Nuclear astrophysics masterclasses as an interest-promoting learning environment

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Abstract. Masterclasses are one-day outreach events for high school students, introducing them to topics of current research. Within the ChETEC-INFRA project, Masterclasses on Nuclear Astrophysics were developed. This interdisciplinary field of science provides a new didactic perspective on nuclear physics and astrophysics by addressing the link between these subjects. The Masterclasses pick up this didactic potential. They include the reconstruction of processes behind the nucleosynthesis with the help of gamification elements and the analysis of scientific data. The masterclasses are evaluated with questionnaires in a pre- and post-design to investigate the potential of promoting interest in the subject of nuclear astrophysics.

Introduction

The ChETEC-INFRA nuclear astrophysics masterclasses represent an attempt to prepare a (particularly due to its interdisciplinary nature) complex physics subject for Secondary Grade. The subject matter itself offers enormous didactic potential due to its topicality, the possibility of addressing nature-of-science aspects and the opportunity to offer a new and more fundamental approach to nuclear physics compared to most European curricula. Based on the person-object theory of interest (Krapp et. al, 2002), the promotion of interest through the masterclasses will be investigated, whereby the investigations will focus on the influence of the learning dimension of the learning content - specifically the promotion of students' interest through an examination of nuclear astrophysics.

Nuclear Astrophysics Masterclasses

The Nuclear astrophysics masterclasses are an attempt to prepare a complex physical subject area (especially due to its interdisciplinary nature) at Secondary Grade level. In particular, they deal with nucleosynthesis, from the formation of chemical elements through nuclear fusion to neutron capture processes taking place in supernovae and primordial nucleosynthesis. The masterclasses were developed using a design-based research approach and focus heavily on various gamification elements. Multiple learning games were implemented and designed based on the principles of Zichermann & Cunningham, 2011. Special emphasis is placed on the treatment of current research questions, which are dealt with by analysing current scientific data.

First Masterclass: A journey through the elements

The first masterclass focuses on access to nuclear astrophysics via the investigation of nuclear reactions in accelerator laboratories. In the data analysis, gamma spectra of a nuclear reaction, which is assumed to be a relevant neutron sources in s-processes, is examined. The data used is a spectrum of the $^{14}\mathrm{N}(\alpha,\gamma)^{18}\mathrm{F}$ reaction and was provided by the Felsenkeller underground ion accelerator laboratory, Dresden.

Second Masterclass: Fingerprints of the stars

The second masterclass focuses on access to nuclear astrophysics via the investigation of stellar spectra. Lithium abundances in stars with low metallicity will be measured in order to reconstruct the primordial lithium problem. Spectra recorded with the Very Large Telescope, FLAMES Spectrograph were used for the data analysis (Korn et al., 2007).

Research question and method

The evaluation examines the influence of participation in the masterclass on the participants' interest in physics. Three dimensions are considered separately: The learning content, the context of the topic as well as the learning methods and activities. The research questions are:

1. Is students' interest in physics encouraged by participating in the Masterclass?
2. Can effects be observed that can be derived specifically from the subject of nuclear astrophysics?
3. Which activities contribute to a motivating engagement with the subject of learning?

To measure changes in the students' interests the evaluation study is separated in a pre- and post-design, meaning that the participants were evaluated at the beginning and at the end of the Masterclass. The questionnaires are structured according to stable interest variables (interest in physics as a subject, interest in physics as a profession and the self-concept), changeable variables that focus on the special interest in nuclear astrophysics (divided into nuclear physics interest and astrophysics/cosmology interest) and the perception of the activities. For the questionnaires items with a 4-point Likert scale are used. The evaluation is currently being carried out on the basis of the two masterclasses developed to date. So far, 86 students from six different German school classes have been surveyed. The results indicate an increase in the specific interest in astrophysics as well as a motivating influence of the gamification elements. The evaluation will be continued to enable comparability of the results from the two different masterclasses in the future. It is to be expected that the studies to date will only demonstrate short-term effects. The question of long-term effects will be the subject of future studies, which will extend the evaluation to include a follow-up design.

References

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