Diving into Quantum Physics: Challenging the Constraints of Knowledge Transfer Through Engaging School Lab Units

Manuel SCHLEICHER (1), Olaf KREY (1), Marietta MENNER (2), Julia THURNER-IRMLER (2)

(1) University of Augsburg, Institute of Physics, Universitätsstraße 2, 86159 Augsburg, Germany
(2) University of Augsburg, Application Center for Materials and Environmental Research, Universitätsstraße 2, 86159 Augsburg, Germany

Abstract. The following contribution is part of the outreach project of the Transregional Collaborative Research Center (TRR360) that revolves around Constrained Quantum Matter (ConQuMat). To shed light on quantum physics and inspire curiosity among young minds we create three interactive and engaging school lab units bridging the gap between school physics knowledge and high-end quantum matter research. With our first School Lab Unit conducted in the DLR_School_Lab at the University of Augsburg we aim to broaden the students understanding of magnetism. The unit-structure and our evaluation priorities are outlined. First results will be added for our poster presentation at the conference.

Motivation

Quantum physics drives modern technology, from quantum computers to magnetic resonance imaging (MRI) machines, offering transformative breakthroughs in various fields. Bridging the gap of public knowledge and the rapidly evolving quantum research is essential for fostering scientific literacy and preparing an appropriately/fittingly skilled workforce [1]. The focus of the TRR360 research project is on the physics underlining quantum technology. Solid-state quantum phenomena like magnetic band topology, entangled states of matter and non-equilibrium dynamics. The research center consists of various institutes with the university of Augsburg in a/the leading position. The main objective of the outreach team is to spread the regional progress in quantum science to the outside world. For that, however, we need to bridge the gap between school knowledge and the basic concepts needed to understand quantum matter research. The principles of quantum physics are often counter-intuitive, and the mathematical description requires extraordinary math skills. The challenge of this work is to identify typical learning difficulties and to find a comprehensible way of teaching these advanced topics. The acceptance and value of new learned information will be evaluated as it is vital for sustainable learning [2].

School Lab Units

To make quantum matter research accessible, we develop school lab units suitable for enriching public school physics instruction. The development process will involve creating three distinct units tailored to different grade levels (Unit 1: grades 7/8, 13-14 years old (going beyond ferromagnetism), Unit 2: grades 9/10, 15-16 years old (focusing on analytical instruments used in quantum matter research, e.g. AFM), Unit 3: grades 11/12/13, 17-19 years old (basic concepts of quantum matter physics)).

Unit 1 moves beyond the basic high school curriculum concepts of magnetism, laying the ground for more complex quantum principles. To connect students' knowledge with advanced research, in a first step we must guide them from the elementary magnet model of ferromagnetism to understanding more complex magnetic types like antiferromagnetism. Unit 1 is planned as a half day activity, structured as follows:

- *Introduction and Motivation:* Setting the stage by activating prior knowledge, elucidating the significance of magnetism in nature and technology, and outlining the unit's objectives.
- *Ferromagnetism:* (Re-)Activate basic knowledge about ferromagnetism, showcasing examples and applications, and incorporating active elements like experiments or games.
- *Introduction of an "Arrow Model",* in which arrows are used to represent magnetic "units": Comparing elementary magnets model with the new model, emphasizing the arrow model's advantages and its ability to describe magnetic behaviour on a microscopic level.
- *Crystal Lattice and Magnetism:* Exploring the relationship between crystal lattice structures and magnetism, highlighting periodicity in solid materials.
- *Paramagnetism, Diamagnetism, and Antiferromagnetism:* Introducing concepts of non-magnetism, elucidating energy concepts, and providing real-world applications such as magnetic levitation trains.
- *Summary and Discussion:* Recapitulation of key concepts, stimulating open dialogue, and emphasizing the diverse applications and career opportunities.
- *Conclusion:* Wrapping up with a summary of learning objectives and an outlook on further School_Lab units.

To evaluate the success of the School Lab Units interviews of individual students with questions relating the acceptance [3] and the comprehension of the new counter intuitive concepts are implemented. With the iteration of the evaluation cycle the typical learning difficulties of the students can be targeted to improve the units. This iterative process will allow us to fine-tune the units based on feedback from both students and teachers, ensuring that they are engaging, effective, and aligned with educational objectives. Furthermore, by providing teachers with comprehensive teaching material and training on how to effectively implement the units in their classrooms, we aim to amplify the impact of our educational initiatives.

Summary and Outlook

In summary, by developing engaging and inclusive School Lab units, we hope to inspire the next generation of scientists. Through ongoing collaboration with teachers, students, and researchers, we are committed to advancing STEM education and promoting diversity in the field of physics. An iterative development approach will be adopted with multiple cycles of implementation, evaluation, and refinement. *As the project just launched, we are currently in unit development. The poster in Kraków will display the then revised version of School Lab Unit 1, the planned evaluation and first interview-based results concerning students' acceptance.*

References

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