Bringing informatics concepts to students through e-activities and contests

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***Abstract*—**The very fast evolution of Internet is stimulating changes in all sectors and economies globally. Information and Communication Technologies (ICT) provide us enormous opportunities about any subject, how learning and teaching, for all levels of education, in a ubiquitous web-based format, and in ways that were inconceivable a few decades ago. However, effective application of ICT in education continues to be a challenge worldwide.

In several countries, different actuations in the educational systems are being developed. In Europe, this development has as main novelty eight basic competences to be acquired by all pre-university students, but ICT is mainly being used to sustain or support existing pedagogical approaches as opposed to being used to transform teaching and learning.

The development of training and learning activities in virtual contexts must be considered a key element in the educational planning. E-activities can be a very good tool for improving abilities and skills of different subjects. And contests are a way to implement e-activities in the per university educational system. The International Contest on Informatics and Computer Fluency, called Bebras, can be an example of bringing informatics concepts to students in an informal way.

***Keywords*—**Contents, digital competence, e-activities, learning, pre university education, transversal competences.

I. Introduction

IN 2006, the European Parliament and the Council [2] published a recommendation identifying eight Key Competences for Lifelong Learning: Communication in the Mother Tongue; Communication in Foreign Languages; Mathematical Competence and Basic Competences in Science and Technology; Digital Competence; Learning to Learn; Social and Civic Competences; Entrepreneurship; and Cultural Awareness and Expression. Four years afterwards, the value of this recommendation is recognized in the Europe 2020 Strategy [3]. The 2006 recommendation already points to Digital Competence as a fundamental basic skill. Digital Competence is there defined as follows:

"Digital Competence involves the confident and critical use of Information Society Technology (IST) for work, leisure and communication. It is underpinned by basic skills in ICT: the use of computers to retrieve, assess, store, produce, present and exchange information, and to communicate and participate in collaborative networks via the Internet." [2].

This definition takes into account several matters not only related to the use of ICT, but belong to them related to Computer Science. Moreover, the implementation of the idea can be extended to different levels of education –from Primary schools to University-, different fields or subjects –from subjects related to Humanities to Science, through Health or Business and Law- and different states in the life –for young or elder people, for employed or unemployed persons, etc.

Basic competencies are not tied to a particular subject, but to all. The basic competencies must be acquired from all subjects and areas. This implies a conception of curriculum that goes beyond the juxtaposition of the contents of each subject. The acquisition of basic skills required to build bridges among subjects for integration of contents. This integration must be meaningful, that is, to produce knowledge. Thus, it is trying students to have the capacity to confront and solve new problems and to use ICT efficiently.

And we can not forget that the fourth basic competence is "information processing and digital competence", digital competence defined as the knowledge of the essential characteristics of information processing; basic uses; basic knowledge of networks in general and Internet; operation and services offered by these networks, risks and protections to ensure safety in use and the rights and freedom of people in the digital world.

In addition, the European Union has defined the fourth, among 16 indicators of educational quality, to ICT.

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II. ICT AND EDUCATION HAVE A COMMON PATH

In the current and near-future educational context, education systems are governed by the acquisition of competences by students. In addition, new technologies are no longer an object available to few persons and their presence, or potential presence, has generalized in all areas of life, including education.

In Spain, not only the current Spanish Law of Education, but the one recently approved, clearly marks the competences that should be acquired by students, including the Digital Competence.

We have also to take into account that in other competences, such as the linguistic competence, which is evaluated by the international PISA report for student performance, not only understanding continuous texts is under consideration, but also the discontinuous texts, which consist of graphs, charts or diagrams, widely used in ICT. Specific treatment of ICT, integrated into the subject to be taught, provides a unique opportunity to develop the competence for information processing and the digital competence.

As it is said in the new Spanish Law of Education, "the widespread incorporation of Information and Communication Technologies (ICT) in the educational system will personalize education and adapt to the needs and pace of each student. On the one hand, it will reinforcement and support in cases of poor performance and, on the other hand, it will expand the knowledge taught in the classroom without limitations. Students with motivation can thus access, according to their learning ability, to the educational resources that many national and international institutions are providing. ICT will be a fundamental piece to support the methodological change in order to achieve the goal of improving educational quality. Likewise, the responsible and orderly developed use of these new technologies by students must be present throughout the educational system. ICT will also be a key tool in teacher training and in for lifelong learning, since they enable citizens to combine training and learning with personal or work obligations and to manage processes".

However, Spain is lagging behind, being the penultimate of the 27 members of the European Union on the use of the internet for educational activities, including school and university (according to the report Catalonia 4.0 [4]), although 98.6% of the public centers (Primary and Secondary) and 98.3% of private centers had internet connection during the 2005/06 academic year. And being the difference between Spain and the European Union, regarding the great majority aspects of ICT equipment, only tenths of a percent. So the problem is not technical or of equipment. For example, Lithuania, a country where contests are normally used for education, is the first country in the European Union in the list of Internet use for educational activities.

For modern economies, knowledge, rather than resources, represents the main pathway to growth. In these economies, in addition to the more obvious cost cutting reasons, the needs for qualified people with appropriate expertise and experience have forced many enterprises to offshore part of their operations. In the recent past, the skills shortage and gap for ICT expertise plays a major role in this process. With lower enrollment in tertiary level courses, the break between available and required degree-qualified workforce is rapidly growing. The problem is aggravated in most countries with the general tendency of lowering the public funding for higher education sector. The problem is predominantly alarming, for ICT education being also hit by lower student numbers. Additionally, with the rapid intensification of the use and need for ICT services, the retraining and education of current workforce in this area is inevitable. To tackle these issues realistically, there are clear needs for increased public funding, as well as recognizing ways to expand the collaboration between industry and ICT education providers. Furthermore, ICT education and industry need to find ways to spread the inspiration of the discipline and make it more attractive and appealing to high school students. High school curriculum must also be looked at and redeveloped to make them inspirational, up-to-date, and imaginative [5].

III. LEARNING ACTIVITIES IN VIRTUAL CONTEXTS

The development of training and learning activities in virtual contexts must be considered a key element in the educational planning, as the acquisition of knowledge by the learner will depend on these activities, to a large extent. Hence, its design must be careful to achieve a high level of involvement, motivation and interest in the subject, while an autonomous, active and constructive learning is favored beyond mere memorization of content [6].

The development of mobile communication will have a significant influence on the future of our learning and knowledge, whose focus is a new dimension of informal learning [7].

The activities through virtual contexts are referred to as e-activities ([6], [8], [9], and others), which refers to all actions that aim to facilitate the process of teaching and learning through the network [10]. Through the e-activities, students put into play abilities and skills of various kinds, which together with the use of Information and Communications Technologies (ICT), make possible the learning, both individually and as a group. Following Barberá [8], the formative e-activities refer to a set of sequential tasks or interlinked among themselves to achieve the educational objectives.

The formulation, design and implementation of formative e-activities can serve different purposes, for example:

- awakening the initial motivation of the learner to the subject, incorporating in them tasks that progressively increase their level of conceptual complexity;
- e-activities with a training aim, oriented to achieving cognitive objectives;
- or those markedly evaluative, which confirmed the level of student's progress.

When we will design the e-activities, we must make a major effort oriented towards addressing the diversity of learning styles that learners have, since the pedagogical implications arising from their cognitive preferences are normally different. These implications are referred to the fact that each person uses his own method or strategies in learning. However, the implementation of either strategy will be conditioned by the educational interests of each person, as pointed Cazau [11].

From another point of view, Keefe (1998) -mentioned by [12] - defines learning styles as cognitive, affective, and physiological traits, which serve as relatively stable indicators of how learners perceive, interact and respond to their learning environments.

Basically, there seems to be some consensus when they are identified as the characteristics of a person, relatively stable, although they are susceptible of changes and improvements over time, adapted to the different situations that this person can pass through; and if they are taken into account when designing learning activities, students can learn more effectively.

Therefore, if we inquire into the different ways of categorizing existing cognitive styles, we found a large number of theoretical studies that have addressed the analysis of them. Silver, Hanson and Perini [13] provide a classification based on four types:

- The Mastery style learner absorbs information concretely; processes information sequentially, in a step-by-step manner; and judges the value of learning in terms of its clarity and practicality.
- The Understanding style learner focuses more on ideas and abstractions; learns through a process of questioning, reasoning, and testing; and evaluates learning by standards of logic and the use of evidence.
- The Self-Expressive style learner looks for images implied in learning; uses feelings and emotions to construct new ideas and products; and judges the learning process according to its originality, aesthetics, and capacity to surprise or delight.
- The Interpersonal style learner, like the Mastery learner, focuses on concrete, palpable information; prefers to learn socially; and judges learning in terms of its potential use in helping others.

Meanwhile, Honey and Mumford [14] establish four cognitive styles (activist, theorist, pragmatist and reflector), based on the model proposed by Kolb [15], which in turn are the four phases of a cyclical learning process: action, theorizing, experimentation, and reflection.

This research is based on the theoretical studies developed by Honey and Mumford [14], which establish the four cited cognitive styles:

- Activists involve themselves fully and without bias in new experiences. They enjoy the here and now, and are happy to be dominated by immediate experiences. They are open-minded, not sceptical, and this tends to make them enthusiastic about anything new.
- Theorists adapt and integrate observations into complex but logically sound theories. They think problems through in a vertical, step-by-step logical way. They assimilate disparate facts into coherent theories.
- Pragmatists are keen on trying out ideas, theories and techniques to see if they work in practice. They positively search out new ideas and take the first opportunity to experiment with applications.
- Reflectors like to stand back to ponder experiences and observe them from many different perspectives. They collect data, both first hand and from others, and prefer to think about it thoroughly before coming to a conclusion.

For an optimal learning, it is necessary to cross the four phases. This involves designing learning activities for each of them. Thus, the learning of all students will be facilitate, regardless of their predominant cognitive style, and it also helps them to strengthen those styles which have lesser degree [16].

Therefore, the e-activities should be designed aimed at dealing with the learning preferences of the learners through the implementation of practical training that will give them the opportunity to develop various skills based on their cognitive preferences, with the ultimate goal of optimizing the process acquisition of new learning.

ICT can contribute very effectively to make possible an instructional design that considers the performance of different types of activities, based on the Virtual Learning Environments, using digital tools to facilitate monitoring of training activities in which students participate; and the organization and management of the own learning process. Similarly, the use of these technological tools, both in virtual and blended learning, favors a more active participation of learners and greater ability to interact with users through which we can establish new forms of social relationship that can enhance learning.

In addition, we should mention that the formulation of activities of group nature or for individuals, which deal with the cognitive diversity of students, helps student to acquire and consolidate both specific competences, that is, the competences of his profile, and generic or transversal competences, categorized into instrumental, interpersonal and systemic, according to the project Tuning Educational Structures in Europe [17]:

1. Instrumental competences: related to cognitive skills and methodological capabilities for environmental adaptation, as well as technological and language skills.
2. Interpersonal skills: those related to skills required to develop a process of criticism and self-criticism, as well as social skills used in the implementation of a collaborative work.
3. Systemic competences: in relation to the ability to integrate understanding, sensibility and knowledge that allow to give an overview of the global reality.

According to Benito [18], it is not easy to define unambiguously what the teaching quality is because there is no single definition or a unified criteria of what is teaching quality; there is a certain relativism depending on which the goals of the education system that are taken into account are or which actors are implied in this scenario, as De Miguel [19] mentions. When quality is understood in terms of production, different concepts are emphasized: knowledge, time invested in making profitable investment, investment profitability, or frequently customer satisfaction.

Harman and Lynn [20] found ambiguous the term teaching quality and after reviewing the meaning attributed to the term, they conclude that its meaning is the level of the scope of a target scope and the value of such scope; or what is the same, the measure in which certain outputs or activities have a few predetermined characteristics according to certain previously established standards or criteria. In this sense, it is closer to what Ball [21] calls adjustment to the aims or intentions.

As Aguaded, Guzman and Pavón said [22], if we wish excellence in university and that the university professorship is capable of joining and becoming author of the knowledge society, undoubtedly one of the basic needs which we meet is the development of competences necessary for the integration of ICT in their teaching and research practice. That is, that we will have to use in minor measure the methodologies centered on the teacher (characterized like explanatory and passive) to be evolving towards methodologies and e-activities focused on the student (active, dynamic and participative) [23].

In an analysis performed by Ewell [24] on the current characteristics of university education quality scenarios, highlights the emphasis on, among others, developing deep skills and cognitive skills to solve problems. It is therefore recommended that in previous stages, pre-university stages, gradually work these skills and abilities with activities such as those intended to carry through this research.

Moreover, the information society with its associated phenomena, globalization, mobility, primacy of knowledge, etc., has significantly modified the language objectives for the XXI century. Thus, the Council of Europe has made in recent years two general goals for the coming decades: multilingual training and education for multilingualism.

In the field of multilingual training, the objective is developing different linguistic repertoires and it is stated that, in the near future, European people must know three, four or more languages, and in the field of education for multilingualism, it is proposed a modification of language attitudes in the sense of making more tolerant European people in the face of the linguistic diversity.

In fact, in the last years, the pressure on school education has increased in order to, along compulsory education, students acquire acceptable competence in one or two foreign languages.

Indeed, actions taken, for example, advance their education, firstly to the cycle of Primary School and now in Nursery School, do not solve some historical problems of education systems on this issue, particularly in Spain [25], [26], [27], but did express concern by the educational authorities about of the importance of the development of linguistic competences in foreign language or languages.

In this scenario, contests as Bebras can be a good starting point. This is a contest used in non-university centers throughout Europe and it is starting to be implemented outside Europe in countries such as Canada and Japan.

The main objective of the Bebras contest is to promote among students of non-university education ICT, and Informatics and Mathematics as support for these technologies.

With this activity we try students to see an entertaining use of ICT, that these technologies appear in everyday life in a more common way we think of, and we want to promote the intensive use of modern technologies in education. Thus, this contest should help children become interested and know more about computers and the application of ICT from the start in schools, from Primary to High School.

Bebras should enhance the use of new technologies in the learning activities of students in a more intense and creative way. It should involve all students in schools and encourage them to exchange ideas and share experiences.

As ICT have become common tools of education, this playful contest could ensure that children alike benefit from these technologies. We hope Bebras encourage students to learn these skills and knowledge that they will need in the future labor market.

Therefore, in this scenario the e-activities are used within virtual contexts, increasing the use of ICT to improve teaching quality and to support at the same time the multilingualism.

These activities are clearly encouraging in the countries that apply them the incorporation of new technologies in the field of non-university education and are allowing to have a reference to compare the implementation of ICT in different European countries [28].

IV. Contests on Programming for General Education

Developing abilities to master modern technologies and skills for solving problems is among the most important capabilities of an educated future citizen of an information society and it can be straight connected with informatics education [29].

While there many indications of the need for qualified ICT workforce, not enough students choose to study this discipline to follow a career in ICT. A specific reason for that, has been attributed to problems with computing and IT curriculum development in high schools. The lack of creativity and restricted teaching of material that new generation students are already fluent in, have resulted in students being turned off ICT as a career path. These teachings have given the students the misconception that ICT is merely about keyboard skills or the ability to work with some packages like Microsoft Office, Word, Excel, or just browsing the Internet. These have been documented to show that in UK there has been a 50% decline

in students taking Alevel Computing as they find Computing dull, signifying the need to make a distinction between the very basic computing literacy skills taught in high schools and the creative ICT curriculum in higher education institutions [30].

In the most of the educational centers of the majority of European countries there is not a problem the informatics equipment or the internet connection. Moreover, in almost all curricula, along the pre university education, computers are used in a major or minor way. Sometimes, because students use the computers in during "normal" classes and other times because they go to the laboratory to develop some exercises by using computers. So the concept of programming, of understanding the information processing, of being able to read an algorithm, etc., is a real and very present skill that students must obtain and develop in schools.

Programming, with emphasis on algorithms, remains the core of several worldwide contests, e.g. International Olympiad in Informatics (IOI) and the USA Computing Olympiad (USACO). The USACO holds six internet-based contests each year and has several difficulty divisions [31].

According to Dagiene [29], in developing teaching of programming, they recommend considering the attractiveness of instructional methods and consolidation of pupils' motivation. The following aspects should be taken into account:

- For school students, practical activities are much more interesting and attractive than academic studies.
- Elements of contests and competition stimulate the learning process.

More time should be dedicated to the motivation, aims, connection between practice and theoretical concepts, and especially to the internal context of the presented theory.

Programming is an activity composed of several components: comprehension of the problem, choosing algorithm, encoding it, debugging, testing, and optimizing [32]. Since many of the skills required for successful programming are similar to those required for effective problem solving, computer programming and particularly choosing one of several possible solutions and later debugging in a short period of time, provides a fertile field for developing and practicing problem solving skills in an environment that is engaging for young students [33].

In the programming contests, pupils use and develop, at the same time, their problem solving skills. Furthermore, pupils especially gifted can be challenged by problems that cannot be solved by applying learned mechanisms, but that require special talent, mental abilities, and probably extraordinary effort, too.

There have been many academic competitions and contests in computer science throughout all over the world. Most of them are programming contests with focus on algorithmic problem solving. There are several contests covering other scientific areas, most prominent examples are contests in robotics: Robocup Junior and First League. There are mixed contests that cover different areas, for example, the American Computer Science League (ACSL). The contests of the ACSL mostly consist of a short answer test and a programming problem. A short answer test contains five questions from categories like number systems, logic, Lisp, data structures, graph theory, digital electronics and WDTPD (What Does This Program Do). Typically answers are very short. The programming problem is solved by submitting a program source code within 72 hours. Framework of classification on computer science contests for secondary school students is provided by Wolfgang Pohl in [34].

There are two main paradigms for implementing contests: from an international level to the local one (top-down strategy), and vice versa, from local activities to an international promotion (bottom-up strategy). The first paradigm is a challenge to find some suitable international contests, analyze, train students, and join them after intensive work. The second paradigm stresses an opportunity to establish the local contest and attempt to develop it to an international level. The IOI is a contest referred to the first competition paradigm while the Bebras International Contest on Informatics and Computer Fluency belongs to the second paradigm.

V. BEBRAS CONTEST

In 2007, the OECD Centre for Educational Research and Innovation (CERI) launched the New Millennium Learners (NML) project [35]. It has the global aim of investigating the effects of digital technologies on school-age learners and providing recommendations on the most appropriate institutional and policy responses from the education sector.

The concept of New Millennium Learners suggests that the technology uptake, particularly by younger generations, has an effect on the way people build their identities, communicate socially, and manage information and knowledge. However, the fact that young people are increasingly attached to and knowledgeable in terms of technology does not necessarily mean that they develop by themselves the range of skills and competencies that the knowledge economy requires [36]. Today's children are thought to be flexible with computers, immediate to communicate, creative with technology, and highly skilled at multitasking in a world where ubiquitous connections are taken for granted [37].

Bringing informatics in a formal track to schools by means of curricula is quite important. However, it is necessary to support the informal ways of introducing students to informatics. So another way to bring informatics to school can be through developing attractive activities based on informatics concepts. Contests are among them. Contests are exceptionally valuable for motivating and involving pupils in computer science [29].

Several programming contests and olympiads [29], [38] are arranged globally on a regular basis, supporting almost all fields of education: Mathematics, Informatics, Biology, Chemistry, Astronomy, etc.

The aim of these contests and olympiads is usually to promote their fields and detect talented students through examinations. The olympiads have certainly generated considerable excitement and interest among the meritorious and motivated students of the world. This is evident from the increasing enrolment of students for doing these events. They try to encourage young students to strive for excellence but they also promote competitiveness among students, which means there are winners and losers. This latter sometimes does not help greatly to the promotion of Informatics or Mathematics or what the field is, but the frustration of certain students. So, in the usual format, these events are not a suitable way for promoting Informatics (or other field) for the majority of students.

The idea of a contest in informatics that every child could take part in, and learn basic informatics concepts from, was proposed in Lithuania [39].

The International Contest on Informatics and Computer Fluency (named Bebras in Lithuanian, or Beaver in English, www.bebras.org) can be an example of bringing informatics concepts to students in an informal way. The Bebras contest started in a coordinated way: running contests at schools, where solutions may be submitted to some central authorities or some local organizers.

Any contest needs a challenging set of tasks. The Bebras tasks' developers are seeking to choose interesting tasks (problems) for motivating students to deal with computer science and to think deeper about technology. Collaboration in developing Bebras tasks during international workshops reveals six concepts significant for general informatics education [40], [41]:

- **Information:** the conception of information, its representation (symbolic, numerical, graphical), encoding, encrypting;
- **Algorithms:** action formalization, action description according to certain rules;
- **Computer systems and their application:** interaction of computer components, development, common principles of program functionality, search engines;
- **Structures and patterns:** the components of discrete mathematics, elements of combinatory and actions with them;
- **Social effect of technologies:** cognitive, legal, ethical, cultural, integral aspects of information and communication technologies;
- **Informatics and information technology puzzles:** logical games, mind maps, used to develop technology-based skills.

These tasks are prepared by the countries that are participants in Bebras, whose number has been increased since 2004, when Lithuania started with the first Bebras contest. The last available statistics are from 2013, when 29 countries took part in this contest with more than 700,000 students [42].

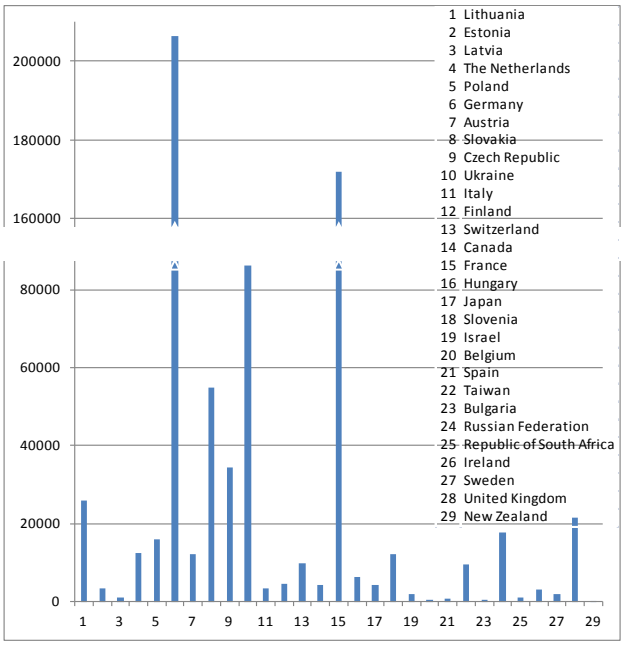

Fig. 1. Number of participants in Bebras in 2013.

The Bebras contest implies students from 8 to 18 years old corresponding to Primary, Secondary and High School. These levels are divided in five age groups: Mini (grades 3-4, age 8-10), Benjamin (grades 5-6, age 10-12), Cadet (grades 7-8, age 12-14), Junior (grades 9-10, age 14-16), and Senior (grades 11-12, 16-18). Normally all countries develop this contest for groups from Benjamin to Senior, and some of them also for the group Mini.

The main goals of the Bebras contest are to raise all students' awareness of informatics and evoke interest in the field, as well as to motivate students to understand its fundamentals and become fluent with the technology, e.g. to be able to communicate with a machine [43]. The contest should help children get interested in informatics and to stimulate thinking about contributions of informatics to science at the very early stage of their education. Since informatics is not a subject in its own right in many countries [44], this kind of contest might be one way, or even the only way, to introduce children to what informatics really is.

Number of participants is quite different among countries and it depends on several variables. Table I shows these numbers for four Bebras countries distributed in the age groups in 2013. In Spain, the first official contest was organized in this year, 2013. Finland organized its first national contest in 2010 and Sweden in 2012. The number of participants has increased in both countries from the beginning (1472 in Finland, 1625 in Sweden), and in 2013 there were 4434 participants from Finland and 1798 from Sweden. Participation numbers usually increase rapidly, sometimes even double on an annual basis, during the first years [43]. Compared to other countries, Lithuania has a very high participation rate: in 2013 over 25 000 students (0,9% of the population) participated in the contest.

Table I. Distribution of participants in Bebras contest in 2013 in four countries.

	Finland	Sweden	Lithuania	Spain
Mini	826	262	2176	-
Benjamin	852	201	7022	63
Cadet	1294	451	6550	375
Junior	1281	413	6490	238
Senior	170	471	3671	112
Total	4423	1798	25909	788

VI. Conclusion

ICT can contribute very effectively to make possible an instructional design that considers the performance of different types of activities. Knowledge is interconnected with the cultural tools we have, and not only with "content", and tools change over time. It is important to have knowledge-building skills, not specific technology skills.

The improvement of digital competencies or related skills can be an important additional goal or side-effect in settings where technology is used in education for other purposes, mainly learning of some subject domain content. Contests can be a very powerful tool in order to obtain these goals. In this way, some contests and particularly Bebras contest should improve and make easier the learning of different subjects, since Bebras is a non-competitive contest that can reach to all levels of education and to the majority of students. Concepts developed by the tasks included in Bebras are used not only in Informatics but in other subjects.

Students are full of potential and Bebras is a tool to elevate the importance of technology strategy, ICT and Informatics use in teaching curriculums.

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