

The effect on the perception of quantum science and technology with secondary school students through a university-based quantum lab and game experience

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Abstract. A visit to *Quantum Rules!* at Leiden University allows secondary school students to appreciate the principles of quantum science and technology. We report the outcomes of quantitative research on the effect on students' perceptions of quantum science and technology, following the addition to the *Quantum Rules!* experience of a serious game that uncovers ways in which quantum is part of daily life.

Introduction

The *Quantum Rules!* lab and game experience (<https://www.quantumrules.nl>) at Leiden University is a one-of-a-kind opportunity for secondary school Physics students to understand and appreciate the principles of quantum science and its applications in technology in a full-day playful educational setting. Yearly, over 30 classes from schools in the vicinity or further away (as far as 150 km) consisting of final-year students taking Physics in their exam, visit *Quantum Rules!* for free.

From its creation in 2018, the *Quantum Rules!* experience consisted of practical experiments followed by a lecture and group presentation of the research results. Research by Moraga-Calderón et al. reported a positive effect on the perception of the relevance of quantum science and technology among visiting secondary school students, and more salient was the decrease in negative perception. However, the students did not feel personal relevance [1]. To improve the *Quantum Rules!* experience in the latter respect, in 2021 a serious game that uncovers societal aspects of quantum science and technology was added to the lab experiments. The game is outlined below.

Description of the serious game

The serious game is of the 'escape room' type: within 1 hour, the students solve 5 society oriented puzzles using the results of the practical experiments in the morning. The puzzles each consist of 6-8 questions. By answering these, students discover the following: What colour is the Sun? Can we produce energy in a sustainable way? Can technology help us to be healthy? How do we smell? Why are blue butterflies blue?

The English-language game is available to players at <https://app.quantumrules.nl>. To answer questions within a puzzle, players collect their results of the morning's practical experiments, gather information objects hidden in the lab, and do additional practical tests. Questions are of the multiple choice or open type. The students post all information items on the game wall (Fig. 1) and discuss their findings with the game master, who records a grade for each answer.



Fig. 1. The game wall with five questions (yellow, red, green, orange and blue), behind students experimenting in the *Quantum Rules!* environment.

Research

Research question: How does the *Quantum Rules!* lab and game experience contribute to visiting students' perceptions regarding the importance of quantum science and technology and their knowledge of how quantum technology is already part of everyday life?

Research method: We asked students from schools visiting this March and April to fill out surveys to obtain quantitative data. Participants will fill out these questionnaires before and after the visit (pre- and post-tests). The quantitative data from the Likert-type and Semantic-Difference scale questions in the questionnaire are analysed in MATLAB, using the paired t-test.

As a base for the survey, the questionnaire created by Kennedy, Quinn & Taylor (2016) is used. Using exploratory factor analysis, they showed a categorisation in secondary school students' attitude towards school science. Using this division into four uni-dimensional (enjoyment, intention, difficulty and self-efficacy) and two two-dimensional categories (relevance and usefulness) [2], an attitude change within a certain direction is obtained by comparing the pre- and post- attitude factors (averages) using a paired t-test.

We have successfully obtained valid data from 77 respondents, i.e. visiting secondary school students. At 4WCPE we'll report on the significance of our data and discuss the expected improvement of the students' perception compared to results in [1], when the serious game was not yet in place.

References

- [1] T. S. Moraga-Calderón, H. Buisman, J. Cramer, The relevance of learning quantum physics from the perspective of the secondary school student: A case study, *European J. of Sci. Math. Ed.* **8** (2020) 32-50. <https://doi.org/10.30935/scimath/9545>
- [2] J. P. Kennedy, F. Quinn, N. Taylor. The school science attitude survey: a new instrument for measuring attitudes towards school science. *International Journal of Research & Method in Education* **39** (2016) 422-445. <https://doi.org/10.1080/1743727X.2016.1160046>