BAK 2024 MODERN ASTRONOMY: FROM THE EARLY UNIVERSE TO EXOPLANETS AND BLACK HOLES
300 years Russian Academy of Sciences

Comparison of educational results in Astronomy for high school students in St. Petersburg

V. Grigoriev[1,2]

[1] Crimean Astrophysical Observatory, p. Nauchny, Bakhchisaray, Crimea, 298409 Russia
[2] Lyceum "Physical-Technical High School", 8-3A Hlopina St, Saint Petersburg, 194021 Russia

Abstract. During five academic years from 2018 to 2024, students in grades 10 and 11 of three different High Schools in St. Petersburg studied the subject of Astronomy as part of the school curriculum under the guidance of the author of this study. Teaching was conducted in 15 classes, each of which had at least 20 students. During this time, several approaches to educational process were used, but the methodology of academic achievements in this subject was carried out in the most identical way. This paper describes the approaches to educational process during the specified time, describes the methodology for measuring academic achievements. Based on this methodology, measurable educational results were obtained in the subject of Astronomy among students, an analysis of these results was carried out, features were identified, and a justification for differences in academic achievements was proposed.

Keywords: general: miscellaneous; interdisciplinary astronomy: astronomy education; educational sciences: academic performance

DOI: 10.26119/VAK2024.186

1 Introduction

During several academic years (2018-2021, 2022-2023), I conducted regular astronomy lessons for 11th grade students in three different educational institutions in St. Petersburg. In the 2023–2024 academic year, the astronomy course was also taught to 10th-grade students. The teaching methodology was slightly different, and the purpose of this study is to understand what educational results each method ultimately yields, possibly adjusted for the level of the educational organization. By educational results I mean the results of writing tests (control works CW-1 and CW-2), averaged by student groups and topics.

Various sources containing information on the comparison of homogeneous educational results were found, but first of all this concerns university students (Pogrebnikov et al. 2021), or predicts the academic performance of undergraduate students based on the results of the Unified State Exam in Russian (Zamkov & Peresetskiy 2013). It was not possible to find a comparison of the results of educational activities within one school, especially within one subject.

The three educational organizations (EOs) are: General education high school No. 564 (GEHS), Lyceum No. 366 with advanced study of physics and mathematics (PhML) and Lyceum Physical-Technical High School (PTHS).[1] In each of these EOs, I taught Astronomy in either two or three groups of senior students: 11A and 11B or 10A, 10B and 10C. Due to volume restrictions, not all details will be included here. It is recommended to read the entire article by clicking on the link.[2]

2 Approaches

In the 2018–21 (GEHS and PhML) school year, the astronomy course lasted two semesters. I was to give each student six grades per semester: five grades could be earned for work during the semester (homework, reports, participation in astronomy olympiads, CW preparation and other bonuses), the sixth grade — for the CW.

The contents of the Astronomy course was naturally divided into topics. The first quarter of academic year is Astrometry (coordinates on the celestial sphere, culminations, time). The second quarter was devoted to the Solar system and celestial mechanics (characteristics and motion of planets, configurations, cosmic velocities). Before the New Year vacation, there was the CW-1 on the material covered in the semester. The third quarter was focused on Astrophysics (stellar magnitudes, physics and evolution of stars, H-R diagram). The fourth quarter covered Galactic and Extragalactic astronomy. In the middle of May, the CW-2 on the material covered during

[1] http://school564.ru/, http://www.fml366.org/, http://www.school.ioffe.ru/
[2] https://vk.cc/cyxBgm

the semester took place. In the 2022–24 (PTSH only) academic years the course was shortened to one semester, so two assessment grades per semester were given for the CWs. The coursebook "Astronomy 10–11" by Charugin V.M. (2018) was used.

There were different approaches in different academic years:

- 2018–2019 —"Demanding approach". Self-solving tasks from the coursebook, additional series of problems, strict deadlines;
- 2019–2020 — "Mixed approach". A wide range of opportunities for receiving grades (assignments from the textbook or additional collection of problems, individual homework,[3] various bonuses), the only requirement is the number of grades;
- 2020–2021 — "Least demanding approach". The least stringent deadlines for tasks, the possibility of rewriting individual homeworks;
- 2022–2023 — as in the previous approach, but the course duration is only one semester, there are no coursebooks;
- 2023–2024 — as in the previous approach, but studying the course for the 10th grades and using coursebooks for writing CW-s only, not for homeworks (due to amount of coursebooks).

3 Methodology for evaluating educational results

I consider the results of writing CWs averaged by groups of students and by topics to be the main tool for evaluating the knowledge gained.

The CW format was identical throughout the academic years. The content variants were individual, each variant had 14 questions (one question per topic), each question had one correct answer out of four options. The first 10 questions were available for students to create on their own in preparation for the CW (this was another way to get a grade, and for me, an opportunity to quickly accumulate an extensive database of questions), questions 11 through 14 were created by me and were associated with images displayed on the screen during the CW. In my opinion, students' compilation of questions for the CW demonstrates their level of understanding the material remarkably well, even better than the CW itself. During the CW, the students were allowed to use their own notes, their coursebooks, their calculators (not smartphones), as well as reference data issued during the course.

However, in May 2019–2020, there was an exception: due to the forced distance learning at home, the CW-2 was also conducted in an online format with filling out a questionnaire (as an individual homework assignment), an astronomical hour was allocated for entering answers. In this regard, good work results could be expected.

[3] How to create homogeneous variants, see my speech https://youtu.be/6LqgrWe7rC8 (PIEF-2021)

The CW check was done automatically in MS Excel. Thus, the students knew their results on the same evening when they wrote the test. Since the students took the assignments after the CW, they had the opportunity to appeal their results. There were also successful appeals, since sometimes there were inaccuracies in the question, the answer was not recognized, the option number was forgotten, etc.

4 Results

The results are shown in the graphs below (see Fig. 1 and Fig. 2). The diagrams are divided by year and educational organization. It can be said that the higher the percentage of a topic, the better the relevant group understands it. The larger the area occupied by a single-color graph, the better the overall material is understood on average. The average percentage (see Fig. 3) and deviation for all topics for each group of students were calculated additionally.

In the case of CW-1 in GEHS, there are no fundamental differences in the results, except that 11A of 2019–2020 is a little out of the ordinary, perhaps this is the influence of the class tutor, or maybe they just managed to assemble a more "intellectual" class. In PhML in the 2019–2020 academic year, you can notice a real "sag" in the results in both classes, which may be due to a change in approach: the requirements have become less stringent. At the same time, in one of the classes, the results are even at the GEHS level. In the case of the 11th grades of PTSH, you can see that the results are generally at the PhML level, although a little worse. I think this is adequate, especially considering that only six months of study were allocated for the astronomy course instead of a year, and even without textbooks. When using textbooks in the 10th grades, the spread of results became smaller, and the quality of control remained the same.

The results of the CW-2 in the case of GEHS again do not demonstrate any significant change as a result of a change in methodology. The obvious outlier in the 2019–2020 academic year is explained by doing the CW at home at the computer (which makes it impossible to completely exclude the influence of communications) and, again, 11A performs clearly better than 11B, which probably indicates a greater number of clever students. I explain the lower results in the CW-2 than in the CW-1 on average in PhML by the fact that astrophysics, in its essence and content, differs significantly from what was studied in the first semester (for example, half of celestial mechanics is included in the physics course). In the case of PTSH, the results look quite even, in addition, 10th grade students with textbooks show better results than 11th grade students, and on average the same level of PhML. That is, in general, we

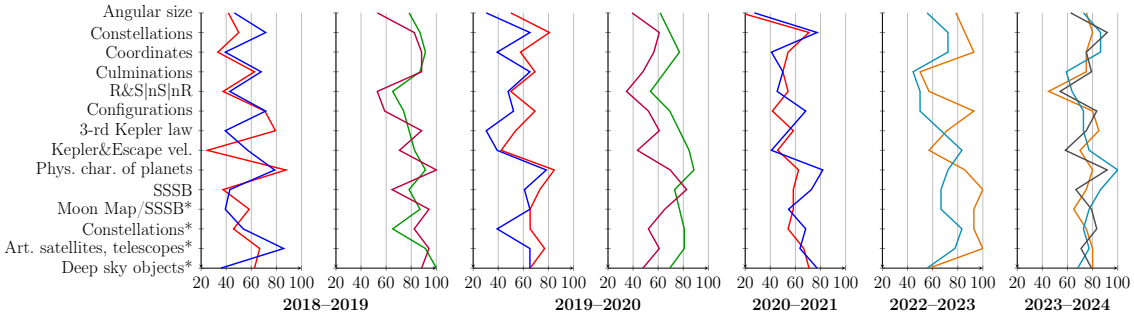

Fig. 1. The results of the CW-1: percentage of mastering a specific topic. Academic year is places under the specific plots. Groups are visualised with different colors: GEHS (11A, 11B), PhML (11A, 11B), PTHS (11A or 10A, 11B or 10B, 10C). Abbreviations used: R&S/nS/nR = star Rise and Set daily/star doesn't Set/star doesn't Rise, SSSB = Small Solar System bodies. Topics marked with * need an image.

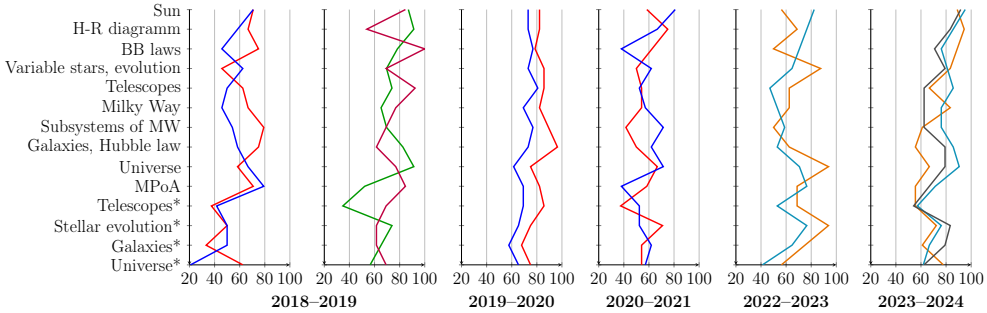

Fig. 2. The same as in Fig. 1, but for the CW-2. Abbreviations used: H-R diagramm = Hertzshprung–Russel diagramm, BB = Black body, MW = Milky Way, MPoA = Modern Problems of Astronomy. Topics marked with * need an image.

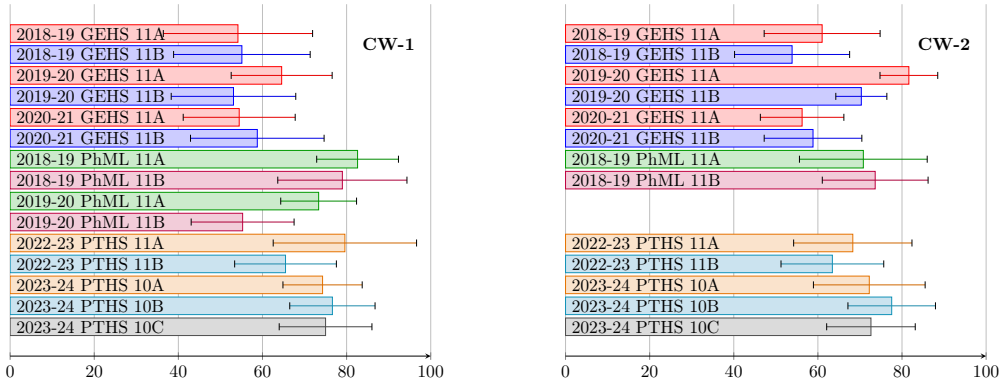

Fig. 3. Average percentage through all topics in CWs and its deviation.

can conclude that age has practically no effect on studying this course of Astronomy. In addition, the textbook itself is intended for study in grades 10–11.

5 Conclusions

As we can see, in PhML the results of the CWs are on average better than in GEHS. This is quite natural: astronomy is more understandable if you have a mathematical mindset, because there are many formulas, geometry is involved, etc. In the case of PTHS, the half-year course was mastered by students at the level of the annual course in PhML.

However, what is more interesting is that regardless of my approach to the teaching process, the results are on average the same, although in the case of PhML, perhaps the easing of the requirements leads to slightly worse results, but this cannot be said with certainty due to the incompleteness of the research in this EO. In addition, one can come to the obvious conclusion: having the opportunity to rely on the coursebook gives a better result than not having it.

References

Charugin V.M., 2018, Astronomy 10–11 grades: coursebook for general educational school: base level, ISBN 978-5-09-053903-6

Pogrebnikov A.K., Shestakov V.N., Yakunin Yu.Yu., 2021, Perspektivy nauki i obrazovania, 52, 4, p. 80

Zamkov O.O. and Peresetskiy A.A., 2013, Applied Econometrics, 30, 2, p. 93