Comparing prior knowledge of first-semester physics students between the cohorts of 2013 and 2023

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Abstract. University instructors often recognize lacking prior knowledge in incoming first-semester physics students. In this study, we refined the 1978 national study entrance test (SET, [1]) to assess the physics dispositions of first-semester students and compared two cohorts of first-semester physics students: 2013 and 2023. Our findings reveal a small improvement in physics dispositions (i.e. prior knowledge) nationwide between the cohorts of 2013 ($N = 2251$) and 2023 ($N = 2007$). In 2023 students performed better on items focusing on physics literacy compared to more traditional items focusing on declarative knowledge of facts or standard calculation routines.

Introduction

With PISA, many countries introduced and reoriented their education systems towards literacy. In particular, in STEM subjects such as physics, high schools changed from a predominant training of specialists to scientific literacy (see e.g. [2]). In contrast to these fundamental changes in schools, universities and the tertiary sector generally still focus on a specialization in one field. This gap between prior literacy and the required knowledge for a university program often leads to hugh challenges for incoming physics students. University teachers often attribute these challenges to decreasing prior knowledge. Contrary to the perception of university teachers [3], studies show that current students are not losing skills, but they are moving towards a different knowledge [4]. It is thus necessary for university teachers to be aware of the prior knowledge and literacy skills incoming students have when they enter university. The present study therefore investigates changes in prior knowledge using samples of two different national physics entrance tests in Germany addressing the question: How does the prior knowledge of current (2023) first-year physics students differ from that of a previous cohort (2013)?

Method

The sample

The present study is based on a previous study which compared the cohorts of 1978 and 2013 [4]. The cohort of 2013 (2023) consists of $N = 2251$ (2007) students from $N_{\mathrm{Uni}} = 27\ (34)$ German universities. All students were enrolled in introductory physics courses. The cohorts are comparable in terms of demographic characteristics such as the distribution of students enrolled in physics major vs. physics teacher education programs (see [4]).

The instrument

The cohort of 2013 was assessed with the 1978 study entrance test (SET) ([1]). Considering the changes that emerged in the German educational system after PISA, it was necessary to adapt the SET for the 2023 cohort. The current version includes two types of items. First, we reused items from the SET of 1978 which focused on declarative knowledge (such as defining "density") and standard routines (such as calculating the velocity of a falling object using energy conservation). Second, we used items that include more advanced skills, such as scientific reasoning, dealing with diagrams in kinematics, measurement uncertainties, or the control-of-variable-strategy (e.g. [5]). All items were validated by lecturers from more than 40 German universities.

Results

Figure 1 displays the relative solution frequencies (rsf) of (a) items applied in only the 2013 cohort ("old items"), (b) items employed in both cohorts ("anchor items"), and (c) those employed in only the 2023 cohort ("new items"). Comparing the anchor items used in 2013 and 2023 a Mann-Whitney U-test showed that the mean sum score differed significantly between the two cohorts, but the difference is only of small effect size (U= 44518, p < .001, d = 0.20, $M_{2013} = 5.64, M_{2023} = 6.45$). Thus, 2023 students performed slightly better on the test than 2013 students.

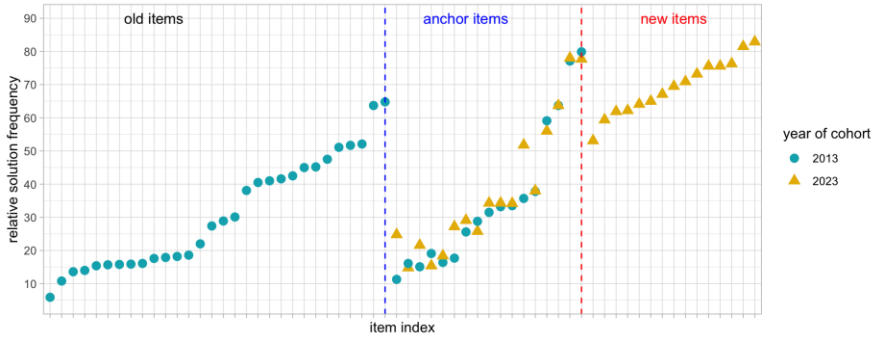

Fig. 1. Relative solution frequency of all items used in 2013 (old and anchored items) and 2023 (anchored and new items).

Furthermore, a Mann-Whitney U-test of the rsf between anchor items and new items in the cohort of 2023 indicated a significant difference with large effect size (U = 1815962, p < .001, d = 2.09, $M_{\text{anchor}} = 6.45, M_{\text{new}} = 13.11$). Thus, 2023 students performed better on items addressing advanced skills than declarative knowledge and standard routines.

Discussion and Conclusion

Overall, there is evidence of differences in prior knowledge between the 2013 and 2023 cohorts, with the 2023 cohort performing slightly better. Contrary to the perceptions of university teachers and in line with prior research ([3,4]), we did not find evidence of decreasing knowledge but rather an increase in physics prior knowledge and a shift towards literacy. Further research will be conducted on the predictive power of different facets of physics prior knowledge and literacy.

References

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