

iNVESTIGA: Connecting the Colombian Scientific Diaspora with Secondary Schools in Colombia

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Abstract: According to recent studies, Latin America is the region with the highest emigration rate in the world, specially affecting the highly educated population. One of the consequences of this process is the expansion of business and scientific diasporas. Colombia has launched multiple projects trying to keep contact with its scientists working abroad, but those initiatives have suffered multiple economic and political limitations. Additionally, technology did not support correctly the processes that could help the diaspora to contribute to projects from their country of residence. However, Internet nowadays allows synchronous communication providing new interactive tools to connect people. In this work we present iNVESTIGA, a project connecting the Colombian scientific diaspora with secondary schools in Colombia using technological resources. We highlight multiple advantages, e.g. increasing students' eagerness for learning, teachers' willingness for presenting innovative materials to their students using technology, and allowing scientists to contribute to projects in their home country. We present the results of three videoconferencing sessions connecting Colombian scientists with secondary schools in Yopal, Colombia. A posterior analysis of these experiences showed that current technologies support this interaction between partners in spite of the physical distance, with great benefits for students, teachers and scientists.

Keywords: videoconferencing, distance education, scientific diaspora, Colombia, digital education

Introduction

Nowadays, human migration is an international fact experienced by every country in the world. This behavior has considerably increased between 2000 and 2010, being Latin America the region with the highest emigration rates (Arslan et al. 2014). This phenomenon has also affected migration of highly educated population. The Migration Policy Institute has reported that emigration of people with tertiary education in low-income countries represents the 24 percent (Newland and Plazas 2014) and Latin America has perceived a growth of two thirds in the number of high skilled emigrants between 2000 and 2010 (Arslan et al. 2014). Additionally, recent reports from the World Economic Forum have shown that most of the Latin American countries have problems retaining and attracting talent, excepting cases like Chile, Panama and Costa Rica (WEF 2015). This data has been strongly corroborated by the IMD World Competitiveness Center who situates countries like Colombia, Peru and Venezuela in the last twenty places of the rankings in talent retention and high skilled emigration (IMD 2015). This “*brain drain*” process has captured the attention of the governments of multiple Latin American countries and has highlighted the necessity for developing new strategies, policies and mechanisms in order to transform the negative effects of high-skilled human emigration into a constructive “*brain circulation*” allowing skilled people to extend their knowledge in other countries, but also contributing to the competitiveness of their countries of origin.

The Colombian case has attracted the attention of multiple researchers and institutions. Multiple initiatives led by the government and/or some independent organizations have tried to connect the scientific diaspora with Colombia (Chaparro et al. 2006, OCyT 2013, Tejada and Bolay 2010, UNESCO 2015). Some examples of these projects held by Colombia's Administrative Department for Science, Technology and Innovation (Colciencias) are: a network of Colombian expatriates working in science (*Red Caldas*), new policies and advantages to attract scientists to return to the country (*Es hora de Volver*), and scientists working abroad visiting schools in Colombia to develop courses or short projects (*Clubes de Ciencia*). However, the country still needs more investment on these projects to take advantage of all the advanced knowledge acquired by the diaspora. Additionally, Tejada and Bolay (2010) highlight the willingness of Colombian scientists to contribute into projects running in their home country, particularly in education and social activities. Therefore, this context presents a notable opportunity to develop new ideas that enhance the education quality, considering that Colombia has been ranked among the countries with the worst results in the PISA survey, and it has been placed within the last ten places in countries with less emphasis in science in the schools (IMD 2015).

On the other hand, several studies in countries with distinct economic conditions have published encouraging results on the positive impact of creating links between the scientific community and schools. Woods et al. (2015) expose the results of short face-to-face sessions between scientists and teenagers in the United Kingdom. The authors describe how the students changed their stereotypes about science and scientists, and they acknowledge a very positive balance for both the scientists and the students. Other reports in New Zealand state that sessions like the aforementioned allow to show the students not only the real work in research, but also to make them feel that scientists are people like them and even being influential for the young minds (Chen and Cowie 2013). The Kenyan experience also shows how the collaboration between schools and scientists has both a motivational impact in students and teachers, as well as an impact in the society (Davies et al. 2012). Interestingly, the positive outcome of these interactions has also been perceived in connections with scientists working abroad using information and communications technologies (ICT), such as pre-recorded videos or videoconferences. We will describe in detail some of these experiences in the following sections.

Following this idea, we present iNVESTIGA (<http://www.investiga.co>), a project aimed to connect the Colombian diaspora with secondary schools in Colombia using current telecommunication technologies. In the following sections we present a short review of similar projects in the world involving videoconference to connect researchers and schools in other countries. Next, we expose the methodology of iNVESTIGA sessions, the results of our first pilot study launched in 2015, and we conclude with a discussion presenting a balance of the full experience and some perspectives for the future.

Background

Several international projects have established links between skilled migrants and their countries of origin, involving them into transnational and/or knowledge transfer activities. One consequence of these initiatives is the creation of the scientific and business diasporas with all the positive benefits that they bring (Amagoh and Rahman 2014). Baruffaldi and Landoni (2012) provide elements to prove that the engagement of scientists in activities with their home countries increases the probability of returning to their land. They also expose the advantages of cultural and language affinities for knowledge flow and impact in the individuals. An interesting example of an active diaspora promoting links with its country of origin is the *ChileGlobal* initiative (<http://www.chileglobal.net/>). Since its creation in 2005, they achieved to create a network of skilled migrants that share their knowledge with their collaborators in Chile and they contribute to the development of their country promoting innovation and entrepreneurship in companies and start-ups. Accordingly, a recommendation by some experts is to use the technological tools available nowadays to create strong networks that enhance distance communication (Amagoh

and Rahman 2014, Baruffaldi and Landoni, 2012). Nevertheless, the diasporas have not fully exploited the capabilities of current technological advances, only supporting their activities in email lists, web portals, and wikis.

Some independent projects have tried to use other mechanisms other than emails, such as videoconferencing, focusing in a specific task such as participating in lecturing or educational purposes. Lawson et al. 2010 present a review of multiple examples of videoconference applied in education between 1994 and 2005. They highlight the advantages and disadvantages of applications such as distance education and videoconferencing lecture. A recent experience has been reported by Ndiaye et al. (2011) who expose how videoconferences has helped African countries to spread knowledge about health subjects in universities, only limited by a lack of technical resources in the academic institutions and a poor Internet quality. Hopper (2014) presents the results of a study case following a project-based learning approach between a school in Texas, USA and multiple distant partners around the world. She argues that this activity enhance communication skills and motivation in students, as well as other aspects such as global awareness and collaboration by bringing the world into their classroom. This also applies for science education in schools and universities. McCombs et al. (2007) exposes the results of more than a hundred videoconference sessions between scientists and schools between 2003 and 2006. The surveys filled by students, school teachers and scientists showed that videoconference was an effective and motivating teaching medium. Fallon (2012) exposes guidelines for videoconferencing with educational purposes, as well as his results in establishing sessions between a scientist in a research center in New Zealand and a school classroom in the same country. His experience concludes that videoconferencing was an effective learning mechanism, but still presenting important drawbacks due to logistics, costs, and technical issues. In Canada, Basiliko and Gupta (2014) present the positive outcome of some sessions organized between national or foreign scientists and a local university, to share about scientific advances in biology. Despite the positive overall result of these projects, none of them reported to have worked specifically with the scientific diaspora.

According to our research, we did not find similar initiatives in Colombia using videoconferences, despite the interest of Colombian government and some independent institutions to keep the connection between the scientific diaspora and the country. Colciencias has been involved in most of these projects with skilled migrants. The first project in this direction, called Red Caldas, was the first step in the construction of a Colombian scientific diaspora. It started in 1990 with the objective of connecting Colombian scientists abroad with the academic institutions and research groups in Colombia in order to propose research projects together (OCyT 2013). This network quickly became an example for other countries seeking to establish a scientific diaspora and it has been deeply studied in all its success and its failure. The network was dissolved in 2006 due to multiple factors: an accelerated growth without clear objectives and mechanisms to support it, the centralization of data and decisions in Colciencias was limiting the flexibility of the international nodes and a lack of technological resources in Colombia at that time (OCyT 2013).

During the following years, Colciencias has promoted the increase of scientific production, dissemination and education in the country and it has developed new strategies to bring talented people back to the country. For instance, the education in science in Colombia has been divided in three main initiatives according to the educational level: education in science for primary and secondary schools in Colombia is managed by the *Ondas* project (Colciencias 2015), the training and involvement of undergraduate students or young professionals by *Jovenes Investigadores*, and finally some incentives and mechanisms for the promotion of doctoral students. Unfortunately, all these strategies have been limited by a lack of financial resources and political decisions. The situation does not change for the contact with scientific diaspora and its contribution in the development of the country. In December 2013 Colciencias launched the program *Es Tiempo de Volver* (It is time to come back) incentivizing the reintegration of Colombian scientists working abroad into academic institutions or research centers in Colombia. The program asserts that these scientists will contribute in the economic and social development of the country bringing back their knowledge and the experience acquired in other countries. However, the project has already suffered important logistic and financial problems during the first two years (this has been extensively

documented by the national media) and its credibility has been considerably affected, as well as the willingness of the diaspora to participate in these agreements with the government. Nonetheless, the Colombian scientific diaspora has not stopped exploring new mechanisms to intensify the transnational activities with the country. A recent project has been started by the Latin American Science Education Network and a group of Colombian scientists in the United States and Mexico who launched *Clubes de Ciencia* (Science Clubs, <http://www.clubesdeciencia.co/>) based on similar experiences in Mexico and other Latin American countries. Their goal is to promote science education in Colombian young population through intensive courses in exciting topics in science and technology given by Colombian scientists working in the most prestigious institutions. This initiative has already presented their first results in the media, but it is important to consider the associated high costs associated to the transport and logistics of moving the scientists directly to the country in order to participate in this activity.

iNVESTIGA: scientific diaspora and schools in Colombia connected

Despite some international groups have demonstrated the positive effect and the advantages of establishing remote connections between scientists and young students in schools or universities, Colombia has not implemented a strategy to use these mechanisms for the promotion of science in the country and the recirculation of knowledge acquired by the diaspora. In order to close this gap we present, iNVESTIGA, a project aiming to connect the Colombian scientific diaspora with secondary schools in Colombia using current telecommunication technologies.

The project is based on the international experiences previously exposed and takes into consideration the pros and cons of the multiple initiatives in Colombia intended to support the contribution of the diaspora in the development of the country. We want to give an optional answer to the question of how scientists working abroad could bring part of their knowledge and experience back to their country of origin. One of the most common activities of scientists, despite their heterogeneity, is their involvement in educational or pedagogical activities in universities. We consider that providing the technical mechanisms and a proper pedagogical support to allow skilled migrants to participate specific educational tasks, such as giving a lecture on his/her topic of research in a school in Colombia, could lead to multiple benefits for young students and school teachers. The emotional aspect of these transnational activities affects and motivates all the three actors: the Colombian scientists working abroad, the students and the school teachers. Additionally, we have seen that most of the projects in the past were not exploring all the capabilities of the technological resources available nowadays (most of them relied exclusively on mailing lists), however we strongly believe that the current status of the telecommunications and Internet network in the country could allow an interactive communication with a reasonable good quality, despite the thousands of kilometers of distance between the participants.

In order to achieve this, we organize videoconferences between schools in Colombia, mainly in rural regions or in small towns, and scientists working in different countries around the world. We have contacted a pool of scientists (doctoral students, postdoctoral and independent researchers) who agreed to voluntarily participate in the pilot study of this project. Every experience followed a basic script with expected timings (in parenthesis) for each section: 1) the iNVESTIGA team starts with a general introduction to the session (5 minutes), 2) the scientists presents a short introduction of his/her career and personal achievements (10 minutes), 3) one of the students in the classroom presents a short introduction of the school and his/her classmates (5 minutes), 4) the scientist starts the lecture in the scientific topic of the day (15 minutes), and 5) finally a “Questions & Answers” (Q&A) session (15 minutes). The topic of the lecture was chosen beforehand considering three factors: students’ enthusiasm for a specific subject, teachers’ opinion according to their academic program, and availability of the scientists participating in the pilot test. Additionally, the students were asked to read a document preselected by the scientists that was used as introduction to the topic of the talk. In most of the cases the reading was a one-page document prepared between the iNVESTIGA team and the scientist, based on articles published in international newspapers related to the topic of

the lecture. The document was usually written with some advanced scientific terms and descriptions. This was intentionally used to induce questions in the students about the topic of the lecture and the scientific work.

Pilot study

For the pilot study, we contacted two public schools in Yopal, Colombia, the capital of the Casanare region, located at 300 km from Bogota in the eastern foothills of the Andes. The town has dramatically increased its population during the last decade coming to have today more than 140.000 habitants with an economy that has been historically based in petroleum extraction, animal farming and agriculture. Although the region has improved its human development index, it is still grouped within the low competitive areas in Colombia due to the late development compared to other regions (DNP 2014). Moreover, they still suffer basic problems such as access to clean water and important social inequalities. We conducted four one-hour sessions with scientists who voluntarily agreed to participate in the videoconferences: a postdoctoral researcher in applied mathematics, a PhD. student in materials engineering, a scientist in biomedical engineering, and a scientist in biology and environmental sciences. The groups in the schools consisted of 20-30 students with an age range between 14 and 19 years old, as described in Table 1. A schoolteacher was dynamically participating during the sessions, plus one member of the iNVESTIGA team coordinating the session remotely. Previous to the experience with the students, teachers and scientists had a training session for the technical aspects of the videoconference. For the pilot study one member of the iNVESTIGA team was also in the school to support any technical issue, but we expect to waive this requirement using properly dedicated technological tools and a proper training of the schoolteachers. Finally, we asked both the students and the scientists to fill out a survey, before and after the sessions, using as reference the questionnaire described by Woods et al. (2015). The students' surveys were not filled in the last session, because the group was the same that participated in the previous experiences. All the four sessions were recorded for posterior analysis and the first experiences were used as examples during the following sessions. We also summarized the content of the surveys to have a clear overview of the whole experience.

Session No.	School	Grade	Age Range	Num. Students (surveys completed)	Topic
1	A	9 th grade	14-18	30 (19)	Biomedical Engineering
2	B	11 th grade	16-19	24 (21)	Applied Mathematics
3	A	9 th grade	14-18	27 (14)	Materials Engineering
4	A	9 th grade	14-18	22 (--)	Biology and Environment

Table 1. Summary of the four sessions conducted for the pilot study in Yopal, Colombia. The 11th grade corresponds to the last year in secondary education in Colombia. The last session included students from the first and third sessions, thus the surveys were not filled out.

The students were enthusiastic by the fact of having a videoconference with a scientist living in another country. Only one of the 54 students reported having had previous contact with a scientist before. Most of them imagined a scientist as “serious, bald, fat, old, wearing glasses and lab coat” (sic.), however after the session they were surprised by finding “young, enthusiastic and easygoing” researchers that they could speak to. This opinion was also shared by one of the schoolteacher who noted at the end of one of the Q&A sections: “As a teacher I enjoyed this session and I would like to thank you for your time. The truth is that we always see the scientist as someone too far and for me it was important to have contact with people with such brilliant minds and who truly are contributing to humanity”. Despite the classic physical stereotypes, the students described scientists as “responsible, intelligent, perseverant, hard-working, creative, passionate about their work, and organized”. Figure 1 shows the main words (translated from Spanish and grouped by similar terms) used by the students when they were asked by the skills a scientist should have in his/her work. They emphasize on the need of having advanced knowledge in areas like physics, mathematics, chemistry, biology and philosophy; two students indicated that scientists should have special skills that are innate or close to perfection. During the Q&A section, several questions were mainly centered in the

process that the scientist followed to achieve his/her goals and the challenges of living in another country being Colombian. However, in all four sessions the students also asked advanced questions related to the topic of the lecture motivating the scientists during the rest of the activity. The majority of the students affirmed that the content of the lectures was easy to understand and some of them were requesting complementary material about the topic of the lecture before the session. Nevertheless, when the lecture was extended due to technical problems or due to a long talk by the scientists (more than 20 minutes), the attention of the students was dramatically affected and some students started to get sleep or bored.



Figure 1. Words used by the students to answer the question: Which skills should a scientist have in his/her work. The size of the word is proportional to the number of occurrence in the completed surveys, e.g. the word *commitment* corresponds to 31 occurrences in the 54 surveys.

All the sessions were planned for less than an hour, but the four of them took more than one hour and 20 minutes. This was due to multiple factors: problems with the audio and/or video in the school, difficulties for the scientist to change between the presenter mode (showing the face of the scientist to the students to help the communication and the interaction) and the share screen mode to display the slides of the lecture, questions of the students during the talk, and the enthusiasm of the scientists to show much more about their research work. With respect to the technical issues, we noticed that any problem with the video and/or the audio impacted strongly the students' attention during the lecture. However, the Q&A section preserved its dynamism and fluency having questions from both the students and the schoolteachers. Three factors positively affected the interaction between students and the scientists: 1) the participation of the school teachers was an icebreaker that increased the motivation of the students to ask their questions, 2) the technical restrictions for the audio forced the students to get close to the microphone and the camera, thus they needed to move around the classroom making the session more active and dynamic, and 3) the use of simple terms used by the scientists motivated the students to discuss with a person who looked and expressed like them.

On the other hand, the four scientists had positive comments about the overall experience. First, they considered a challenge to present their work to school students because they were forced to use simple expressions and didactic examples; a challenge they considered important in their professional life as scientists. One of the researchers commented: "Before the session I was afraid about how would I be able to capture the attention of students and how could I motivate them to study a little more than the minimum required in school. However, we had much more than that. The students were intellectually eager and I think they had fun delving into scientific aspects, always willing to go to a higher level of knowledge". They all agreed on the positive impact these experiences could have in students and schoolteachers because it provides an extended vision of the world and other subjects that they are not used to listen in the classroom or at home. Moreover, two of them considered very important to continue interacting with small groups developing scientific projects and not only relying on the lectures. After the session, the four researchers and the schoolteachers were remarkably surprised by the positive and dynamic reaction of the students. One of the scientists said: "I am very surprised by the interest of students per session. I was expecting that they were

much more passive, but they were very active and curious". All the four scientists would like to participate in more sessions later.

Discussion and Perspectives

The results of the pilot sessions were encouraging. We established a link between schools in Colombia and scientists abroad using current technologies and we experienced the positive impact this interaction has in the students, the schoolteachers and the researchers. Particularly, the following key aspects were observed: increasing students' eagerness for learning, teachers' willingness for presenting different and innovative materials to their students using technological resources, and helping scientists to contribute to the improvement of education in their home country.

More specifically on the students' side, these sessions had an effect on their perception of the world. Their first reactions about science and scientists correlate to the erroneous perception of science previously perceived in the adult population in Colombia (Daza-Caicedo et al. 2014). According to these national surveys, television and Internet are the main channels that motivate Colombian people to learn about science, even more than the motivation induced by schools and universities. During the iNVESTIGA sessions we perceived that using technological mechanisms attracted students' attention, as well as it increased their interest to participate in a different experience. Thus, using new communication and interaction techniques correspond not only to a great opportunity to develop new pedagogical strategies in science education, but also a necessity to attract the attention of most of the people that have already access to these mechanisms. Fortunately, the Colombian government has made important efforts in order to extend the coverage of digital television and Internet in all the country. Strategies like *Vive Digital*, an ambitious project that promotes a national digital ecosystem (Molano-Vega, 2013), has increased the penetration of Internet in all the regions of the country. In order to use these technological resources properly, the country requires new projects and initiatives that exploit all their inherent benefits, particularly for the improvement of the education and health treatment quality, amongst others. Accordingly, schoolteachers and young people need more training activities that allow them to understand all the capabilities that current technology could bring them and their community.

Initially, we decided to work with students in the last years of the secondary school, mainly because we thought it would be easier for scientists to transmit their message and for the students to understand the advanced scientific topics. However, we discovered during the process that these activities could also have a special impact on this student population, particularly in the decisions they have to make in the close future about their professional or academic career. The possibility to listen in their own language about advanced topics in diverse scientific fields opened their mind about the practical applications of professions, such as engineering and biology. At the end of the sessions the students were asking for sessions in additional fields such as medicine, economy, biology, informatics, among others. Nevertheless, the effect that this interaction with scientists has on the professional decisions of the students must be further explored and some metrics should be defined to have objective indicators that help to measure the impact of these initiatives. A similar study should be performed with the scientists in order to analyze the effect that this motivational activities have on their approach to the country and their involvement in transnational activities. Newland et al. (2013) already reported the difficulties to measure the real impact of diasporas contribution to their countries of origin, however we believe that for this particular activity, an objective analysis could be performed having appropriate tools that collect the results and the feedback of all the users at every session. An interactive, friendly and easy-to-use software application supporting not only the videoconferences, but also including the feedback and follow-up of these activities could provide concrete data to establish new pedagogical strategies for the transnational activities of the diaspora. Additionally, this software platform should follow a holistic approach providing not only synchronous communication (videoconferences), but also asynchronous methods to store information and strengthen those links for a longer term (e.g. blogs, wikis and

portals). This pilot study helped us to formalize the requirements to develop the platform that support the interaction between the diaspora and schools.

Moreover, the four experiences helped us to define important details about logistics and infrastructure requirements to obtain the biggest benefit from the experience. We consider important to limit the number of students in each session to thirty and the camera should be set at a proper distance to see all the students within the camera field of view. This also corresponds to the results described by Basiliko et al. (2014) who report a better outcome with groups of less than twenty students, but contrasts with school classrooms in Colombia that usually have 30-40 students. Additionally, allowing the students to sit wherever they liked created a relaxed environment in the room that helped to have a natural conversation with the scientists. This flexibility was positively perceived by the school teachers, and, despite the session did not have a reward or a grade for the students, their dynamism and participation were always present. Nevertheless, we noticed that bad sound quality has an important negative impact in the interaction, more than bad video quality. During the following sessions we plan to have better hardware to improve the sound quality and reduce the impact of this factor.

We already experienced a positive result in establishing communication and interaction links between Colombian scientists working abroad and schools in Colombia. According to the results of this pilot study our future work will focus on: 1) the development of a friendly and easy-to-use software platform that support the register and logistics processes, the feedback from the users, the videoconference sessions, and asynchronous communication, 2) proposing a package of multiple sessions (max. five sessions per group) in different scientific topics to the school, and 3) expanding both the scientists' and the schools' (in other regions) networks. We are currently working on the three aforementioned aspects. Scientists in diverse fields and schools in other regions of the country (e.g. Saravena, Bucaramanga, and Cali) contacted us expressing their willingness to participate in an iNVESTIGA session. We have also participated in an event organized by the Colombian diaspora in Switzerland (ACIS 2015) where we exposed the project iNVESTIGA and we started to establish goals for a cooperation project between Switzerland and Colombia on the education in schools for the management of water as a vital resource. This collaboration would enlarge both the schools' and scientists' network allowing us to establish new sessions with schools already registered in the *Ondas* project (more than 17000 schools in all the regions of Colombia make part of this initiative). Additionally, it will inject important funds for the development of the software platform, hardware requirements, and logistics. Lawson et al. (2010) described already the big challenges in order to develop initiatives like iNVESTIGA, mainly because they are often underfunded and understudied. However, we believe that the technology available nowadays, plus combining the experience and the willingness of the Colombian diaspora to participate in these activities and the motivation of the schools in Colombia, will bring us to a next level in the education of science in the country and will open a unique opportunity to include the scientific diaspora in the development of new solutions for the social problems in the country.

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