Preparing Girls for Mathematics Olympiad

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Abstract

In this article, we present the subproject Mathematics Olympiad that integrated the project Encouraging Girls in Exact Sciences, Engineering, and Information Technology, at the University of Caxias do Sul. The referred subproject contemplated both planning and execution of workshops to prepare students for Mathematics Olympiad and was developed by a girls' team of undergraduate students, guided by university instructors, and assisted, in the initial stage, by an exchange student from University of Verona, Italy. For the planning of the workshops, the students raised recurring themes in Brazilian Mathematics Olympiad for Public Schools and carried out diagnostic evaluations to identify difficulties of co-executing schools' students. The workshops were developed based on the active learning strategy "Challenge in Groups" for the resolution of questions and problems already applied in Brazilian Mathematics Olympiad for Public Schools. At each meeting, the number of the group members was reduced, so that little by little the students could be able to work individually. After this stage of preparation, the girls 'team of undergraduate students selected new questions and assisted in the organization and conduct of mini Olympiad (Phase 1) with a classificatory nature. Five public schools from the UCS coverage region participated, with all students interested and divided by levels: Level 1 for 6th and 7th grades and Level 2 for 8th and 9th grades of Elementary School, and Level 3 for High School. The three students with the best performance at each level went on to Phase 2, representing their schools at the University of Caxias do Sul Mathematics Olympiad 2019. In Phase 2, the undergraduate students sought questions from previous Olympics of greater complexity to challenge and highlight the best students with gold, silver, and bronze medals, and their schools with first, second and third place trophies. In developing this important study and engagement project for the co-executing schools' students, the undergraduate students also collaborated to develop autonomy and self-confidence in the co-executing schools' students, encouraging them to participate in OBMEP.

Keywords: Mathematics Olympiad; Active Learning; Mathematics Workshops.

1 Introduction

During the history that includes the great discoveries in the area of sciences and technologies, the names of women mathematicians, physicists and chemists generally do not have the same greatness of recognition as the male scientists of the time. This reinforces that the difficulties of women's insertion in this area is a dilemma that, even at different levels of equity, is found on the world stage. It is of most importance this valorization of women as well as the constancy in what refers to the study in the area of exact sciences, promoting in girls self-confidence, encouragement and, above all, the feeling of belonging, directly linked to the increase in mathematical performance. (Thrasher, 2008; Gavin & Reis, 2003; Buser & Yuan, 2019; Salmon, 2015; Rimer, 2008).

Over the past few decades, attracting girls to science has been an apprehension for many researchers concerned with gender issues and with the importance of female participation in science, technology engineering and mathematics (STEM) (Rasmussen & Hapnes, 1991; Anderson, 1994; NSF, 1998; Blickenstaff, 2005; Du & Kolmos, 2009; Tessari & Villas-Boas, 2013; Dasgupta & Stout, 2014; González-González et al, 2018; Sauer et al, 2020a; Sauer et al, 2020b).

In Brazil, the process of insertion of women in scientific and technological careers occurred in the same proportions as in other countries of the world, however, during much of the twentieth century there was still a great prejudice related to women's aptitude or even to their intellectual abilities to pursue these careers (Tessari

& Villas-Boas, 2013). In the last decade, a considerable number of public calls aiming to support projects intended for stimulating the education of women for careers in Exact Sciences, Engineering and Information Technology in Brazil has been launched.

Since 2009, a group of instructors from the University of Caxias do Sul (UCS), a community institution of higher education located in the southern region of Brazil, has been developing projects for encouraging girls for careers in Exact Sciences, Engineering, and Information Technology. In 2018, this group of instructors had a project approved in a public call of the National Council for Research and Development (CNPq), the "Encouraging Girls in Exact Sciences, Engineering and Information Technology" (EMC&T).

In this project context, and in order to improve the participation and female award indices in the Brazilian Mathematics Olympiad of Public Schools (OBMEP in the Portuguese acronym), a subproject named "Olimpíadas de Matemática" (OlimMat) was created. In this subproject, preparation workshops for local Mathematics Olympiad were planned and carried out at the co-executing schools of EMC&T, and later at UCS.

OBMEP is a nationwide project aimed at Brazilian schools, public and private, carried out by the Institute of Pure and Applied Mathematics (IMPA) and with support from the Brazilian Mathematical Society (SBM). OBMEP has as some of its main objectives to stimulate and promote the study of Mathematics, to contribute to the improvement of the quality of basic education, to identify young talents and to encourage the improvement of public-school teachers (OBMEP, 2021).

In OBMEP the participants are students from the 6th year of Elementary School until the last year of High School, divided into levels, namely: Level 1 to 6th and 7th years of Elementary School, Level 2 to 8th and 9th years of Elementary School and Level 3 for high school students (OBMEP, 2021). In the first phase, which takes place in schools, the tests are made up of objective questions and all students from public and private schools are invited to participate. In the second phase, participate 5% of the students with the best performance in the first one, with a discursive test, applied in specified places, outside the school, designated by the national organization.

An analysis of official OBMEP data (http://www.obmep.org.br/em-numeros.htm) reveals that from 2005, when it was created, until 2019, the awards to girls have always been lower than those to boys, both in number of gold, silver, and bronze medals and honorable mentions, even with several initiatives to encourage girls' participation in science competitions.

In 2005 the girls had the worst results in the number of bronze medals and honorable mentions, and in 2007 they had the worst results in gold and silver medals. As for the girls' best results, these occurred in 2016, when they obtained the best results of all competitions in the analyzed period.

As for the number of medals, the highest percentage of girls gold medalists was 23.15% in 2016. The highest percentage ever reached by the female audience at the awards also occurred in 2016, with 40.32% of the honorable mentions being destinated for girls (OBMEP, 2021).

Even so, the percentage is well below that achieved by boys in the same year, and this was also the case for silver and bronze medals. The lowest percentage of gold medals won by girls happened in 2007, when the female audience represented 14.95%.

However, data on the classification for the second phase of the OBMEP reveal that "since 2006, at the three levels, approximately half of the students classified for the second phase are girls. Therefore, in all age groups, approximately half of the top 5% math students are girls" (IMPA, 2019).

Considering then that the test in the second phase has been held with equal numbers of boys and girls, the number of boys awarded has been expressively higher.

Therefore, as preparation workshops for the Mathematics Olympiad, as part of the activities of the EMC&T program, they aim to encourage the study and development of mathematical skills, but also had a social feeling for the insertion, incentive and encouragement of girls students to participate preparing themselves to face the challenge of OBMEP with the same conditions and resources as boys. The application of the workshops by young undergraduate students, who chose to dedicate their careers to the exact sciences, encourages girls to

think of Science and Mathematics as possible paths for the future, expanding female representation and a consolidation of the concept of gender equality. As stated by Freire (1996), "Sometimes, one barely imagines what a simple gesture from the teacher can represent in a student's life. What can an apparently insignificant gesture be worth as a formative force or as a contribution to the assumption of the student by himself."

The design methodology, preparation, and application of the workshops, a description of the Olympiad in the schools, the stage at UCS, and some results and conclusions are presented below.

2 Method

The preparation workshops for OlimMat took place in schools and were implemented by undergraduate scholarship students from the Exact Sciences courses (Engineering, Physics and Mathematics) at UCS, under the supervision of a master's student exchange student and teachers, members of the EMC&T Project team (Figures 1 and 2).

Figures 1 and 2. Image of the members of EMC&T Program team, authors' collection.

After the planning, done at UCS, through seminars, the execution of the workshops occurred in five stages, including moments of analysis of results, accompanied by studies, in the intervals between each stage. At the end of the workshops, each school held its own Olympiad, and the best ranked students then participated in the OlimMat at UCS, ending with an awards ceremony to close the activities. The methodology is described below.

2.1 Planning of the OlimMat Stages

The planning of the preparation workshops for the Mathematics Olympiad at UCS was based on the active learning strategy known as Challenge in Groups (Elmôr-Filho et al, 2019) and was structured based on the learning objectives organized in Bloom's Taxonomy, seeking to reach higher levels of complexity. In the classroom, when applying the methodology, the intention was to create a relaxed, safe, and slightly competitive environment in order to engage the participants in the activities, promote the exercise of cooperation, as performances depended on everyone in the team, and encourage the personal development of each student. At the end of each meeting, the members of the winning team were awarded with symbolic prizes.

Bloom's Taxonomy has guided planning and practice so that it is possible to evaluate and stimulate students' performance at different levels of knowledge construction, exploring, remembering, and understanding in the review and deepening of theoretical content; to apply and to analyze the resolution of questions in simulations; and to evaluate and to create by developing other colleagues' own methods of resolution and evaluation of resolutions.

Bloom's Taxonomy has also collaborated to encourage educators, who accompanied the workshops, to think strategies to help their students, in a structured and conscious way, to acquire specific skills from the perception of the need to master simpler skills (facts) for, later, master the most complex (concepts) (Ferraz and Belhot, 2010).

In the application of the workshops, emphasis was placed on active learning, placing the students as protagonists of the learning itself. The performance of undergraduate scholarship students was oriented to

conduct activities in such a way that students felt motivated to apply and produce knowledge, interact and share their experiences, to strengthen the team and, thus, qualifying the educational process. Active learning can result from any teaching method as long as it engages students in the learning process, which therefore requires that they perform meaningful activities and reason about what they are doing (Elmôr-Filho, Zanol Sauer, Almeida and Villas-Boas, 2019).

Freire (1996) also emphasizes the attention regarding the respect for the student's autonomy and identity, since through this means the mobilization of his knowledge takes place, which propels him to new discoveries and conceptions.

The workshop activities were proposed aiming to awaken the students' imagination, intuition, and curiosity in a natural way, considering that "The more spontaneous curiosity is intensified, but above all it is 'rigorized', the more epistemological it becomes" (FREIRE, 1996).

2.2 Preparation Studies at UCS

The first stage of the workshops was for theoretical and procedural preparation and taught by an exchange student for undergraduate scholarship students, preparing the girls for later application in schools. From a survey of the most recurrent themes in the OBMEP tests, each meeting was focused on one of the topics of mathematics among the following: rules of standards; counting permutations and combinations; logic; diagrams; visual subtraction and subtraction; order of operations; inequalities; analytical geometry; fractions; basic statistics; expressions with unknowns and equations and percentages.

In the preparation meetings at UCS, initially the theme of the day was presented and OBMEP questions from previous years related to the content were solved. During pre-determined times, each scholarship holder solved the questions individually and then discussions were promoted about difficulties and possible resolution, considering the target audience. Thus, through interaction and sharing of knowledge, it was guaranteed that different resolutions were explored and that all the fellows were prepared for the application in schools.

2.3 Diagnostic Evaluation

In the first meeting in the schools, a diagnostic evaluation was performed, prepared by the undergraduate scholarship students, with easy, medium, and difficult questions, covering all the topics that would be covered. Each student solved the questions individually and was asked to solve them as detailed as possible, so that it was possible to identify knowledge, difficulties, and the type of errors, if any.

During the analysis of the resolutions, the right and wrong answers were analyzed, and in subsequent meetings the questions with content that presented the biggest gaps were emphasized, according to the particularities of each school. With this, it was possible to improve the workshop activities, giving more attention to situations in which the girls presented the greatest need.

2.4 Girls' Preparation in Schools

Among the five schools participating in the program, all from the region covered by UCS, three are elementary and high schools, one is a middle school, and the fifth is a high school.

The workshops took place over six weeks, with weekly meetings of four hours, with a 30-minute break, and in shifts opposite to the school classes. Although the main objective was to encourage women in Science, Mathematics and Engineering, providing encouragement and self-confidence to girls, in the Group Challenge there was also the participation of male students (Figures 3 and 4).


Figures 3 and 4. Images of the workshops with the Group Challenge, author's collection.

By working with mixed teams, we sought some adaptation to the school environment and its routine, considering the difficulty of separating boys and girls in this first stage. With this characteristic, we also explored the benefits that this shared work provides. Freire (1996) defends true dialogicity, where individuals learn and grow from differences, creating a bond of respect for the autonomy and opinion of others.

The classes were composed, on average, of 20 students from the 6th to 9th grades of elementary school and 20 students from the three years of high school. When the number of participants exceeded the limit for a good quality of the methodology's application, two groups were formed and a new day of the week was chosen to attend to everyone, avoiding dispersion of the students' attention and focus.

2.4.1 Content review

Following the planning guidelines, prior to the application of the Group Challenge strategy, a brief review of concepts was held, in an expository manner, for a maximum of 15 minutes, with an introduction involving each mathematical topic present in the questions that the students would later solve.

It was noted that a large part of the students had difficulties with elementary mathematical concepts, and practically all of them had difficulties interpreting the questions. Over time, the students got used to doing the activities and discussing the resolutions, thus providing the development of competencies and skills that also contribute to the understanding of the questions.

2.4.2 Group Challenge

The Group Challenge contains 5 stages of application. In step 1, instructions are provided about the execution of the activity, informing the girls about the main topic of the dynamic. For each meeting questions of the same nature were separated, contemplating a topic among those mentioned in subsection 2.1.

In the execution of stage 2, the teams were divided, and each group was represented by two of its members, who solved the problems drawn in each round on the board. Everyone went to the board at least once, and for each correct answer a point was added to the team. The groups were diversified throughout the meetings so that, in this way, the girls could socialize their thoughts with as many colleagues as possible.

In step 3, each group presented a solution to a problem, and the colleagues followed the resolution and wrote it down in their notebooks. The participants at the board had no access to support material but were allowed to interact with their colleagues at the tables. In step 4, the teams evaluated their opponents' resolutions, and in cases where there was nothing to add, the group won the score. When the other group identified some error in the development of the question presented by their colleague, this group received a score.

In step 5, the teacher discussed the questions and their resolution, clarifying doubts and making the necessary records. This moment, in the application of the Group Challenge, is extremely relevant, because it allows errors to be noticed and methods to be improved.

As the activities went on, the larger groups were reduced so that the girls could develop the autonomy and confidence to solve the math problems by themselves, thus preparing them for the next step - the first phase of the exam.

At the end of each workshop the winning group was presented with a symbolic reward, but all the students who participated in the dynamic were also recognized and presented with a gift. This small competition

encouraged everyone to improve their individual performance and productivity, and to be in the next winning group.

2.4.3 Strategy for conducting long tests

During the preparation workshops, it was noticed that the girls had difficulties in solving long tests, thus the need to solve doubts related to this arose.

In moments of exchange of ideas, short instructions were created and passed to the students, trying to encourage them to face more complex questions. Auxiliary resources, provided by the exchange student, were discussed during the meetings with the students, such as the use of the method of exclusion of alternatives, for the case of objective tests, and, when the questions were similar or difficult to understand, it was suggested to start with the easiest and best understood problems.

To encourage the student's problem-solving and persistence, a maximum time of 7 and a half minutes was stipulated for the completion of each question present in the test of phase 1 of OlimMat, instructing that, in case of an obstacle or indecision, a change of questions would be chosen, contributing to the complete completion of the test.

2.5 Olympiad in Schools

After the preparation workshops, Phase 1 of the Olympiad was held in the schools, with the test being open to all students. At the school, the students were separated into classes by test levels (Level 1, Level 2 or Level 3) and each class was accompanied by a teacher or person in charge (Figure 5).

Figure 5. Image of the students on Phase 1 of the Mathematics Olympiad at Tancredo Neves School, author's collection.

The tests were developed along the lines of Phase 1 of the OBMEP, that is: objective test, of a classification nature, composed of twenty multiple choice questions, each worth one point, totaling twenty points, where each question had five answer options (A, B, C, D and E), among which only one was correct. The duration of the test was two hours and thirty minutes, except for students with special needs who needed assistance, such as Braille or magnified tests, for which the duration was three hours and thirty minutes.

After the exams were corrected, the students and their math teachers - who obtained the best results - were awarded prizes. Girls were awarded gold, silver and bronze medals to the first three places on each level, as well as boys. His mathematics teachers received certificates of honor to the merit.

2.6 Olympiad at UCS

The students classified in phase 1 participated in a new test, representing their school, in phase 2. The second test was held at UCS - Central Campus, in which 72 students participated (Figure 6). The test was prepared with essay questions along the lines of the OBMEP. The undergraduate scholarship holders supervised, in order to avoid fraud, and corrected the exams.
The award ceremony took place in the same place as the test, with representatives from the five participating schools, students and their families. In the awarding of the second phase, the participants were separated into two categories: best girls and best boys, also receiving gold, silver and bronze medals for the best placed.

As awards, the teachers received certificates of merit and a math book. The participating schools received first, second and third place trophies, based on the performance of their students, and book kits were awarded to

the five schools. The highlight of the Level 3 awards was that the high school students, gold medalists, also won university scholarships, with a choice of courses in Exact Science, Engineering, and Computing.

Figure 6. Image of the students on Phase 2 of OlimMat at UCS, authors' collection.

3 Results

Throughout the application of the Group Challenge strategy, it was noticeable the gradual increase in the students' participation and enthusiasm for the proposal. A notable improvement was noticed during the chats and the integration among class members.

During the application of the evaluation in the 1st phase, all the students respected the rules and demonstrated commitment in performing the activities, as well as respecting the timetable and waiting for the other students to finish their evaluations.

Among the five participating institutions, an estimated 150 students participated in Level 1, 52% of whom were girls. At Level 2, 110 students participated, 48% of whom were girls. For Level 3, 230 students were accounted for, 49% of whom were girls. With these data, the promising results that the strategy applied to the girls can be extolled.

In view of the analysis of the answers obtained in the three levels, it is possible to highlight the significant increase in the averages obtained in OlimMat - 2019 (in relation to those of the OBMEP that occurred on May 21, 2019), which may have been propitiated by the directed studies carried out during the Encouraging Girls in Science Project, taught since March 2019, in the afterschool, added to the Group Challenge strategy, which intensified the studies and sharpened the students' goal.

The students selected to participate in the 2nd phase of OlimMat showed commitment and dedication in solving the problems proposed for study, attending the meetings, and making assertive choices. Some students went further, studying at home previous editions of phase 2 of OBMEP. These students sought out the school's mathematics teachers daily to ask questions or clarify the issues they were trying to solve in their studies. Attitudes like this show that, in fact, there was a change in attitude of these students, who felt motivated and encouraged to seek more, generating, in addition to knowledge and development of logical-mathematical reasoning, interest in learning and autonomy.

During the OlimMat awards, subdivided into awards for boys and awards for girls, it was possible to highlight the feeling of recognition, capacity and competence felt by the students. The possibility of achieving their goals through dedication and studies gave each OlimMat participant the awareness that they are capable and deserving of what they aim for.

4 Conclusion

From the development of this subproject, it was possible to notice a great evolution in the girls, both in the cognitive and social areas and in the behavioral and educational areas. Furthermore, the development of the students' autonomy and self-confidence is evident.

The OlimMat represented a motivation for dynamic activities, acting as a facilitator in deconstructing the idea that Exact Sciences are difficult to understand. When preparing the workshops, the whole team was concerned

with bringing practical, uncomplicated explanations to the young people, in order to make learning more concrete.

Therefore, it can be seen that the work done in the subproject brought many benefits both to those who were assigned to it and those who applied it, because education is a double track that is always aimed at the constant development of all those involved.

This promotes the beginning of a process to break paradigms and stereotypes that segregate girls and women. With the extinction of such prejudices, everyone should exercise their choices with more freedom, being able to better develop their skills and participate significantly in the advancement of scientific and technological knowledge. Thus, it is important to emphasize that it is extremely important to implement projects to encourage and value female participation in the STEM field.

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