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THE STUDY OF VARIABLE STARS WITHIN EXTRACURRICULAR ASTRONOMY ACTIVITIES

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This paper presents the impact of extracurricular astronomy activities, with a special focus on the study of variable stars, on the development of students' investigative competence. Involving 55 students from grades VI-XII in the Republic of Moldova, the extracurricular activities combined theory with practice, using modern technologies for astronomical observations and data analysis. The students were introduced to the use of astronomical equipment and software necessary for conducting detailed analyses of variable stars. The results showed a significant improvement in understanding and applying scientific concepts, as well as an increase in digital skills and critical thinking. The article highlights the value of interdisciplinarity and innovative approaches in scientific education, providing a valuable model for enhancing educational programs through practical activities and direct interactions with scientific phenomena.

Keywords*: astronomy, variable stars, extracurricular activities, astronomical observations, investigative competence, scientific education, interdisciplinarity.*

STUDIUL STELELOR VARIABILE ÎN CADRUL ACTIVITĂȚILOR EXTRAȘCOLARE DE ASTRONOMIE

Această lucrare prezintă impactul activităților extrașcolare de astronomie, cu un accent special pe studiul stelelor variabile, asupra dezvoltării competenței investigaționale a elevilor. Prin implicarea a 55 de elevi din clasele VI-XII din Republica Moldova, activitățile extrașcolare au combinat teoria cu practica, folosind tehnologii moderne pentru observații astronomice și analiza datelor. Elevii au fost inițiați în utilizarea echipamentelor astronomice și a softurilor necesare pentru a efectua analize detaliate ale stelelor variabile. Rezultatele au demonstrat o îmbunătățire semnificativă a înțelegerii și aplicării conceptelor științifice, precum și o creștere a competențelor digitale și a gândirii critice. Articolul subliniază valoarea interdisciplinarității și a abordărilor inovatoare în educația științifică, oferind un model valoros pentru îmbunătățirea programelor educaționale prin activități practice și interacțiuni directe cu fenomenele științifice.

Cuvinte-cheie*: astronomie, stele variabile, activități extrașcolare, observații astronomice, competență investigațională, educație științifică, interdisciplinaritate.*

Introduction

Astronomy is a fundamental science that not only reveals information about our vast and dynamic universe but also serves as a powerful educational tool, stimulating curiosity and inspiring critical thinking. Engaging students in the study of astronomy can have a profound impact on their perception of science and technology and can motivate students' future scientific career choices.

Variable stars are stars that change their brightness regularly or irregularly over periods of time due to physical processes occurring inside or on the surface of the star. There are also variable stars whose brightness changes due to the mutual eclipsing of two stars in a binary system or because of physical processes related to their rotation [8, p. 89].

Their study not only contributes to the understanding of the universe but can also stimulate interest in science and astronomy among students. Extracurricular activities provide a flexible and dynamic framework through which students can explore scientific subjects outside the standard curriculum.

These activities allow students to learn through investigation and to deepen their understanding of complex concepts and notions, such as those in astronomy, in a flexible and dynamic environment [7].

Astronomy extracurricular activities, which include astronomical observations and data analysis, offer

a practical and interactive learning experience, stimulating students' interest and involvement in scientific research.

The study of variable stars within these activities allows for the exploration of interdisciplinary connections, from physics and mathematics to information technology, presenting science in an integrative manner and promoting a holistic understanding of the world.

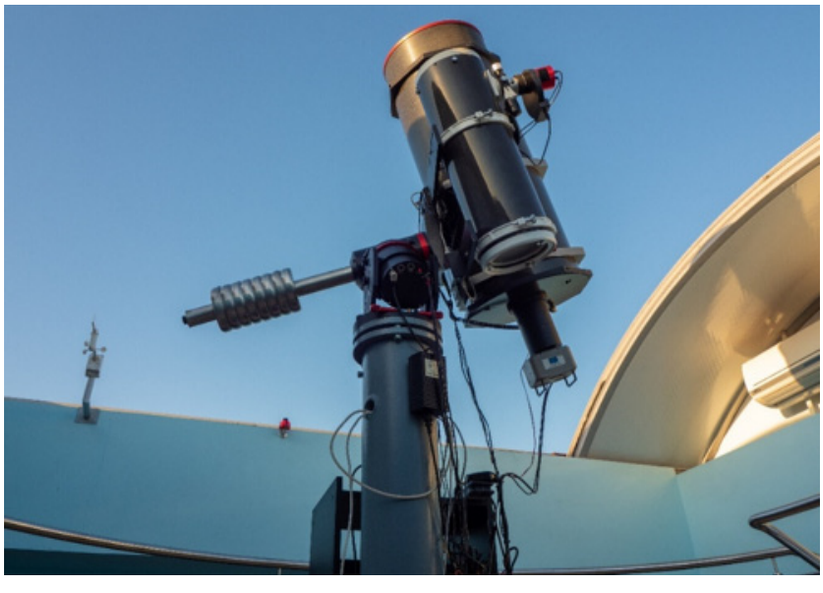
Furthermore, these activities can be an effective pedagogical tool for the development of students' investigative competence, providing an attractive alternative to traditional learning methods.

Methods and Materials

In the study of variable stars, 55 students from grades VI – XII, coming from different schools in the Republic of Moldova, were involved. These students formed the experimental group in a pedagogical experiment aimed at the formation of investigative competence, which took place from February to August 2023.

They were engaged in both theoretical and practical extracurricular astronomy activities, including the study of variable stars. All activities were conducted online within the Astronomical Observatory of the „Răsvan Angheluță” Natural Sciences Museum Complex in Galați, using Google Meet [5] and AnyDesk Remote Desktop applications [2] (Fig. 1.).

Fig. 1. The Astronomical Observatory of the „Răsvan Angheluță” Natural Sciences Museum Complex Galați.



Source: © O. Tercu

These applications facilitated the remote conduct of astronomical observations, as well as the reduction and analysis of scientific data by students. Within the theoretical component of the investigative competence training program, various courses were organized, including those focused on the classification and observation methods of variable stars. Throughout the practical activities, students were trained to use the astronomical observatory's equipment, including the telescope and the CCD camera. During the astronomical observation sessions, students acquired skills in selecting variable stars, using resources offered by The International Variable Star Index (VSX) webpage. They were also introduced to determining the optimal exposure time and configuring the CCD camera for acquiring uncalibrated images, using the MaxIm DL program [4].

An important component of the practical training included the calibration of images by applying master flat, master dark, and master bias frames, using the same program. During the practical activities, images from the database of the Galați Astronomical Observatory were used so that students could become familiar with using the AstroImageJ (AIJ) software for photometric data reduction [3]. They also learned to use the

Peranso [6] and VStar [1] programs for light curve analysis, including determining the period, epoch, and the minimum and maximum brightness of variable stars.

To facilitate independent investigations, students were given images from the astronomical observatory's database, which they could use utilizing AstroImageJ and VStar on their personal computers. The assessment of the knowledge, skills, habits, and abilities acquired by students in the study of variable stars was conducted through a research project. To accomplish this task, students were provided with images from the observatory's database, the title and structure of the project, as well as the necessary bibliography. The evaluation of these projects was carried out using the grades: „Very Good", „Good", „Satisfactory", and „Unsatisfactory".

Results and Discussions

During the extracurricular activities, students analyzed scientific data on variable stars. Table 1 presents some of the results obtained together with the students:

Table 1. Scientific results obtained during extracurricular activities.

Numele Stelei	Perioada (zile)	Epoca (HJD)	Minimul Luminozității	Maximul Luminozității
ASASSN-V J133717.40+653116.6	0.066858 +/- 0.005473	2459653.290	15.03 +/- 0.01 R	14.74 +/- 0.01 R
GSC 02456-00517	0.060258 +/- 0.008159	2459658.427	11.13 +/- 0.001 V	11.11 +/- 0.001 V
2MASS J23581334+5038031	0.125471 +/- 0.000082	2459100.295	11.26 +/- 0.005 V	11.20 +/- 0.006 V
2MASS J00004537+5857083	0.099553 +/- 0.000001	2459440.396	12.39 +/- 0.004 V	12.35 +/- 0.006 V

The analysis of light curves of variable stars highlighted the students' ability to apply theoretical knowledge in a practical context. Furthermore, the efficient use of software for data reduction and analysis emphasized the students' remarkable adaptability to modern research methods.

Extracurricular activities demonstrated the effectiveness of combining theory with practice in stimulating students' interest and investigative competence. The results obtained from these activities underline the importance of integrating technology and practical research into education. Through direct involvement in observations and analyses, students acquired not just scientific knowledge, but also developed critical thinking and problem-solving skills.

This approach can serve as a model for improving scientific educational programs in schools and universities. Extracurricular activities have proven their efficiency in achieving the goal of developing investigative competence as students have shown a significant increase in understanding of astronomy concepts as well as skills, abilities in using astronomical equipment, and software for the reduction and analysis of scientific data. Although extracurricular activities have yielded positive results, there are limitations in the Republic of Moldova related to students' access to equipment for conducting astronomical observations.

The necessary equipment, such as telescopes, CCD cameras, and other specialized instruments, can be costly and are not available in schools. Conducting remote astronomical observations requires a good internet connection and suitable IT equipment. Students in areas with poorly developed IT infrastructure or with limited access to high-speed internet may have difficulties in accessing and using remote telescopes. Additionally, it would be beneficial to explore ways in which these learning methods can be adapted to be more inclusive and accessible to a broader spectrum of students.

Extracurricular activities represent a significant step towards improving scientific education through practical and innovative activities, stimulating students' interest and competencies in general, and in the

field of astronomy in particular. In the research project, it was found that approximately 85% of the students achieved performance levels characterized by the grades of „Very Good” and „Good”, while about 15% of the students were evaluated with the grade of „Satisfactory”.

We observe that the majority of students (85%) have reached high levels of performance, which suggests a significant effectiveness of the pedagogical methodology adopted in the study of variable stars. The results obtained in the research projects reflect a high level of development of the students' investigative competence. The fact that a large proportion of students received grades of „Very Good” and „Good” highlights that they have acquired essential knowledge, capacities, abilities, and skills necessary for using the software required for the reduction and analysis of scientific data for the study of variable stars.

This demonstrates that the students were able to apply theoretical knowledge in a practical context, a crucial skill in the scientific field. There is a minority of 15% of students who received grades of „Satisfactory”. This indicates the need for a more differentiated approach within the investigative competence training program, which takes into account the various levels of understanding and abilities of the students. It may be important to explore additional support methods to help these students improve their performance.

The results obtained in the research projects suggest that the study of variable stars within the investigative competence training program was relevant and motivating for the majority of students. This is evidence of the importance of including practical activities and modern technology in the educational curriculum, especially in complex scientific fields such as astronomy.

Conclusions

The study of variable stars within extracurricular astronomy activities has shown a significant impact on the development of students' investigative competence. The educational program for the development of investigative competence provided not only a platform for enriching theoretical knowledge but also valuable opportunities for the practical application of this knowledge in the analysis of scientific data. The program's results indicate the effectiveness of the adopted pedagogical approach, highlighted by the fact that approximately 85% of students achieved high levels of performance.

This suggests that integrating practical and theoretical activities, along with the use of modern technology, is an effective strategy in stimulating students' interest and involvement in science. Students involved in this program have demonstrated a high level of investigative competence formation, acquiring knowledge, capacities, abilities, and skills for using the software necessary for the reduction and analysis of scientific data.

Their ability to apply theoretical knowledge in practical contexts underscores the success of this program. The presence of a minority of students (15%) with satisfactory performance highlights the need for a more differentiated pedagogical approach. This involves adjusting learning methods to address the diverse levels of understanding and abilities of students, thus providing additional support to those who need it to improve their performance. The extracurricular activities carried out have revealed that involvement in the research of variable stars was both relevant and motivating for the majority of students.

This highlights the importance of including practical activities in the educational curriculum, especially in complex scientific fields such as astronomy, to stimulate scientific curiosity and promote a holistic understanding. For the future, it is advisable to explore ways to make these learning experiences more accessible and inclusive. This could include ensuring access to various equipment used in astronomy and online resources, as well as adapting activities to meet a wide range of learning styles and ability levels.

The study of variable stars within extracurricular astronomy activities has been an effective pedagogical tool, promoting not only scientific understanding but also developing students' investigative competence. It provides a valuable model for improving scientific education through innovative and practical methods. In addition to the significant impact of extracurricular activities on the development of students' investigative competence, highlighted in this paper, there are several important aspects that deserve mention.

The study of variable stars within extracurricular astronomy activities has highlighted the value of interdisciplinarity in education. Students had the opportunity to integrate knowledge from various fields, such as

mathematics, physics, and computer science, demonstrating how different disciplines can merge to provide a deeper understanding of astronomical phenomena. The activities conducted encouraged students to think innovatively and creatively in addressing scientific problems.

By working with advanced technologies and exploring complex concepts, students were challenged to find original solutions and approach various subjects from new perspectives. In the digital age, familiarizing students with advanced technologies and specialized software is essential. Extracurricular activities provided students with the opportunity to develop their digital skills, which are vital in modern education and their future careers. Through participation in these activities, students acquired not just scientific knowledge, but also a greater awareness of the role of science in society.

This can contribute to the formation of more informed and civically engaged citizens, capable of making decisions based on a solid scientific understanding. The experience gained through extracurricular astronomy activities has the potential to shape future educational initiatives in the field of sciences. Demonstrating the success of a practical and interactive approach, these activities can serve as an example for the development of other educational programs that make learning science more attractive and effective.

The study of variable stars within extracurricular astronomy activities has surpassed the initial goal of developing investigative competence, significantly contributing to the holistic development of students in many essential areas, from scientific thinking and digital skills to collaboration and civic awareness. These conclusions underline the vital role of innovative scientific education in shaping the future of society.

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