Inhaltsangabe

In dieser Arbeit wurde ein Lehr-Lern-Labor zum Thema der Radioaktivität unter der Perspektive der didaktischen Rekonstruktion entwickelt und die Perspektive der Lehrenden in die didaktische Rekonstruktion als weiterer theoretischer Baustein einbezogen. Dabei stellt sich die Frage, welche Vorstellungen Lehramtsstudierende nach dem Studium der Kernphysik im Themenbereich „Radioaktivität“ haben.

Die didaktische Rekonstruktion des Themas Radioaktivität erfordert die Untersuchung von kernphysikalischen Bezügen, wie Kernreaktionen, Kernspaltungen und Kernzerfällen. Die Thematisierung von z.B. der Neutronenstrahlung und der Kernspaltung spielen eine wichtige Rolle bei der Anwendung auf alltagsnahe Kontexte. Die Interviews in dieser Arbeit wurden mit Lehramtsstudierenden der Universität Stuttgart und der Friedrich-Schiller-Universität Jena durchgeführt, um ihre Vorstellungen über Radioaktivität zu untersuchen ($N = 13$).

Die Ergebnisse zeigen, dass die Studierenden teilweise Schwierigkeiten haben, zwischen radioaktiver Materie und ionisierender Strahlung zu unterscheiden und die Prozesse der Kernspaltung und Kernzerfälle unzureichend differenzieren. Es konnte dabei identifiziert werden, dass das Konzept der Energie als Koordinationsklasse bei der Beschreibung von Radioaktivität genutzt wird. Es ergeben sich damit auch Konsequenzen für die fachliche und fachdidaktische Lehre in denen die Vorstellungen von Studierenden stärker repräsentiert sein müssen.

Im Rahmen der Entwicklung des Lehr-Lern-Labors wurden Materialien für Schüler entwickelt, die im schulischen Alltag integrierbar sind. Der außerschulische Lernort wird von Schülern als anspruchsvoll wahrgenommen. Das Lehr-Lern-Labor stellt einen attraktiven außerschulischen Lernort für die Metropolregion dar. Derzeit ist die Betreuung des Lehr-Lern-Labors für Studierende ein

Pilotangebot, das noch nicht in einem Modulkatalog verankert ist. Um das Programm im Lehramtsstudium zu verstetigen, ist es notwendig, einen geeigneten Rahmen für die Einbeziehung des Lehr-Lern-Labors als Teil einer Lehrveranstaltung zu finden.

Summary

Society's attitude toward physics or the natural sciences is essentially shaped by the technological achievements associated with them. In contrast, to this general recognition is the ability to describe the underlying physical effects appropriately. This generalized description applies in particular to nuclear physics. The beginning of the atomic age can be traced to the discovery of nuclear fission and the subsequent Manhattan Project. The release of these massive amounts of energy increasingly spurred the civilian use of nuclear energy, which led to a veritable nuclear euphoria. However, accidents and catastrophes such as Chernobyl in 1986 led to a change in thinking, at least in German-speaking countries. In the 21st century, the application of nuclear technologies in Germany, which include research reactors or medical applications, is met with resistance in large parts of society.

Many of the typical experiments on radioactivity can no longer be carried out in schools due to various factors, including legal framework requirements and weaknesses in funding. This represents a central issue for the development of teaching-learning laboratories regarding radioactivity. The establishment of such an offer promises to bring universities and schools together and, if they are teaching-learning laboratories, make a suitable contribution to the early practical orientation of pre-service teachers. In this work, a teaching-learning laboratory on the topic of radioactivity was developed from the perspective of the model of educational reconstruction. Given that pre-service teachers may hold their own conceptions of topics related to radioactivity, part of this study also included the investigation of these conceptions using guided interviews and qualitative content analysis. The perspectives of the pre-service teachers elucidated by this investigation were then included in the educational reconstruction model as a further theoretical building block that in turn aided in the development of the teaching-learning lab.

The educational reconstruction of the topic of radioactivity requires the investigation of references to nuclear physics, such as nuclear reactions, nuclear fission, and nuclear decays. The subjects of neutron radiation and nuclear fission, for example, play an essential role in the application to contexts close to everyday teaching. In the context of the technical clarification, however, the factual links between the range of the radiation, the interaction processes, and their occurrence could be described qualitatively and, in far-reaching approaches, also quantitatively. Although this is not required from a school perspective about the design of the teaching-learning laboratory, it does provide teachers with an appropriate basis for reflection. The clear separation of the concepts of nuclear reaction, nuclear fission, and nuclear decay is not a purely linguistic problem but is associated with ideas that require an initially phenomenological description. The separation of the terms is done along the kinetic consideration of the respective processes and the inclusion of neutron radiation as a typical type of ionizing radiation.

Laying the foundation for conceptual change is a central goal of physics education. Research has shown that high school students hold specific conceptions about radioactivity (Alsop, 2001; Boyes & Stanisstreet, 1994; Colclough et al., 2011; Cooper et al., 2003; Eijkelhof, 1990; Henriksen, 1996; Prather, 2005; Riesch & Westphal, 1975). Fundamental to commonly held conceptions is the conflation of radioactive matter with ionizing radiation (Eijkelhof, 1990; Riesch & Westphal, 1975). Further, high school students often fail to distinguish between ionizing and non-ionizing radiation (Eijkelhof, 1990; Riesch & Westphal, 1975). The ideas that school students hold about radioactivity are well described in the literature. However, this is not the case for pre-service teachers. To bridge this knowledge gap, we conducted a semi-structured, problem-centered interview study using four different prompts addressing the penetrating ability of ionizing radiation, food irradiation, radiopharmaceuticals, and nuclear power. We transcribed the interviews following the content-oriented semantic orientation of Dresing and Pehl with slight modifications (Dresing & Pehl, 2015). The interviews in this work were conducted with pre-service teachers from the University of Stuttgart and the Friedrich Schiller University of Jena to investigate their ideas about radioactivity ($N = 13$).

According to the conceptions observed, pre-service teachers differentiated in part inadequately between radioactive matter and ionizing radiation. Some also failed to distinguish sufficiently between the processes of nuclear fission and nuclear decay. As a result, pre-service teachers misused central elements of neutron-induced nuclear fission in terms of the processes that occur. The concepts of energy and size guided their concept of the interaction of ionizing radiation with matter. This leads to a naive, geometric understanding of the effective cross-section, which was extended by the reference to interactions. Their knowledge of the effect of ionizing radiation on biological structures was based on the damage the energy input of this type of radiation does to hereditary information, which is therefore connected to the concept of energy. A small proportion described the effect as a stochastic phenomenon. The destruction of organs or genetic information was said to be a direct process or input of energy in the context of the student's ideas. The results show that the students need help distinguishing between radioactive matter and ionizing radiation and insufficiently differentiate the processes of nuclear fission and decay. Further, we identified that energy is used as a coordination class in the description of radioactivity. This has consequences for the subject-specific and educational courses in which students' conceptions require stronger representation. The poor understanding of the effective cross-section exemplifies this importance for nuclear physics courses. Although these concepts were the subject of the nuclear physics courses attended by the pre-service teachers interviewed, pre-service teachers still have only a simplified, geometric image.

As part of the development of the teaching-learning laboratory, materials for students were developed that can be integrated into everyday school life. The teaching-learning laboratory is perceived as a challenging yet attractive extracurricular place of learning for the metropolitan region. Currently, supervision of the teaching-learning lab for students is a pilot offering that has yet to be incorporated into a course module catalog. To make the program permanent in the teacher-training program, it is necessary to find a suitable framework for including the teaching-learning lab as part of a course program.

The ideas that were collected during the qualitative content analysis of guideline structured interviews were enriched by their cross-reference to an energy

concept. Therefore, the aim of the following investigations must be to collect conceptions for more prominent or representative groups. This applies to pre-service teachers as well as to active teachers and their students, whose conceptions must all be investigated to replicate or verify the results or working hypotheses presented here. Furthermore, the importance of interdisciplinary concepts and their associated ideas applies to other complex subject areas (e.g. climate change), which makes the methodology used seem suitable for tapping into these. In addition to describing the conceptions, it is worth investigating whether and how the conceptions change because of the learning opportunity offered by the teaching-learning laboratory. An intervention study could be conducted as part of a pre-post design.