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Participation in iGEM Competition; Education toward Synthetic Biology Innovation

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Abstract

Synthetic biology knowledge has been enhanced around the world through a ´learn by doing´ approach. The iGEM competition is being used as a catalyst to get students involved in molecular biology, mathematics, and physics multidisciplinary research and application. This groundbreaking method has reached its 10th anniversary and is going viral through the academic community. This strategy is transforming science by encouraging creative ideas and innovation in academic research, which could be a major advantage for South America technological development.

Keywords: Synthetic biology; iGEM; Education; Biotechnology

Review

The iGEM competition (International Genetically Engineered Machines), was created in 2004 by the MIT (Massachusetts Institute of Technology), it celebrated its 10th anniversary last October. It already counts with 1,243 collegiate teams from universities from all around the world [1-3]. The competition, which resembles the robots student-oriented engineering competitions, uses biological platforms (bacteria, yeast, plants, among others) to develop solutions/products to our over-growing society's problems through synthetic biology. The students that participate in the competition learn basic principles of molecular engineering improving their education by resolving worldwide problems. Even more exciting is to see the projects that this community of motivated students was able to develop along the last 10 years, some teams developed more than one project per year and most of them deal with "real world" applications (Table 1). The iGEM has encouraged, all around the world, the student's protagonist in the design and standardization of biological material as a new source of manufacture that can be applied in several fields. The project's distribution during iGEM 2013 was the following: health and medicine (40 related projects), environment (36 related projects), food and energy (25 related projects), manufacturing (13 related projects), information processing (12 related projects), software (8 related projects), entrepreneurship (4 related projects), foundational advance (29 related projects) and new application (24 related projects) [1]. The iGEM features enhance the participant's skills in key biotechnological project creation phases; brainstorm and problems/solutions-identification, planning and design of genetic circuits, development and debugging of the biological functions/applications, sometimes even technology scaling [1].

This knowledge will be "game changer" for the future of the biotechnology industry. The open source community around iGEM has a worldwide impact. Nevertheless, the South American participation (5.3%) along these 10 years is small when compared to the North American (38.6%), the European (28.3%) and the Asian (27.8%). Africa has only participated twice while Asia has presented a fast growth in the number of teams at the competition (Figure 1).

Most of biotechnology companies in the South America region focus in the sales sector, not in the research and development area, except for companies/organizations such as Amyris (Biofuel), EMBRAPA (Brazilian Corporation of Agricultural Research, focus on biofuel and crops), Braskem (chemistry), CTC (Sugarcane Research Center, focus on biofuels) and the IAC (Agronomical Institute of Campinas, focus on sugar biorefineries). The knowledge and courage to change this scenario of a new generation of South American scientist/inventors could come from the experience learned from the iGEM. South America biotechnology currently is focused on the biofuels (Brazil, Argentina, Chile, Colombia), genetically modified crops (Argentina) and vaccines (Brazil and Cuba). Still, there are plenty other areas in the modern biotechnology scenario with a lack of investment, development and human resources. Brazil has few big biotechnology companies when compared to industrialized countries; most of them work with biofuels and related chemistry. Among small companies, a more diverse scenario is reported, FAPESP (São Paulo Research Foundation) has granted 3,146 grants and fellowships among different fields from health and chemistry to agriculture [4]. Brazil as a case study, which has the 7th biggest GDP (Gross domestic product) in the world and the first in Latin America [5], shows that this region has the capacity/necessity of technological expansion. Unfortunately, translating academic research and spin-offs to market applications has been limited [6]. Nevertheless, the conditions to improve this rate are emerging. Brazil published 49,819 scientific publications in 2011, which counts for the 54.7% of the Latin-American production and 2.26% of the world production [7], it also educated 8,430 PhDs in 2010 [8]. Brazil invested 1.16% of GDP in science and technology in 2010, while the United States, one of the leaders in technology, invested 2.83% in the same period [9]. It also produced 33,395 patents in 2012 [10]. Characteristics that are important, however, remain ineffective without "real world" market application of the generated knowledge in solving the regional problems. The newborn synthetic biology industry could find a fertile environment in Brazil, a country that has the characteristics to emerge in the field. Also, it could use the experience that the students have learned from the iGEM. The year

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Year	Environment	Food or Energy	Health and Medicine	Manufacturing	New application	Number of teams
2004					Photographic bacteria UT Austin Team	5
2005					Caltech Team	13
2006	Arsenic biosensor Edinburgh Team		Tissue generation in mammalian Princeton Team			32
2007	Self-powering electrochemical biosensor Glasgow Team	Butanol production using bacteria Alberta Team	A synthetic biology approach against HIV Ljubljana Team		Extensible logic circuit in bacteria USTC Team	54
2008	Electrical reporting system to detect toxins in water Brown Team	Bacterial biosensors with electrical output Harvard Team	Immunobricks against *Helicobacter pylori* Slovenia Team	Biofabricator using *Bacillus subtilis* Imperial College Team	Engineer epigenetic control of gene expression USTC Team	84
2009	E. Chromi, a kit for biosensors construction Cambridge Team	Ethanol production through whey metabolization UNIPV-Pavia Team	Immuni-T. coli, a probiotic approach to diagnosing and treating inflammatory bowel disease Standford Team	The E.ncapsulator, a drug production and delivery platform Imperial College Team	Lighting Cell Display Valencia Team	112
2010	Heavy metal bioreporter and bioabsorbent Pekin Team	agrEcoli, detects and signals the presence of nitrates BCCS-Bristol Team	AAV 'virus construction kit', gene delivery using viral vectors Freiburg Bioware Team	Controlling the production of an organized biostructure MIT team	Platform of DNA-guided scaffold to arrange various functional protein domains Slovenia Team	130
2011	A Biosensor for Naphthenic Acids Calgary Team	Make It or Break It, diesel production and gluten destruction Washington Team	Tissue self-construction to achieve specific patterns of cell differentiation MIT Team	Cell-free method to produce complex biomolecules Cornell Team	Synthetic biology tools for space exploration Brown-Stanford Team	165
2012	bWARE, mechanisms of biosafety in synthetic biology Paris Bettencourt Team	Food Warden, system that detects meat spoilage Groningen Team	Bistable toggle switch for mammalian cells Slovenia Team	Arachnicoli, spider silk production in *E. coli* Utah State Team	Beadzillus, biobricks collection from *B. subtilis* LMU-Munich Team	190
2013	Physco Filter, transgenic moss capable of reducing contamination TU Munich Team	FerryTALES, biosensor identify cattle that excrete *E.coli* O157:H7 Calgary Team	Cardiobiotics, prevent cardiovascular disease by reducing the metabolism of dietary L-carnitine UIUC Illinois Team	Plasticity, bioplastic production from mixed waste Imperial College Team	WormBoys, first artificial synthetic symbiosis with bacteria engineered to ride on worms Valencia Biocampus Team	215

*2014 iGEM was not over at the time this document was written.

*The selection of the projects intends to give an overview of the projects application and not to qualify the projects relevance when compare to others.

Table 1: Selection of representative applied projects along the 9 years iGEM competition [data extracted from 1,2].

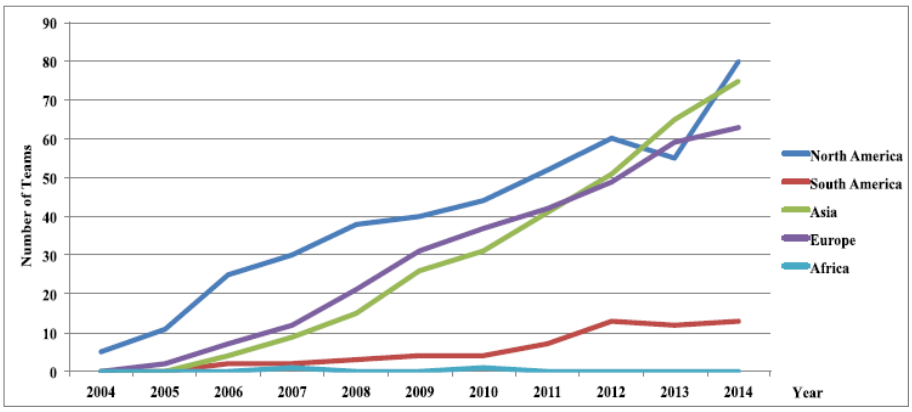

Figure 1: Number of iGEM teams per region each year [data extracted from 1,2,3].

2014 was the fifth Brazilian participation in the iGEM competition. The two first participators, 2009 (http://2009.igem.org/Team:UNICAMP-Brazil) and 2011 (http://2011.igem.org/Team:UNICAMP-EMSE_Brazil), were from the UNICAMP University with a single team each year. In 2012 a single team conformed by two Brazilian universities, USP-UNESP (http://2012.igem.org/Team:USP-UNESP-Brazil) participated. The 2012 team made an effort to promote synthetic biology among the students and the academic community, helping to expand the number of participants in 2013. That year for the first time Brazil had three teams participating from different corners of the country: Amazonas, São Paulo and Minas Gerais [10]. The 2014 competition had these same three regions participating plus a new team from Recife. As Brazil, the South American countries are also expanding their participation in iGEM. Nevertheless, we need to enhance politics and educational incentives to participate in this type of events and cultivate the "learn by doing" culture in our next generation of scientists, hoping to boost the impact of these initiatives in Latin American biotechnology industry.

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