Level of scientific reasoning of university students and grammar school pupils

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Abstract. Level of scientific reasoning was measured using the Lawson test of scientific reasoning for 1st-year students entering the Faculty of Science at Palacký University in Olomouc and 3rd-year pupils in grammar school in Czechia. Besides the standard item and test characteristics, we also identified possible factors affecting the scores. We tested five hypotheses based on sex of the examinees, field of study at university and grammar school, year of testing comparison of scores between university students and grammar school pupils.

Introduction

Scientific literacy is in our modern times gaining increasingly high attention from education and governments likewise. For 21st century citizens it is an ability that can affect and determine their future employment especially in science, technology, engineering or mathematics. One of its parts is scientific reasoning which represents the cognitive skills necessary to understand and evaluate scientific information, which often involves understanding and evaluating theoretical, statistical, and causal hypotheses [1].

Therefore, mapping the level of scientific reasoning skills within a class or a course may be useful to reveal students have more difficulty in learning and may provide the information to develop an appropriate method which overcomes the pedagogical issues.

A well-known assessment instrument for assessing students' level of scientific reasoning was designed by Lawson in 1978 [2] and later improved by him in 2000 [3]. The assessment instrument named Lawson's Classroom Test of Scientific Reasoning (LCTSR) is a two-tier, multiple-choice test with 24 items. The LCTSR tests six dimensions including conservation of matter and volume, proportional reasoning, control of variables, probability reasoning, correlation reasoning, and hypothetical-deductive reasoning, all of which are crucial skills identified as necessary for a successful STEM career. According to the scores divided into three equal intervals, Lawson suggested classifying students into three formal reasoning categories: concrete operational (scoring up to 8 points, i.e., 33%), transitional (scoring between 9 and 16 points, i.e., 34% and 67%), and formal operational (scoring above 16 points, i.e., 67%). In our research, we used the LCTSR.

Since 2018 we have been collecting data on how developed scientific reasoning is among 1st year students at our faculty using the LCSTR. By analysing them we want to get a better understanding how to construct teaching at university level so we can increase the scientific reasoning of our students. Starting from year 2023 we have also extended our testing to grammar school pupils to get a better insight on how developed is scientific reasoning at grammar schools.

Methods and findings

Data from first-year university students at the Faculty of Science in Palacký University in Olomouc were collected between the years 2018 and 2023 comprising of $N_U = 825$ examinees. For grammar school pupils, we obtained data during the year 2023 and we tested classes which were two years before graduation. These classes were divided into pupils who were studying

four-year or eight-year grammar school programs. The number of tested grammar school pupils was equal to $N_G = 104$.

Besides the standard characteristics for test items and the whole test, we tried to verify four hypotheses:

H1: "Males score the same as females.",

H2: "Among tested university students the future science teachers reached a different level of scientific reasoning than students of technical study programs.",

H3: "University students have higher scores than grammar school pupils.",

H4: "University students have the same scores in each testing year.",

H5: "Pupils of eight-year grammar school program have higher scores than pupils of four-year program.".

All hypotheses were checked by the Mann-Whitney U test with a significance level $\alpha = 0.05$ and a two-sided t-test for identical means with the less strict assumption of different variances. We also studied the variability of the results in dependence on the year the students entered our university.

Conclusion

Scientific reasoning is an integral part of physics education. We used LCTSR to test the level of scientific reasoning of 1st-year university students at our Faculty of Science and 3rd-year grammar school pupils. On the obtained data we have tested five hypotheses. Results show that LCTSR is more accurate in the case of grammar school pupils than university students which is in accordance with [4].

References

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