Effects of the COVID-19 Pandemic on the Bebras Computational Thinking Challenge: Comparing Numbers, Examining Reasons and Investigating Recommendations

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Abstract. The Bebras Challenge is organized in more than 70 countries worldwide. It aims to foster pupils' interest and passion for informatics and computational thinking. Although the Bebras Challenge is by its nature an online activity, most countries had a decline in participation numbers compared to non-pandemic years. Some countries recorded larger relative declines than others, certain countries even recorded increases. In order to investigate this issue, a comprehensive study, applying quantitative and qualitative methods, was conducted. Based on reported participation data, an interactive online graphic was created in which the reach (participation per thousand inhabitants) of the Bebras Challenge in individual countries or groups of countries in the respective years can be compared with each other. Following an online research regarding homeschooling during the Bebras weeks in different countries, an online survey among 40 Bebras representatives worldwide delivered important key data, such as main reasons for an incline or decline of participation numbers or which measures have been taken to hold the challenge during the pandemic. This was accompanied by qualitative interviews with selected Bebras representatives. The results of this study could help organizers of national and international school activities to respond more effectively to possible future adverse situations.

Keywords: Bebras Challenge · Computational Thinking and Informatics · Pandemic Impact

1 Introduction

As digitization steadily increases, ICT becomes an integral part of our everyday lives. It is therefore crucial to foster skills which young people need to ensure

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them a social and economic participation in this rapidly changing technological world. Having knowledge of fundamental informatics concepts and being able to perform computational thinking (problem-solving, algorithmic-thinking, logical-reasoning) are key skills of the 21st century [6,17]. Introducing young people to informatics and computational thinking in a playful and engaging way can help to develop a strong foundation in this area.

In this context, the international Bebras Challenge on Informatics and Computational Thinking has proved to be extremely effective. With a yearly participation of more than 3,000,000 school students from more than 70 countries, the Bebras Challenge is the largest school competition in the area of informatics [2]. The international recommendations and initiatives to increase the amount of teaching hours related to digital skills and informatics at school led to steadily increasing participation numbers in most of the participating countries. The Bebras Challenge is performed online and usually at school under surveillance of teachers during one or two weeks in November [3,4]. Since the Bebras Challenge is an online competition, it had a good chance to be taken by the students during lockdown and homeschooling.

For investigating the effects of the COVID-19 pandemic on the Bebras Computational Thinking Challenge, this work was guided by the following three main research questions:

- Q_1: Did homeschooling have an influence on the participation numbers of the Bebras Challenge in different countries?
- Q_2: What were the reasons for a decrease or an increase of participation numbers?
- Q_3: What are possible recommendations for Bebras organizers to better address future adverse situations?

The remainder of this paper is structured as follows: Sect. 2 summarizes related literature, Sect. 3 outlines the applied methodology, Sect. 4 presents the results of our investigation, Sect. 5 discusses the findings with regard to the guiding questions, while Sect. 6 provides conclusions, limitations and outlooks.

2 Related Research

Only very few studies have explored shifts taking place within participation rates for the Bebras Challenge for specific regions, yet none so far have examined these trends on a larger scale across wider geographical areas such as Europe. An analysis recently conducted by Maranatha Bebras Bureau Christian University offers unique insights into this matter regarding the region of Indonesia. Despite facing numerous challenges posed by distance learning during the COVID-19 pandemic period last year, they recorded over twice as many students participating at their Bebras Bureau in 2020 compared with numbers just one year before (i.e., increasing from only 6,846 students in 2019 to 16,177 in 2020). The investigation also highlighted the apparent effectiveness of teacher workshops and students' enthusiastic participation to ensure the success of these outcomes, despite the various obstacles posed by remote learning during the pandemic [1].

A similar initiative, the Math Kangaroo - a highly regarded international mathematics competition for school students - usually takes place on the third Thursday of March and usually uses paper and pencil multiple choice tests. They had a significant decline of participation numbers in the years 2020 and 2021 after a long period of steadily increasing participation numbers. The competition had over 6 million participants from 57 countries in 2014, and by 2022, it had 84 participating countries and claimed to be the largest competition for school students in the world [8]. In the United States, participation in the competition was reported 30,550 students in 2022 and 31,004 in 2021 which was a decrease from 35,171 participants in 2020. However, in 2023, the competition saw a significant increase with 36,421 participants [12]. Compared to the figures from the US, the figures from the Netherlands and Germany show a much higher decline [9,10].

The pandemic has led to a significant surge of online education, which is discussed in Sá and Serpa's paper "COVID-19 and the Promotion of Digital Competences in Education." They argue that schools require robust educational infrastructure to ensure that remote teaching can be successful during such a pandemic. To support effective online instruction, teachers must adapt and develop standardized home-based equipment while developing crucial digital competencies. This paper discusses, namely, which changes were made and how. Sá and Serpa argue for national-level research on remote-learning methods and practices as well, which can help educators implement effective training methodology. They also acknowledge challenges associated with disparities in access to digital tools, worsened by the pandemic impact at large. While the document provides a broad understanding of the impact of the pandemic on digital learning, it lacks concrete data on how the pandemic has specifically altered participation numbers in IT competitions [14]. Our study targets participation numbers exclusively within one of the biggest, namely the Bebras Challenge, during these times when concrete data has been reported less frequently despite requiring the attention from an overall research standpoint.

It's important to recognize that several factors can affect participation rates during the pandemic. These reasons are contingent upon various elements such as the manner in which schools were impacted by the pandemic, lockdown types/durations, homeschooling frequency along with other such variables. Nevertheless, there seems to be a need for comprehensive studies that allow us to better comprehend patterns and factors influencing these statistics across different areas/cultures. This leaves a gap in our understanding of the global impact of the pandemic on student engagement in computational thinking challenges, like Bebras. The goal of this research paper is to close this gap, enable further research in those topics, and spark discussions.

3 Methodology

Qualitative and quantitative methods have been applied to gather data with regard to the main research questions (which were stated in Sect. 1) [13], following an inductive approach [15]. Collected data has been anonymized and treated

confidentially in accordance with data protection regulations. The next paragraph describes the steps and methods used in this process, while results of each step are presented and discussed in Sects. 4 and 5.

a) Participation numbers: The first step was the collection of participation numbers of past Bebras Challenges based on the reported participation numbers of the community. On the basis of this data, an interactive visualization was created. This visualization provided further insights into the data set and also eased the task of data cleansing, which was done in close cooperation with the national Bebras representatives (e.g. in case of ambiguities, open questions or potential errors in the data).
b) Homeschooling: The next step was to perform an online research regarding type and length of homeschoolings based on the data of the *European Centre for Disease Prevention and Control*[1] [5,11]. This information was then correlated with the participation numbers, taking into account the slightly different dates for the Bebras Challenge in each country.
c) Survey: Based on the findings of the previous steps, an online questionnaire[2] was created and distributed among the Bebras community worldwide using *Google Forms* [16]. The survey comprised questions regarding measures to ease participation during the pandemic, reasons why numbers declined or inclined, as well as further comments or suggestions. Furthermore, a link to the interactive visualization was included in order to additionally verify the participation numbers investigated in step a). The survey also served the purpose of further investigating reasons for an incline or decline of numbers of certain countries (which were identified by the analysis performed in step b).
d) Interviews: Additionally, semi-structured interviews [7] with selected Bebras representatives were prepared and conducted. In particular, countries which have recorded small or large decreases/increases during the pandemic years were of interest. The goal of the interviews was to get more in-depth information regarding the reasons for an increase or decrease, and to examine good-practice examples for handling this difficult situation.

4 Results

By adhering to the methodology outlined in the previous section, the following results could be acquired.

Step a: Participation data from 2004 to 2022 from 57 countries worldwide was collected and visualized as interactive online graphic (Fig. 1)[3]. The visualization shows the reach (participation per thousand inhabitants) of the Bebras Challenge for individual countries or groups of countries in the respective years.

[1] Here the focus was on EU countries.
[2] https://forms.gle/rdzcFLbnpzanyg3PA.
[3] The decline of Belarus' and Russia's numbers are a result of being suspended from the Bebras Challenge.

This could also be useful for the community, e.g. for comparisons between countries of similar size or between neighboring countries.

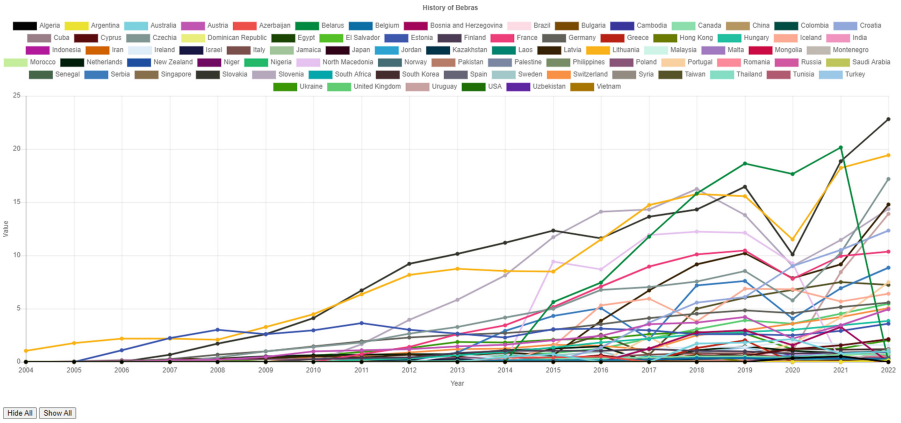

Fig. 1. Visualization of Bebras participation numbers as interactive online graphic (screenshot); the y-axis shows the reach (participation per 1000 inhabitants; or in other words: from 1000 people - how many took part in Bebras in that year); the graphic is available at https://www.coding4you.at/history_of_bebras/

Step b: The analysis of the data clearly showed a correlation between homeschooling and a decline of participation numbers (Fig. 2). In general, most countries that experienced a collision of homeschooling and the Bebras week demonstrated a decline of participation numbers, whereas most countries where the Bebras week did not collide with homeschooling accordingly did not show a decline of numbers (Fig. 3). Exceptions from these observations could also be identified. For instance, Hungary showed an increase of participation numbers during homeschooling, while, for instance, Bulgaria showed a decrease of numbers, although homeschooling did not overlap with the Bebras week. Reasons for this were investigated in the subsequent steps and are discussed in Sect. 5.

Step c: The response rate was high - in total 40 representatives from 35 different countries participated in the online survey[4]. Sixty percent of the survey respondents reported a **decline of participation numbers** during the pandemic, stating the additional overall workload as well as lockdown/homeschooling during the Bebras week as the main reasons for a decline of numbers (Fig. 4). Further factors that led to a decline include the following:

- Lack of suitable devices/technology and/or lack of proper internet access at home.
- Access to computer room was sometimes limited, due to regulations put in place by the government, which forced some schools to allocate computer rooms for other purposes.

[4] Multiple answers per country were allowed.

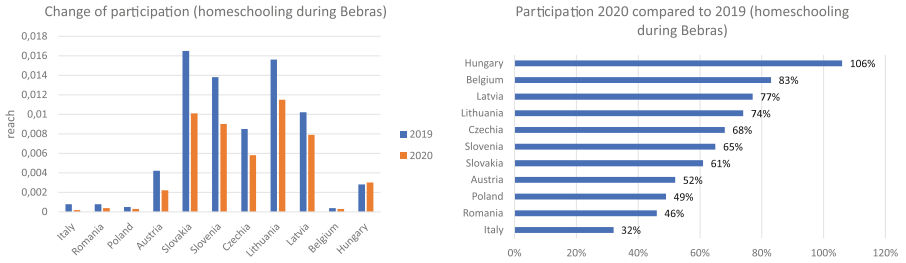

Fig. 2. Countries in which Bebras week collided with homeschooling: Change of reach (participation per thousand inhabitants) from 2019–2020 (left); participation numbers compared between 2019 and 2020, for instance, in 2020 Italy only had 32% the numbers of 2019 (decline), while Hungary had 106% the numbers of 2019 (incline)

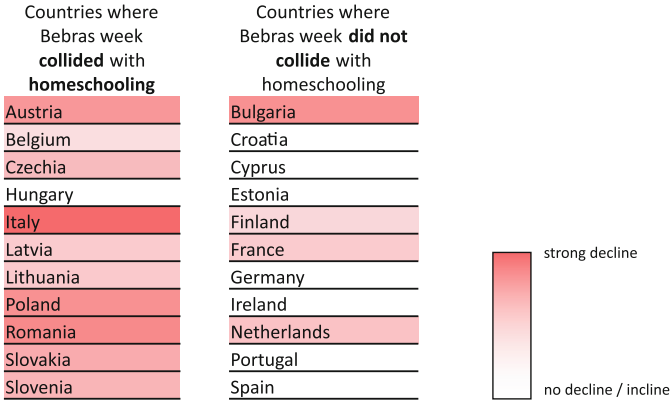

Fig. 3. Correlation between homeschooling and decline of participation numbers based on reach (participation per thousand inhabitants) from 2019–2020.

- In general, the government support for schools experienced a decline in certain countries. Furthermore, in several other countries, the government cancelled school competitions such as Bebras in particular.
- Many teachers reported being very exhausted because many administrations expected the same or even a higher performance of the students compared to regular school years.

In contrast, the survey respondents also reported reasons why Bebras **participation numbers did not decline**, (or even inclined) during the pandemic. A summary of these reasons is presented below:

- Due to fewer opportunities for co-curricular activities, the demand for participation in the Bebras Challenge increased.
- Offering the possibility of participating from home/from anywhere, which encouraged even those students who might not have participated in school.
- Most students already participated from home even before the pandemic.

- Certain countries did not close schools for as long and extensively as other countries during the pandemic.
- Students were well-equipped to engage online from home, with computers and internet connections readily available.
- The Bebras Challenge was proposed by one country as part of a nationwide computational thinking program, which saw an increase in participation year by year.
- A large campaign was conducted through schools to promote participation in the Bebras Challenge.

In order to **ease students' participation in the Bebras Challenge**, participation from home, and at any time respectively, was encouraged by the majority of the countries (Fig. 5). Other measures mentioned by the study respondents can be summarized as follows:

- Offering flexible dates or extending the Bebras Challenge up to several weeks.
- Postponing the Bebras Challenge until schools reopened.
- Making the Bebras system/platform accessible for the whole Bebras week 24/7, with access from anywhere, respectively.
- Offering the competition at the same time for all students.
- Using old tasks to create "Bebras at home" challenges as practice and as tools for teachers to easily teach computational thinking in remote settings.
- Reopening the access to the Bebras Challenge for the youngest categories so that they could compete from schools after the top of the pandemic wave was over.

Step d: At the time of writing this paper, two interviews with Bebras representatives from Hungary and Switzerland were conducted. Additionally, an interview with a representative of Uruguay was conducted in written form (due to scheduling reasons via email). The responses were qualitatively analyzed, following an inductive approach [15]. The findings of this analysis can be summarized as follows:

The registration of students for the Bebras Challenge was conducted prior to the start of homeschooling. Due to remote teaching limitations faced by teachers of various (non-technical) subjects, the Bebras Challenge was more flexible in its implementation, not being limited to the informatics subject only. During the Bebras Challenge, students were not closely monitored, nevertheless, cases of cheating were minimal. This can be attributed to the high motivation of students and a reduced number of students refusing to participate or submitting incomplete responses. Additionally, some teachers included the Bebras results into their grading, providing an additional incentive for students. A fixed time window was provided for students to complete the Challenge (since a fixed time window might foster students' preparedness to participate). Other solutions included flexible time windows as well as fixed time windows with one alternative time window, ensuring that students had the opportunity to participate at a time that suited best for them. Furthermore, fostering the participation in the Bebras Challenge as part of a nationwide computational thinking program turned out to be a viable solution.

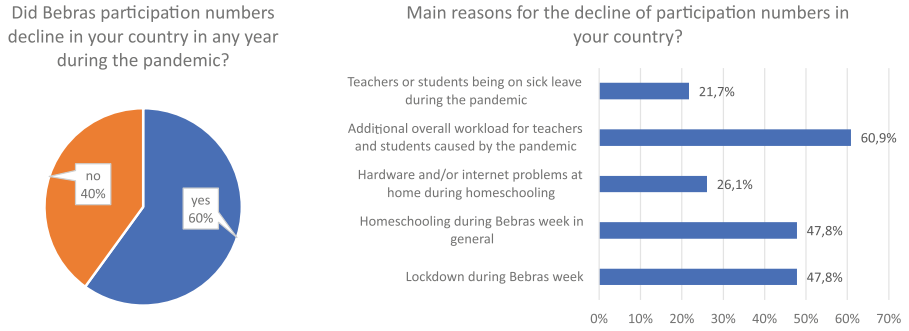

Fig. 4. Did participation numbers decline, and what were the main reasons?

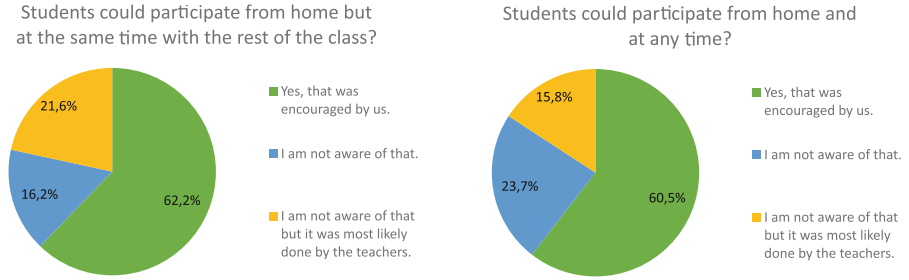

Fig. 5. Measures to ease students' participation in the Bebras Challenge.

5 Discussion

Based on these results, we were able to answer the research questions which were stated in the introduction in Sect. 1.

Regarding Q_1, the gathered and analyzed data showed that, homeschooling had a profound impact on participation numbers of the Bebras Challenge on a worldwide scale. In general, a clear correlation between homeschooling and a decline of participation numbers[5] could be observed (this also corresponds with the numbers of the Math Kangaroo, discussed in Sect. 2). This insight, though not surprising, is based on solid facts through this study. Furthermore, outliers (exceptions) could be observed: Some countries (e.g. Hungary) were able to increase their participation numbers. Their measures taken during the pandemic could serve as best-practice examples.

Regarding Q_2, several factors and reasons for a decrease or an increase of participation numbers could be identified. As presented in Sect. 4, most countries reported a decrease. The main reasons were an additional overall workload for teachers and students during the pandemic, homeschooling/lockdowns during the Bebras week, as well as hardware and/or internet problems at home. Some countries also reported an increase of participation numbers. This was due

[5] In this context, it is important to mention that also a number of other circumstances - besides homeschooling - could have affected the participation numbers.

to fewer opportunities for other extra-curricular activities, so the demand for participation in the Bebras Challenge increased. Furthermore, the opportunity to participate from home or from anywhere, attracted students who might not have participated in the regular form. The duration of school closures varied among countries, with some countries experiencing shorter and less extensive closures. In some countries, students were well-prepared for online engagement from home, having access to computers and internet connections. One country also reported that the Bebras Challenge was part of a nationwide computational thinking program. Another country reported that some teachers included the Bebras results into their grading, providing an additional incentive for students to participate.

Regarding Q_3, a number of possible recommendations for Bebras organizers to better address future adverse situations and measures to ease students' participation were already presented in Sect. 4. This included, among others, the possibility to participate from home, to offer flexible time windows (including alternative time windows) for participation, to take into account Bebras results in the school grading system as well as using the opportunity to incorporate Bebras also in non-technical subjects.

6 Conclusion

This paper presented motivation, methods and results of a comprehensive study investigating the effects of the COVID-19 pandemic on the Bebras Computational Thinking Challenge. Guided by three main research questions, it showed - based on solid quantitative and qualitative data - that the pandemic had a profound influence on the participation numbers. It also investigated reasons for a decrease or an increase of participation numbers during the pandemic and presented possible recommendations for Bebras organizers to better address future adverse situations.

The study also comprises certain limitations. For instance, the online survey mainly addressed national Bebras representatives. In this context, more interviews with further national organizers have to be conducted to gain a deeper understanding. It would also be valuable to expand the survey to include teachers who implement the Bebras Challenge at their school. Furthermore, the analyses of homeschooling and participation rates mainly focused on EU countries in the years 2019 and 2020. An upcoming study could also investigate additional countries and years.

The next steps include the further analysis of the gathered data. Since the data set is quite extensive, the presented and discussed results represent only the first findings, consequently, further conclusions can and will be drawn and will also be provided to the Bebras community. Additionally, we will conduct further interviews and continue to collect the participation numbers to keep the interactive online graphic presented in Sect. 4 up-to-date.

Overall, we envision that the work presented in this paper will support organizers of national and international school activities and competitions, similar to the Bebras Challenge, in tackling possible future adverse situations.

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