

## **Bebras International Contest on Informatics and Computer Fluency**

### **Abstract**

The Bebras International Contest on Informatics and Computer Fluency (short: Bebras) is an international initiative. Its goal is to promote informatics and computational thinking among school teachers and students, but also to the public at large. To this end, Bebras members organize easily accessible and highly motivating online contests in many countries. Such a Bebras contest is to demonstrate informatics and computational thinking to a wide audience and to test participants' talent in this area.



Bebras was founded in 2004 in Lithuania. It first spread within Europe, but now has members world-wide. In 2014, Bebras contests were organized in 33 countries (24 of them European) and had more than 900,000 participants (about 850,000 of Europe). Besides organizing contests, Bebras members provide contest-related teaching material to schools, are engaged in teacher education and promotion of informatics education in general. Moreover, Bebras contests are subject to educational research. Typically, national Bebras activities are supported by government, universities, research institutes, or computer societies.

### **Applicants**

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We apply on behalf of all members of the Bebras community.

# **Project Description and Achievements**

## **Background and History**

Soon after informatics (also known as computer science, or computing) had become an academic subject of its own, experts began to see the relevance and importance of this matter for general education as well. In Germany, for instance, informatics was introduced as optional subject in secondary education in the 1970s already, after the first informatics departments had been founded at universities in the 1960s. However, since then, the role and relevance of informatics in school has been under discussion. With the ever growing number of computing devices, politics often found it to be more important to teach how to use these devices than to develop a substantial idea of their underpinnings.

As a consequence, the general public (and young people in particular) were not taught to develop a clear idea of informatics in general. “It’s got to do with computers.” became the typical answer when people were asked to explain informatics. In education, the following problems arose:

- Courses on using computers, standard software, and “media” were often mislabelled as “informatics”.
- If teaching of genuine informatics happened at all, it did so in the last high school years only, as part of pre-college education.
- Students with good computer usage skills entered but failed in pre-college informatics courses, while students talented in computational thinking avoided them after having perceived “informatics” as boring matter before.

Hence, informatics education was in need of tools to

- improve and clarify the image of informatics;
- promote informatics and computational thinking among (school) students;
- strengthen visibility of informatics at school; and
- let the “right” students develop interest in and detect their talent for informatics.

In the 1990s, the “Mathematical Kangaroo” had successfully proven that a simple and easily accessible contest format could be the right way to excite students, teachers, parents etc. about a subject and to find world-wide acceptance. In 2004, Valentina Dagiene started the Bebras challenge in Lithuania as a comparable contest for informatics. If done in the right way, this contest would pursue exactly the goals mentioned above and therefore become one of the tools that informatics education needed. Moreover, she immediately tried to find partners for organizing Bebras challenges in other countries as well. Estonia, Germany, Poland, and The Netherlands organized their first Bebras challenges in 2006, partly as trials. The following years saw Austria, Latvia, Slovakia (all in 2007), Czech Republic, Ukraine (both in 2008), Italy (2009), Finland, and Switzerland (both in 2010) join the motion.

That is, Bebras is a truly European initiative. Although, as of 2014, it has become spread all over the world. In addition to 24 European states and Israel, in 2014 Bebras contests were also organized in 9 further countries like Australia, Japan, South Africa, and the USA. In that year, Bebras challenges had more than 900.000 participants world-wide, with about 850.000 participants in Europe, and about 450 000 participants in France and Germany only. Fig. 1 shows the rapid development of European participation in the first 10 years of Bebras.

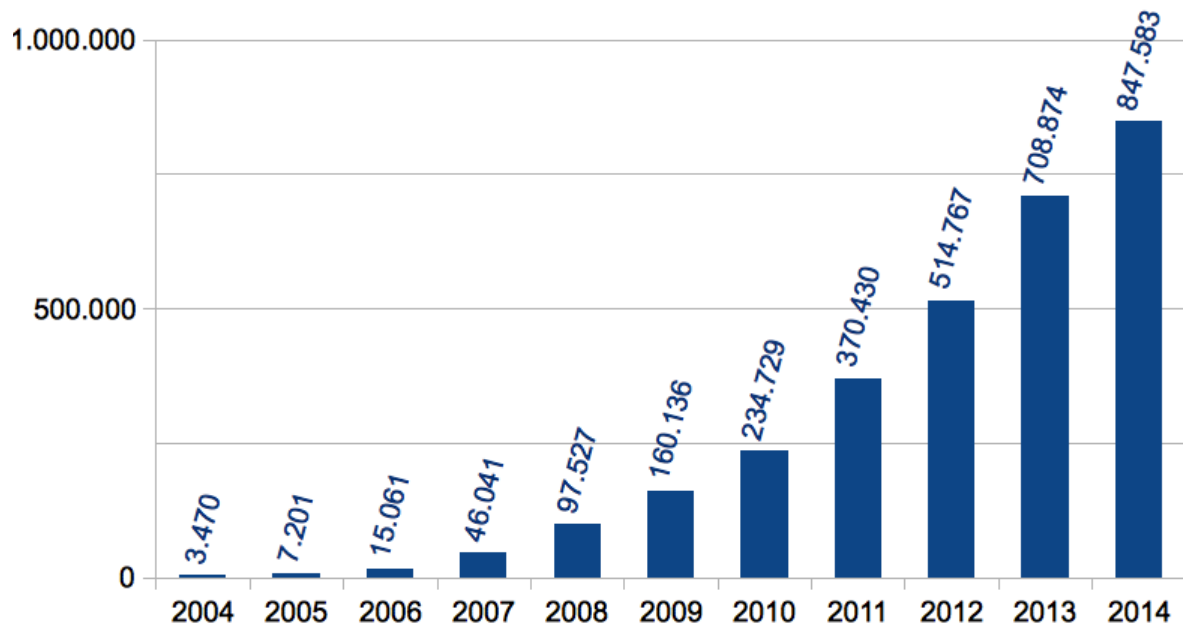


Figure 1: Number of Bebras participants in Europe

The important point about these numbers is that many participants have not enjoyed informatics education before. In the German Bebras challenge, for instance, students from grade 5 up are allowed to participate in the national Bebras challenge, while in most parts of Germany, informatics is (optionally) taught from grade 8 onwards. That is, Bebras often provides a first motivating encounter with informatics and computational thinking.

## Bebras Challenges and Tasks

In order to succeed with its goals (as mentioned in the previous section), a Bebras challenge would have to meet the following requirements:

- Its organization should allow for easy participation of as many students as possible.
- Participation should be fun and motivating.
- Tasks usually can be solved without prior knowledge in informatics.
- Tasks should be clearly related to concepts of informatics, and while this does not have to be obvious during participation, it should be explained to participants and teachers after the contest.

We will first explain how a Bebras challenge is organized and then show examples for Bebras tasks.

### Organization

A Bebras challenge is organized as an online contest. Participation time is very limited, so that only little time needs to be invested. In a typical Bebras challenge, 15 tasks have to be solved within 40 minutes. Details may vary among countries, however. Most online systems used for organizing a Bebras challenge allow for easy registration of large numbers of participants. Participation itself requires access to the internet; and while it typically should happen at school, in some countries students are allowed to participate at any time and place they want.

A Bebras challenge is organized into several age groups, so that the difficulty of tasks can be made to match their age. Among the tasks to be solved, difficulty ranges from easy to hard; a perfect Bebras task set will include both tasks that can be solved by almost everyone (in order to leave no-one frustrated) and tasks that can be solved only by highly talented students. As of now, there usually are up to five age groups: 0 (for primary schools, grades 3-4), 1 (grades 5-6), 2 (grades 7-8), 3 (grades 9-10), and 4 (grades 11 and higher).

Within Europe, Bebras challenges usually take place in the second week in November. Some countries have a stricter perspective on the competitive aspect and assign one specific day to each age group. In other countries, participants of all age groups may freely choose their participation time.

In spite of the relatively little effort of participation, most national Bebras challenges issue certificates to all participants or the major part of their participants. Then, many schools organize specific events for presenting the certificates or include Bebras participants in general presentation ceremonies. Moreover, certificates generate visibility with friends and families of the participants.

### *Tasks*

As feedback by students and teachers show, the tasks are crucial to the success of Bebras. Every year, tasks are proposed by all Bebras countries. Then, delegates of all countries meet at the annual Bebras Task Workshop to further work on the proposals and finally decide which proposals to recommend for use in the Bebras challenges of that year. The organizers of the national Bebras challenges select their tasks from this pool of recommended tasks. That is, Bebras challenges may differ in the tasks used.

This procedure guarantees that the national Bebras challenges may use tasks from diverse backgrounds, but still have the freedom to preserve a specific national character.

We will now present a few sample tasks. They are all taken from a booklet published by the organizers of the Bebras challenge of the United Kingdom<sup>1</sup>; they were used in 2014. On the top right of each task, you see in which age groups and at what difficulty level the task was used. In the UK, there are six age groups, and the difficulty level is indicated by the letters A (easy), B (medium), and C (hard).

Fig. 2 shows the task “Loading Lisas”. It is based on a proposal from Germany (as indicated by the little flag). The task presents an instance of a partitioning problem. As the task instruction shows (“Drag barrels onto the two boats ...”), a participant will be able to interactively construct the solution. Technically, such interactivity is usually implemented by adding scripts to the online pages of a Bebras challenge system. Such “constructive tasks” have proven to be particularly popular among participants. Below the task, at first the correct solution is explained, and second the relationship to concepts of informatics and computational thinking is highlighted.

Fig. 3 shows the task “Monster”. It is a constructive task as well, and nicely introduces participants to the idea of binary search. Below, Fig. 4 shows an easy Bebras task. It uses the stacking of ice-cream scoops to illustrate the “last in, first out” order of stack storage. This task was presented as easy task even to the youngest participants.

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1 <http://www.beaver-comp.org.uk/uploads/2/1/8/6/21861082/ukbebras2014-answers.pdf>

# Loading Lisas

Kits:  
Castors:  
Juniors: C

Intermediates: B  
Seniors: A  
Elite:

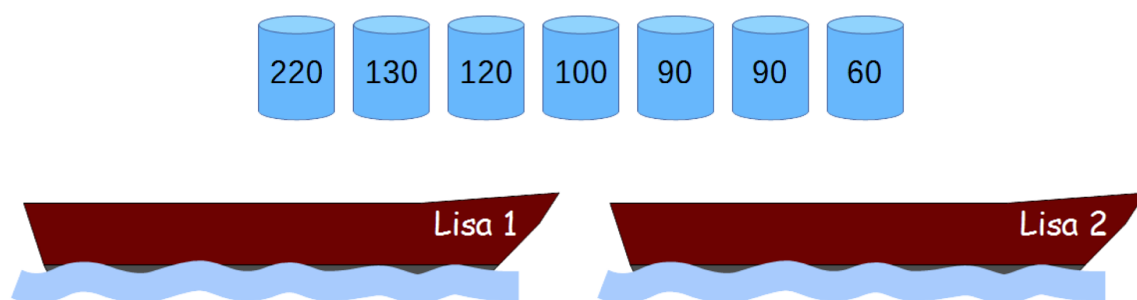


Two fishermen own two boats, named "Lisa 1" and "Lisa 2". Each boat can hold a maximum cargo of 300kg.

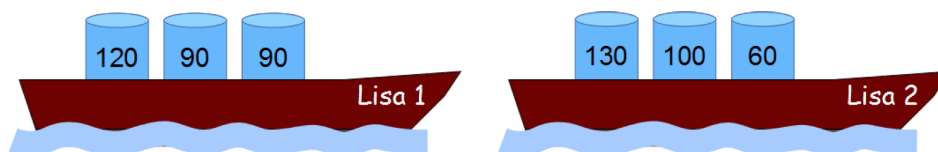
The fishermen are given barrels filled with fish to transport. On each barrel is a number that shows how heavy the barrel is in kilograms.

You must make sure that neither boat is overloaded.

**Drag barrels onto the two boats so that the maximum possible load of fish is carried.**



**Answer:**



**Explanation:**

It is possible to get the boats loaded with 590 kilos:

$20+90+90=300$  kilos on one boat,  $130+100+60=290$  kilos on the other.

Do not be greedy! If you try to load heavy barrels first, you will end up at  $220+60=280$  kilos and  $130+120=250$  kilos which is only 530 kilos total.

Also, we cannot do more than 590. Indeed, if we want to do more, we have to fill both boats with 300kg. But there is only one way to make 300:  $120+90+90$ .

**It's Computational Thinking:**

*Concepts - Decomposition (DE), Evaluation (EV)*

In many areas of life, people like to optimise things – typically in order to maximise their profit. Computers are often used for optimisation: for finding the shortest route, for determining optimal loads like in this task, and so on. In some optimisation tasks, it can be sufficient to use a "greedy" approach: to take the most profitable step next. But in most interesting applications, greediness fails and does not deliver optimal solutions. More complex algorithms have to be used. Unfortunately, for many optimisation tasks it is only possible for Computer Scientists to develop algorithms to find close-to-optimal solutions.

Figure 2: Example Task: Loading Lisas



In the basement of a castle lives a monster. The monster is hiding in one of the yellow rooms. The monster can only stay in yellow rooms.

You want to catch the monster. Click on any yellow room. This will reduce the total number of yellow rooms by half. Click again on another yellow room, etc.

When there is only one yellow room left you have caught the monster.

Find the lowest number of rooms you need to click to trap the monster.

**Save the lowest number of clicks required as your answer.**

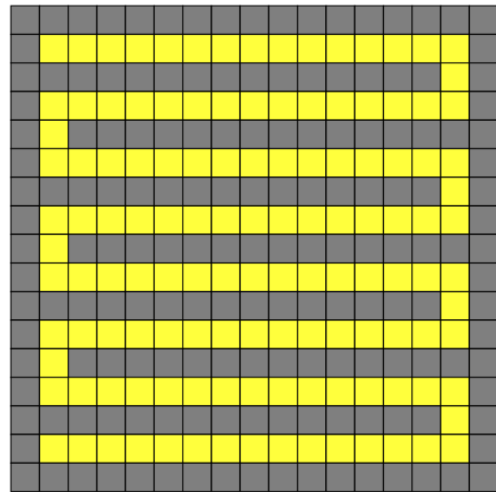


Figure 3: Introducing binary search in a Bebras task



At the LIFO ice cream parlour the scoops of ice cream are stacked on your cone in the exact order in which you ask for them.

**What do you have to say in order to get the ice cream shown in the picture?**

I would like to get an ice cream with ...

- ... Chocolate, Smurf and Strawberry!
- ... Strawberry, Smurf and Chocolate!
- ... Chocolate, Strawberry and Smurf!
- ... Strawberry, Chocolate and Smurf!



Figure 4: An easy Bebras task

## Availability of Material

The tasks of the Bebras challenges are a very valuable resource. A number of international experts has intensively worked on each of them. Hence, most national Bebras organizers are proud to publish their Bebras tasks after the challenge is over. The international Bebras community puts tasks under a Creative Commons license, and tasks are usually accessible without any cost.

The national Bebras organizers mainly use the following ways to publish tasks:

- Task booklets, which are distributed electronically (PDF format) or in print.
- Online contest archives, which usually allow for solving the tasks once again.

The international Bebras web site provides a few task examples (<http://bebras.org/?q=examples>) as well. In the following, we provide links to some of the national Bebras web sites within Europe where task booklets or contest archives can be found.

### Task Booklets

Austria	<a href="http://www.ocg.at/node/269">http://www.ocg.at/node/269</a> task booklets of Austrian Bebras challenges 2008 – 2014
Germany	<a href="http://informatik-biber.de/ueber-den-biber/download/">http://informatik-biber.de/ueber-den-biber/download/</a> task booklets of German Bebras challenges 2007 – 2014
Italy	<a href="http://kangourou.di.unimi.it/2013/libretto2013.pdf">http://kangourou.di.unimi.it/2013/libretto2013.pdf</a> <a href="http://kangourou.di.unimi.it/2014/libretto2014.pdf">http://kangourou.di.unimi.it/2014/libretto2014.pdf</a> <a href="http://kangourou.di.unimi.it/2015/libretto2015.pdf">http://kangourou.di.unimi.it/2015/libretto2015.pdf</a> task booklets of Italian Bebras challenges 2012/2013 – 2014/2015
United Kingdom	<a href="http://www.beaver-comp.org.uk">http://www.beaver-comp.org.uk</a> task booklets of UK Bebras challenge 2014
Switzerland	<a href="http://informatik-biber.ch/aufgabensammlung/">http://informatik-biber.ch/aufgabensammlung/</a> task booklets of Swiss Bebras challenges 2010 – 2014

### Contest Archives

Austria	<a href="http://biber-moodle.ifs.tuwien.ac.at">http://biber-moodle.ifs.tuwien.ac.at</a> a Moodle-based archive of the Austrian Bebras 2011 challenge
Czech Republic	<a href="http://www.ibobr.cz/test/archiv">http://www.ibobr.cz/test/archiv</a> Online archive of Czech Bebras challenges 2008 – 2014
Finland	<a href="http://www.majava-kilpailu.fi">http://www.majava-kilpailu.fi</a> Online archive of Finnish Bebras challenges 2011 – 2014 To access the archive, choose the age group first, then the year
France	<a href="http://concours.castor-informatique.fr/?tab=home">http://concours.castor-informatique.fr/?tab=home</a> Online archive of French Bebras challenges 2010 – 2014 To access the archive, press “S'entraîner à la maison ...”
Slovakia	<a href="http://ibobor.sk/sutaz_demo/">http://ibobor.sk/sutaz_demo/</a> Online archive of Slovakian Bebras challenges 2007 – 2014



In addition there are a few activities to distribute and use Bebras tasks in other ways:

- The Austrian Bebras challenge offers an Android app with Bebras tasks in the Google Play Store: <https://play.google.com/store/apps/details?id=org.bebas>.
- The Swiss Bebras organizers offer teaching material based on Bebras tasks; each of the six modules links an application area to an informatics topic (like “traffic / optimization”) and combines a teaching video with work sheets and a set of Bebras task matching the topic: <http://informatik-biber.ch/lehrmittel/>

## Impact

Within its first ten years, the Bebras initiative has been on the right track to reach its goals:

- More than 900.000 participants in the Bebras challenges of 33 countries prove that Bebras is easily accessible and allows for massive participation.
- The growing number of participants indicates what is observed by most national organizers: Once a school has been attracted to bebras, it keeps motivating their students to participate. This is due to the positive reactions of both students and teachers. As one 6-year old student in Switzerland put it: “This was really cool, and now I really want to solve each and every task, of all age groups!”
- Also teachers are satisfied with Bebras: In a survey made by the French Bebras organizers, 92% of 280 responding teachers said they would certainly recommend the contest to their colleagues, the remaining 8% said they probably would.
- With its tasks that usually do not require prior knowledge in informatics, by explaining the informatics concepts in the tasks, and by making the tasks widely and freely available, Bebras has found a way to promote informatics and to clarify the image of informatics to a wide audience.

### *Informatics in Schools*

Bebras managed to strongly increase the visibility of informatics in schools. As a proof, you may try a Google search on “Informatik-Biber” (the name of the German bebras challenge). As of today (June 4, 2015) Google delivers about 73.600 results. Most of the pages in the result list – after the official web site and an entry in the German Wikipedia – are school home pages. That is, Bebras has a high visibility in schools, and not only participants learn about Bebras, but also teachers and families of participants.

In countries where informatics is offered as optional subject in schools, teachers let students participate in their national Bebras challenge in order to get an indication on whom to advise to choose an informatics course. We have heard from Australia and Germany, that Bebras is used in such a way to identify informatics talents and to substantiate school career recommendations.

### *General awareness*

In some countries, Bebras has reached a high level of awareness. In Lithuania, Bebras winners have been honored in the Seimas, the national Parliament building. In Germany, Bebras was invited to present itself at the 2013 “open house day” in the Federal Chancellery, as one of a very few educational projects. In France, one of the national Bebras organizers has been appointed coordinator of a group of experts in charge of writing the curriculum for a new (optional) school subject “informatics and digital creation”.



## Bebras Tasks for Teaching

In a survey made by the Czech Bebras organizers, out of 220 responding teachers more than half report to use Bebras task archives in the classroom, for preparation to the upcoming contest but also as part of their curriculum. But Bebras tasks are not used at school only: A college professor from Regensburg (Germany) told us she would regularly use Bebras tasks both in lectures and in oral exams.

Besides such individual use, Bebras tasks have made their way into a few school textbooks already. A German textbook for informatics in the last years of secondary school makes use of two tasks from the German Bebras challenge (Kempe & Löhr 2012, p. 73 and p. 167; see Fig. 5). A Czech textbook on informatics for primary school contains a chapter about programming; on two pages Bebras tasks are included (Vaníček 2012, pp. 44-45; see Fig. 6 for an excerpt).

### Aufgaben

#### 1. Aus dem Informatik Biber 2010

Im Restaurant gibt es normalerweise zwei Warteschlangen. In der einen holen sich die kleinen Biber ihre hohen grünen Teller, in der anderen holen sich die großen Biber ihre flachen braunen Teller. Wegen Bauarbeiten kann es heute nur eine Warteschlange für alle Biber geben. Die Küchenbiber müssen deshalb einen Tellerstapel vorbereiten, der zur Schlange passt: Sie müssen die grünen und braunen Teller so stapeln, dass jeder Biber in der Schlange den passenden Teller bekommt.

Beispiel:



Ein Tellerstapel, der zu der Warteschlange passt.

a) Begründen Sie, in welchem Fall Tellerstapel und Warteschlange nicht zusammen passen.



- b) Modellieren Sie die Situation mithilfe der Klassen *Teller* und *Biber*. Die Teller sollen in einem Stapel (*Stack*) und die Biber in der Datenstruktur Schlange (*Queue*) verwaltet werden. Entwerfen Sie ein Implementationsdiagramm.
- c) Mithilfe eines Programms soll geprüft werden können, ob der Tellerstapel passend zur Warteschlange aufgebaut ist. Entwickeln Sie einen Algorithmus, der dies leistet.

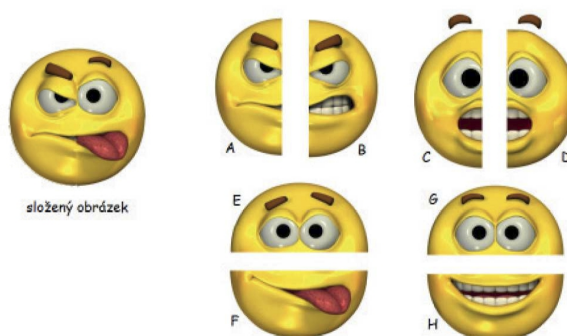
Figure 5: Bebras task used in a German textbook

## PRACUJEME

- 1 Věrka má pět samolepek. Nalepila je na papír a získala tak krásný obrázek. V jakém pořadí samolepky použila? Kterou nalepila naposled a kterou jako první?



- 2 Tomáš rozstříhal obrázky smajlíků. Pak několik z nich složil na sebe a vznikl mu nový, složený obrázek. Jaké obrázky použil a v jakém pořadí je na sebe pokládal?



- 3 Cestu auta ze startovního místa na parkoviště můžeš popsat následujícími příkazy:

- **Dopředu** – jed' rovně k zatáčce nebo k parkovišti
- **Vpravo** – v zatáčce zatoč na místě doprava
- **Vlevo** – v zatáčce zatoč na místě doleva

Která řada příkazů správně popisuje cestu ze startovního místa na parkoviště?

- a) Dopředu, vlevo, dopředu, vpravo, dopředu, vlevo, dopředu, vpravo, dopředu
- b) Dopředu, vlevo, dopředu, vlevo, dopředu, vlevo, dopředu, vpravo, dopředu
- c) Dopředu, vlevo, dopředu, vpravo, dopředu, vlevo, dopředu, vlevo, dopředu
- d) Vlevo, dopředu, vpravo, dopředu, vlevo, dopředu, vpravo, dopředu

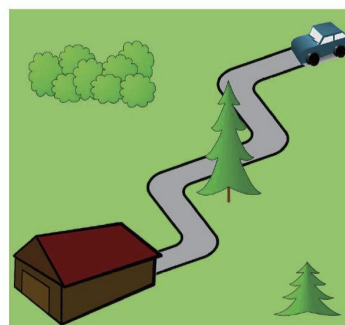


Figure 6: Bebras tasks used in a Czech textbook

### The Bebras Community

In 2014, Bebras challenges were organized in more than 30 countries world-wide, and more countries are to join the initiative. Representatives of potential Bebras organizers from Belarus, Iceland, and Kazakhstan participated in this years Bebras Task Workshop. The tight co-operation at and around the task workshop on one common project has significantly strengthened the links among the individuals involved. As all these individuals are all professionally dedicated to informatics education, Bebras has lead to the formation of a new international community in this area. One of the most interesting properties of this community is that it is constantly evolving and is very open to new approaches and improvements to their procedures.

## Research Activities

Considering the dynamics and open spirit of the Bebras community, it is no surprise that many members of this community are also actively doing research related to Bebras. The international Bebras web site has a long list of Bebras-related publications (which is nevertheless incomplete; several publications in German language are definitely missing). In the References section, we will list selected papers related to Bebras that were published in international journals or conference proceedings.

## References

The international Bebras web site: <http://bebras.org>

### National Bebras Web Sites

Austria	<a href="http://biber.ocg.at">http://biber.ocg.at</a>
Australia	<a href="http://www.bebbras.edu.au">http://www.bebbras.edu.au</a>
Belgium	<a href="http://www.bebbras.be">http://www.bebbras.be</a>
Bulgaria	<a href="http://www.math.bas.bg/bbr">http://www.math.bas.bg/bbr</a>
Canada	<a href="http://www.cemc.uwaterloo.ca/contests/bcc.html">http://www.cemc.uwaterloo.ca/contests/bcc.html</a>
Cyprus	<a href="https://bebras.org.cy/el">https://bebras.org.cy/el</a>
Czech Republic	<a href="http://www.ibobr.cz">http://www.ibobr.cz</a>
Estonia	<a href="http://kobras.ut.ee">http://kobras.ut.ee</a>
Finland	<a href="http://www.majava-kilpailu.fi">http://www.majava-kilpailu.fi</a>
France	<a href="http://castor-informatique.fr">http://castor-informatique.fr</a>
Germany	<a href="http://informatik-biber.de">http://informatik-biber.de</a>
Hungary	<a href="http://e-hod.elte.hu">http://e-hod.elte.hu</a>
Ireland	<a href="http://www.bebbras.ie">http://www.bebbras.ie</a>
Italy	<a href="http://kangourou.di.unimi.it">http://kangourou.di.unimi.it</a>
Israel	<a href="http://davidson.weizmann.ac.il/content/הבונה-המפצח---beaver/">http://davidson.weizmann.ac.il/content/הבונה-המפצח---beaver/</a>
Japan	<a href="http://bebras.eplang.jp">http://bebras.eplang.jp</a>
Latvia	<a href="http://www.bebbras.edu.lv">http://www.bebbras.edu.lv</a>
Lithuania	<a href="http://www.bebbras.lt">http://www.bebbras.lt</a>
Malaysia	<a href="http://beaver.my">http://beaver.my</a>
The Netherlands	<a href="http://www.beverwedstrijd.nl">http://www.beverwedstrijd.nl</a>

New Zealand	<a href="http://www.beaverchallenge.org.nz">http://www.beaverchallenge.org.nz</a>
Poland	<a href="http://www.bobr.edu.pl">http://www.bobr.edu.pl</a>
Russia	<a href="http://bebras.ru">http://bebras.ru</a>
Serbia	<a href="http://dabar.edu.rs">http://dabar.edu.rs</a>
Slovakia	<a href="http://ibobor.sk">http://ibobor.sk</a>
Slovenia	<a href="http://tekmovanja.acm.si/bober">http://tekmovanja.acm.si/bober</a>
South Africa	<a href="http://www.olympiad.org.za/talent-search">http://www.olympiad.org.za/talent-search</a>
Spain	<a href="http://bebras.ehu.eus">http://bebras.ehu.eus</a>
Sweden	<a href="http://bebras.se">http://bebras.se</a>
Switzerland	<a href="http://informatik-biber.ch">http://informatik-biber.ch</a>
Taiwan	<a href="http://bebras.csie.ntnu.edu.tw">http://bebras.csie.ntnu.edu.tw</a>
Turkey	<a href="http://www.bilgekunduz.org">http://www.bilgekunduz.org</a>
Ukraine	<a href="http://bober.net.ua">http://bober.net.ua</a>
United Kingdom	<a href="http://www.beaver-comp.org.uk">http://www.beaver-comp.org.uk</a>
USA	<a href="http://www.bebraschallenge.org">http://www.bebraschallenge.org</a>

## Publications

### *Textbooks*

Vaniček, J.: Informatika pro 1. stupeň základní školy. Prague: Computer Press, 2012

Kempe, Th., and Löhr, A. (eds.): Informatik 2 – Modellierung, Datenstrukturen und Algorithmen. Schöningh Schulbuchverlag, 2012

### *Selected Research Papers*

Bell T., Curzon P., Cutts Q., Dagienė V., and Haberman B: Introducing Students to CS With Programmes That Don't Emphasise Programming. In: Proceedings of the 16th annual conference on innovation and technology in computer science education (ITiCSE'11), pp. 27–30. Darmstadt, Germany: ACM, 2011.

Bellettini, C., Lonati, V., Malchiodi, D., Monga, M., Morpurgo, A., and Torelli, M.: How Challenging Are Bebras Tasks? An IRT Analysis Based on the Performance of Italian Students. To appear in: Proceedings of the 20th annual conference on innovation and technology in computer science education (ITiCSE'15). Vilnius: ACM, 2015.

Dagienė, V., and Futschek, G: Bebras International Contest on Informatics and Computer Literacy: Criteria for Good Tasks. In: Mittermeir, R., and Syslo, M. (eds.): Informatics Education. Supporting Computational Thinking (ISSEP 2008). Lecture Notes in Computer Science, vol. 5090, pp. 19–30. Berlin, Heidelberg: Springer-Verlag, 2008.

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