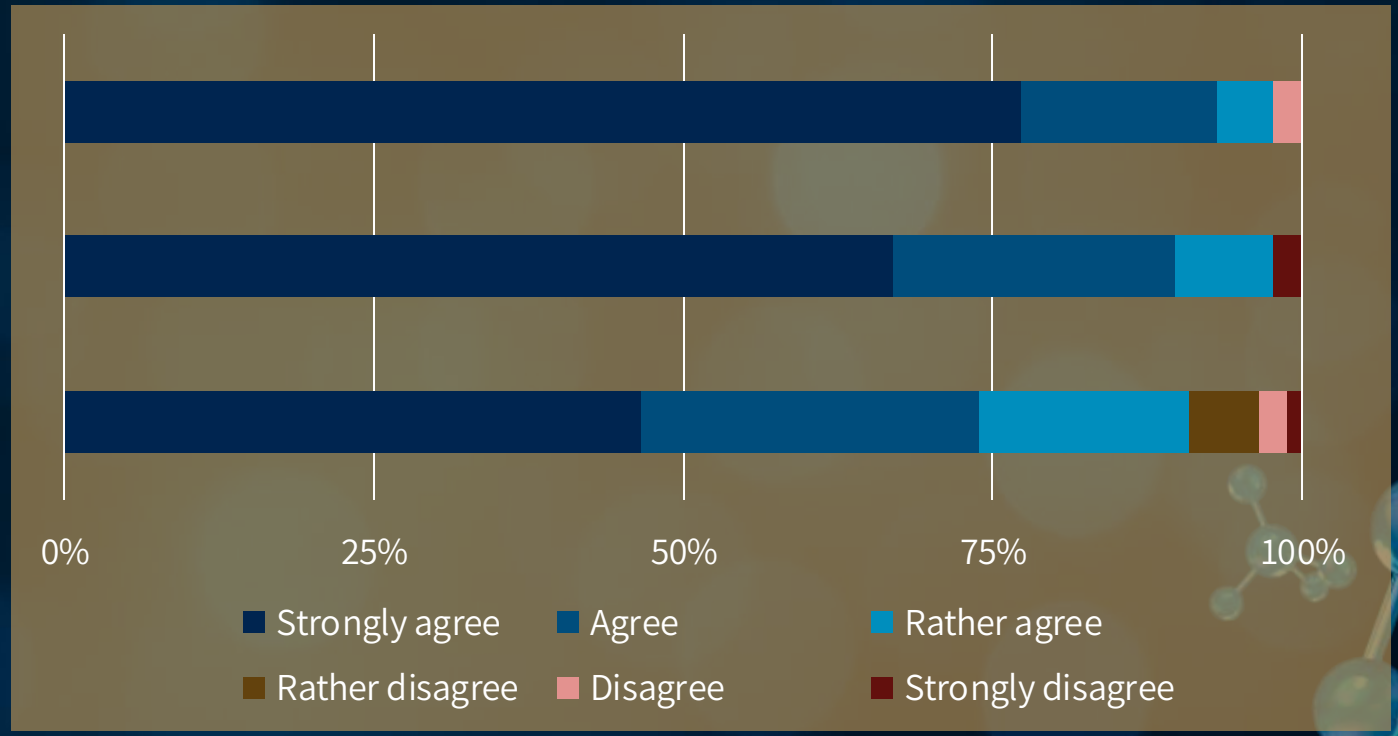


Preliminary students' perceptions

I think online exercises on the new ULg Spectra platform are useful

I think the new answer correction module integrated into ULg Spectra is useful

This new module motivated me to use ULg Spectra



(n = 88)

Conclusion

Diagnosis and molecular structural analysis are both based on evidence-based reasoning

- We should consider explicitly drawing parallels between course content and the professional roles students are preparing for!
- By aligning our teaching with students' professional aspirations, we help them find deeper meaning and motivation

Conclusion

Digital tools enhance

- Student engagement in evidence-based argumentation
- Problem-solving skills
- Motivation (semi-gamification)
- Adaptability to different teaching environments (face-to-face, blended, and distance learning), including successful online adaptation (with synchronous online exercises sessions) during pandemic

Bibliography

- Agnello, A. and Focant, J.-F. (2025). Enhancing Student Engagement in Argumentation Based on Spectroscopic Evidence: A focus on ^{1}H-^{13}C HSQC NMR. *J. Chem. Educ.*, 102, 1555-1562.
- Agnello, A., Vanberg, S., Tonus, C., Boigelot, B., Leduc, L., Damblon, C. et Focant, J.-F. (2020). Introducing Molecular Structural Analysis Using a Guided Inquiry Systematic Approach Combined with an Interactive Multiplatform Web Application. *J. Chem. Educ., 97*, 4330-4338. https://pubs.acs.org/doi/10.1021/acs.jchemed.0c00329
- Agnello, A, Carré, C., Billen, R., Leyh, B., De Pauw, E. and Damblon, C. (2018). ULg Spectra: An Interactive Software Tool To Improve Undergraduate Student's Structural Analysis Skills. *J. Chem. Educ.***,** *95 (2)*, 276–280
- Billig, M. (1987). *Arguing and thinking: A rhetorical approach to social psychology*. Cambridge: Cambridge University Press., p. 44
- Chen, S.-Y., Tsai, J.-C., Liu, S.-Y. et Chang, C.-Y. (2021). The effect of a scientific board game on improving creative problem solving skills. *Thinking Skills and Creativity, 41*, 1-11. https://doi.org/10.1016/j.tsc.2021.100921
- da Rocha Seixas, L., Gomes, A. S. et de Melo Filho, I. J. (2016). Effectiveness of gamification in the engagement of students. *Computers in Human Behavior, 58*, 48–63. https://doi.org/10.1016/j.chb.2015.11.021
- Hiebert, J. et Lefevre, P. (1986). Conceptual and Procedural Knowledge in Mathematics: An Introductory Analysis. *In Conceptual and procedural knowledge: The case of mathematics*. Hiebert, J., Ed.; Lawrence Erlbaum Associates: Hillsdale, NJ, 1–27.
- Jiménez-Aleixandre, M.P.; Erduran, S. (2007). Argumentation in Science Education: An Overview. In: Argumentation in Science Education. Science & Technology Education Library; Erduran, S., Jiménez-Aleixandre, M.P., Ed. ; Springer, Dordrecht, 35, pp 3-28. https://doi.org/10.1007/978-1-4020-6670-2_1
- Star, J. R. (2005). Reconceptualizing Procedural Knowledge. *J. Res. Math. Educ.*, 36 (5), 404−411.
- Stowe, R. L. and Cooper, M. M. (2019). Arguing from Spectroscopic Evidence. *J. Chem. Educ.*, 96, 2072-2085
- Verpoorten, D., Castaigne, J.-L., Westera, W. et Specht, M. (2012). A quest for meta-learning gains in a physics serious game. *Education and Information Technologies, 19*(2), 361–374. https://doi.org/10.1007/s10639-012-9219-7
- Wittmann, E. Ch. (2019). Understanding and organizing mathematics education as a design science – origins and new developments. *Hiroshima Journal of Mathematics Education, 12,* 13–32.
- Yeung, S.M. et Fujita, T. (2021). How to make practice more perfect? How to make practice more productive? *Proceedings of the British Society for Research into Learning Mathematics,* 41(2).

Thank you!

Do you have any questions?

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