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Astronomy through Continents

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Abstract. We present recommendations for teachers and educators of science, based on the results of a survey carried out among secondary-school students from Poland, Australia, and the USA.

Keywords. Educational techniques, Project Method, sociology of science

The wealth, development, and security of each country depend to a large extent on their education systems. Those systems should be based on education curricula that are created in accordance with requirements of the present world, the changes of educational techniques, and the needs of a given society.

In order to shed light on educational needs of nowadays societies, we conducted a survey aiming at evaluation of the level of basic astronomical knowledge and understanding of fundamental astronomical concepts of secondary-school students (see Molenda-Żakowicz & Kołmański (2019)). We strove to formulate recommendations for teachers and educators which might be used for modifications of current educational curricula.

The survey was carried out in 2018 and 2019, among secondary-school students from Poland, Australia, and the USA. It had form of a questionnaire consisting of 20 test-sentences which covered basic astronomical knowledge that might be expected from a secondary-school alumnus. Those test-sentences had to be verified as true or false, however, it was possible to tick an 'I do not know' answer. Each correct verification was 1 point; the maximum score was 20 points. The questioned students provided also some additional information on their gender, the profile of education (STEM or no-STEM), the name of the city where they go to school, and their interest in astronomy.

Table 3 contains information on the number of the total ($N_{\rm tot}$), male ($N_{\rm male}$), and female ($N_{\rm female}$) students surveyed in each country, as well as on their mean, median, minimum, and maximum score. Since not all students provided information on their gender, $N_{\rm male}$ and $N_{\rm female}$ do not necessarily sum up to $N_{\rm tot}$.

We found that scores of Polish secondary-school students are noticeably worse than scores of their peers from the two other analysed countries. First, they are significantly lower, especially when compared to Australia. Second, in the Polish sample there is a much higher difference between scores gained by male and female or STEM and no-STEM students. The mean score of Polish male students is 2.4 points higher than the score of females while in Australia and the USA the respective differences are just 1.4 and 0.8 points. The mean score of Polish STEM students is 2.5 more points higher than the score of no-STEM peers while in Australia and the USA the respective differences are only 0.2 and 2.0 points. We observed also that Polish students from big cities gain significantly

Table 1. Basic statistics and scores.

Country	N_{tot} (N_{male}/N_{female})	Mean	Median	Minimum	Maximum
Australia	28 (21/6)	15.86	16	8	20
Poland	1212 (522/664)	11.76	12	3	20
USA	49 (31/18)	12.45	13	4	19

higher scores than those from medium-size and small cities (in Australia and the USA there were no comparison groups.) Finally, we found that Polish students declare much less interest in astronomy comparing to their peers from the other countries†.

The analysed data shows that the reported scores are closely related to the degree of prominence of astronomical knowledge in different societies. Since that prominence is being formed in the process of socialisation that starts in early childhood, the observed differences in scores reflect various social inequalities. Another issue worthy of consideration is the fact that the strong technological aspect of contemporary astronomical investigation disrupts links between the creator (an astronomer) and the piece of their work (a scientific discovery). That increases the divergence of the 'objective' and 'subjective' culture defined by Simmel (2005), lessens the degree of prominence of science, and enhances magical thinking (here: astronomy vs. astrology) in different societies. As a consequence, the current model of education, oriented on applied sciences and analysis of a process, and marginalising the basic sciences, may result in devaluation of fundamental scientific knowledge and predictions.

To remedy the situation, we recommend the teachers and educators to take into account in the process of education the differences in socialisation of the social roles of male and female scientists, and a generally lower degree of prominence of astronomy in small towns. In our opinion, the formal education needs to acknowledge the Project Method of teaching, in which observations should forerun analysis (see, e.g., Kołomański & Molenda–Żakowicz (2020)). Different results obtained in the framework of a project should be always assigned to respective individuals. Students should understand the whole process of the experiment and analysis, and see their own contribution. That formal education should be supported by pre-emptive teaching in a form of, for example, songs or educational games for kids, which can be started at the age of 2 or 4. Finally, the practical aspects of astronomical knowledge should not be unduly emphasised. Instead, astronomy should be presented as one of the essential sciences needed for proper understanding of fundamental physical concepts, including time, space, and the humanity's place in the Universe understood in the broadest possible sense.

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† The reported differences in scores have not been affected by the differences between analysed samples, i.e., the sample size, the profile of education or the city size (Kruskal-Wallis test, $p < 0.01$).

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