The first results from the TIMSS Advanced 1995 specialized physics test repeated among Czech gymnasium students in 2023

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Abstract. After almost 30 years, we repeatedly administered the TIMSS Advanced 1995 specialized physics test to final-year students of gymnasiums in the Czech Republic. In 1995, 819 students from 90 gymnasiums participated; in 2023, the sample consisted of 1602 students from 73 gymnasiums. We compared the overall mean physics achievement, the mean achievement of males and females, and the mean achievement in the physics content areas between 1995 and 2023. We analysed changes in individual answer categories for open-ended items. A significant decrease in the mean achievement of the students in the physics test compared to 1995 was observed.

Introduction and theoretical framework

A year ago, we presented the repetition of the TIMSS Advanced 1995 physics test in the Czech Republic [1]. In Czechia, there is no uniform final exam in physics at the end of secondary school, so we do not have objective information on what students take away from the study of physics [2].

In 1995, for the first and last time the Czech Republic participated in TIMSS Advanced. Participating countries could test subgroups of final-year secondary school students who have studied more demanding mathematics lessons and physics courses. In the Czech Republic, it was the subpopulation of four-year gymnasium students in the final year of study.

The two-stage sample design ensured the same probability of selection for each student [3], a cluster-based design of the tests enabled to test a wider spectrum of knowledge and applications.

Three test booklets with physics items were created and consisted of multiple-choice, short-answer, and extended-response items. Open-ended items were scored using a two-digit coding scheme [4]. The items were based on curriculum frameworks [5].

Our main goal was to compare the mean achievement in the physics test between 1995 and 2023. Furthermore, we were interested in the changes in mean achievement for males and females, and we also looked at the changes in mean achievement in individual physics content areas.

Since 1995, the Czech secondary school physics education and the time allotment for physics have not fundamentally changed. Before testing in 2023, we verified that the students had the opportunity to acquire the physics knowledge needed to successfully solve the test items.

Methodology and findings

Data collection was carried out from February to March 2023. The form of testing was paper-based, and we used the original physics test booklets from 1995. Of the original 90 schools from 1995, 72 schools participated in repeated physics testing, and another 10 schools participated as replacement schools. In our contribution, we present the results for the year 2023 based on a corrected sample of 1602 students from 73 gymnasiums.

The statistical significance of the differences in mean achievement was evaluated using the t-test for two independent samples. The substantive significance of the differences was determined using Cohen's d. We named the effect sizes using the recommendations given by Cohen [6].

Of 64 analysed test items, 24 were items with an open-ended response. In 15 of these 24 items, the decrease in mean achievement was not caused by an increase in the proportion of incorrect answers. On the contrary, the proportion of missing answers increased significantly for these tasks.

Table 1. Comparison of Physics Achievement

Mean	TIMSS Advanced 1995		TIMSS Advanced 2023		p-value	Cohen's d
	original	corrected[1]	original	corrected[1]		
Overall in the test	38.6 %	38.6 %	30.8 %	30.8 %	< 0.001	0.53
Females	30.5 %	34.2 %	27.9 %	27.9 %	< 0.001	0.51
Males	42.3 %	45.5 %	35.3 %	35.3 %	< 0.001	0.63
Mechanics	44.8 %	44.8 %	32.3 %	32.3 %	< 0.001	0.52
Electricity and Magnetism	36.4 %	36.4 %	30.7 %	30.7 %	< 0.001	0.30
Heat	39.7 %	39.7 %	27.0 %	27.0 %	< 0.001	0.46
Wave Phenomena	40.0 %	40.0 %	32.9 %	32.9 %	< 0.001	0.30
Modern Physics	34.8 %	34.8 %	32.0 %	32.0 %	0.003	0.12

Discussion and conclusions

The statistical significance test results showed a significant decrease in the mean achievement of the students in the TIMSS Advanced physics test compared to 1995. The drop in mean achievement was more significant for males than for females. Student performance decreased the most in items from the area of mechanics. The decrease in student achievement in open-ended items was mainly due to the omission of answers. The median of missing answers to open-ended items from 1995 arose from a value of approximately 28.5 % to a value of 51.0 % in 2023.

It is obvious that the results of this research will be of interest primarily to the national investigators. However, the physics testing that we repeated is a proof that it is possible to continue working with the detailed and precise methodology of international studies. It can also be used on a smaller scale by local organizations to collect unique data, especially in countries that no longer participate in international surveys. We plan to analyse our data deeply using the IRT method.

Acknowledgments

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References

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[1] Since, as a result of the cluster-based test design, different groups of students were assigned different sets of items. We introduced the 'corrected mean', computed from the original mean by correction to the so-called average student.