Mayors vs. STEM: The sad story of a big success in increasing STEM vocations.

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***Abstract*—The lack of interest for Stem degrees among young students is one of the main problems discussed around the STEM acronym. Although this problem can be addressed from many different point of views, we present in this paper the experience gained over the past ten years in a project that has achieved a big increase in STEM degrees enrollments. The project applies a long-term approach that allows young students to develop their skills over several years, and has achieved a large increase in the rate of STEM degrees enrollment compared to the rates in the region in which it is applied; a rate increase that to the best of our knowledge has never been reported for any STEM initiative.**

This paper discusses the unique approach the project applies, and presents and analyzes the outcome of 100 students who attended the project over several years. The analysis focuses on decisions made regarding the university, the degrees chosen, but also discusses results for those students that are still attending middle and high school. Results obtained are compared with a preliminary analysis performed a couple of years ago, and demonstrates the usefulness of the approach.

Unfortunately, and despite the remarkable results obtained, we still find difficulties for extending the model among towns in the region that are not part of the project yet. We provide data showing that policy makers do not pay enough attention to this problem in the area where the project is deployed, and thus we show where the main problem for extending STEM initiatives is found.

I. Introduction

The importance of STEM (Science, Technology, Engineering and Math) education, and the need for young people to be exposed to STEM areas is clearly understood today [1], although a debate exist on how to quantify that social need of STEM professionals [9]. This need is particularly relevant in Spain, where the rate of undergraduate students pursuing STEM degrees is only 24,4%, behind European Union rate, 28,1% [12].

Many STEM promotion initiatives have been developed during the last 20 years, but the success of these STEM projects, programs and actions is not so evident, given that usually an analysis of their real impact is missing. One of the problems for a proper result analysis is the kind of projects developed, mainly based on single day activities. While nobody would bet for single-day workshops whose aim was to transform the future of our society by educating young people in a specific topic (such as health education), and instead consider the need to introduce that topic to a transversal competence within the school curriculum so that a long-term learning process is developed, this has not been typically the case for hands-on STEM projects. One of the reasons maybe related to the subjects addressed, that are already part of the curriculum (consider for instance Maths, one of the area within the STEM acronym). But given the need for improving students perception of STEM areas, which is the basis for most initiatives, better analysis of the initiatives developed is required if we are to assess their real impact.

Moreover, if we focus in other profesional areas, such as music, students that decide to develop a professional career, attending higher music conservatories when pursuing a college degree, we see these students have previously attended music schools or professional music conservatories for a number of years. If this is the case for music students, what should we try when considering future STEM vocations?

During the last ten years we have developed Municipal Schools of Young Scientists (MSYS) project [3], whose preliminary results were already analyzed and published before [4]. To the best of our knowledge, this was the first such analysis published describing a several-years approach in a single STEM promotion activity. Nevertheless, the scope of that analysis was limited, given the number of students involved and the number of years included in the report.

This paper presents a wider and more ambitious study, involving more than 100 students that have attended MSYS for several years. The study has allowed us to analyze what students have decided when reaching the age for entering college. Moreover, a comparison with more widely spread Municipal Schools of Musics is presented, so that the impact of MSYS can be more easily contextualized.

This paper describes a dramatic increase in college enrollment, particularly in STEM degrees, while also provides hints on where one of the main problems for extending this kind of initiatives is: decision-makers in villages and towns are the main barrier we encounter.

The rest of the paper is organized as follows: Section II introduces the situation of STEM initiatives in Spain. Section III describes our methodology, while section IV presents the results. Finally, we draw our conclusions in section V.

II. Studying STEM initiatives' impact

The positive impact that STEM activities have on primary and middle school students perception is out of doubt [1], although quantifying that impact is not so cut and clear. To the best of our knowledge the only of such studies in our country, was developed by the Spanish Foundation on Science and Technology [2], that reported a correlation between participation in a STEM workshop, and an increase of interest of students in science and technology when asked about it after the workshop. Unfortunately, whether this increase correlates with future decisions of the students participating was never analyzed.

There are other reports on the literature, such as [5], that again only compares answers to a series of questions collected from students that had atended an expo designed for STEM, versus those that did not attend.

On the other hand, Olivarez presented in [11] a comparison between 8th graders attending STEM educational program using Project-Based-Learning and hands-on strategies. Although a longer period was considered here, again the main goal was quite different from the one we pursue: the analysis performed by Olivarez tried to find significant academic achievement differences between students included in the program. We are more interested in the long term, and are thus interested in decisions taken by students when reaching university. Although this is partially connected to academic achievement, the purpose of our analysis is quite different, as we will see below.

To te best of our knowledge few, if any, previous studies have considered the long term effect that STEM projects may have on future students decisions, trying to quantify that impact.

III. Methodology

The main goal for Municipal Schools of Young Scientists (MSYS) is to work with young students developing their interest towards STEM areas for a long term period, so that in the future an increase in STEM enrollment in university degrees is achieved. Although a complete description of the project can be found in [3], we describe here some important differences with other STEM initiatives: (i) profesional STEM teachers hired (instead of volunteer based approach); (ii) activities developed along the year (100 hours of activities, instead of single actions 1-2 hours long) (iii) MSYS involves social groups around young students, with a well established methodology which includes meeting with the mayors of the towns, parents and teachers: teachers disseminating information among students, families encouraging them to participate and local administrations funding the project and coordinating activities within the town.

Although a pilot project was launched in 2011, MSYS became publicly available in 2015. Thus, MSYS has been running for more than five years, and students that entered the project at the beginning have recently decided what to do regarding university or professional degrees to be pursued.

TABLE I
Students who ever attended MSYS 2015-2016, and those who provided information five years later.

Model	students participating	data collected
everybody-pays	111	100

TABLE II
Students involved in the analysis

Level	Number of students
Mid School	9
High School	35
Prof. Degree	12
University	37
Job Market	7
Data Not Available	11
Total	111

The analysis we present involves 111 students (see table I): those that entered the project in 2015 (see Table II). The name of the model, *everybody pays*, the best of the two initial models tested, refers to the small fees that families pay for students attending workshops.

We have collected information regarding what these students are doing in 2020, five years after enrolling MSYS. Although not all of them have attended the project for five years, we wanted to analyze the average impact of the project in their final decisions regarding the studies to pursue.

In the following section we present detailed analysis and results found. Interested readers may refer to [3] for a longer discussion on the methodology applied and the activities developed every academic year.

A. Models analysed

Although a preliminary analysis was performed in 2017, data analyzed were obtained when two different models were launched in 2012 with the main goal of deciding which of the models were the preferred one [4]. In that report, we saw that the "Everybody pays" model was the preferred one attending to the final decisions students took when deciding which college degree to be pursued. That model was then selected as the preferred one and extended in 2015 and is the only one applied today in 15 different towns in our Region. In this model, every family pays a small fee for the activity -around 10 euros per month.

What we present below is an analysis of students that entered MSYS in 2015, and their decisions taken in 2019. Thus 111 students were included in this analysis. Given differences in students ages, as shown in table II , decisions affect college degrees, high and middle school but also professional degrees. We were able to retrieve information from 100 students out of 111. Anyway 100 is good enough to perform the analyses we intended. Table IV shows classification of students attending to their ages, so we see the level they could have reached five years after entering MSYS.

Unfortunately, we are not aware of projects like the one described here, that includes an analysis for students that spent several years attending workshops every week. Therefore we have not found data available for comparison. Moreover, a question may arise after the analysis is performed: Are the results obtained due to the work and the methodology applied, or simply a correlation with the kind of students that attended? It could simply be due to prior preferences of students and their families: only those with interest in science and technology enter the project.

Taking those questions into account, and given that no other possibility of comparison with a similar project can be found, we decided to apply an alternative approach. What we have done is to look for other Municipal Schools that operates every week and where students can attend for several years. Moreover, we tried to look for a thematic area were students and families could be positively attached to. And we have been lucky finding that kind of municipal school with the prerequisites described: Music schools. Several of the towns where we launched MSYS offer music school. We decided to select two of them, namely, Castuera [1] and Almendralejo [2], whose total number of new students entering each year is similar to that considered in this analysis.

IV. Results

In order to collect the information we needed, phone calls were performed over the selected group of students. We could only obtain information from 100 out of 111, and this is the data presented below. The main questions we asked students were:

- Are you studying any degree today? (alternatively high-mid school or profesional degree).
- If positive answer, which one?

As we show below, not all of the students who answered were already studying a college degree; some of them were still in high school or have entered the job market, but this informations was also useful for the analysis.

The first thing we have considered is where students are today. Table III collects such information, that can be compared with table IV. Although a first and simple analysis could be performed with this information -for instance, 37 out of 54 possible candidates have reached university colleges- we include a more detailed analysis below.

The first thing we analyze is the *dropout rate*. Table V shows that 93 out of 100 are still studying, which is quite a nice rate. Considering those at university ages, 12 went to professional degrees, while 37 reached university; only 9 went to the job market.

If we focus first on those 12 students pursuing professional degrees (see table VII), we notice a good rate of STEM related degrees (electronics, for instance): 8 out 12. So even in this case, STEM areas have been considered for their future job.

[1]Escuela Municipal de Música de Castuera http://www.castuera.es/plantilla.php?enlace=escuela_musica

[2]Escuela Municipal de Música de Almendralejo http://www.escuelamusicaalmendralejo.es

Something similar can be applied to high school. We show in table IX the number of students involved in *science* at high school. A high rate is noticed again: 23 out of 35 students. So a 65.7% of students in high school have chosen science. This value can be compared with the preliminary analysis we performed a couple of years ago in [4]. There, a 52.6% was reported when two different models for MSYS were applied. Results now confirm that the best of the two models, the one we finally chose when extending the project in our region, have increased science interest in high school.

Finally, we show in VI the number of students currently pursuing university degrees. As we may notice, the percentage of MSYS students is 68%, a value much above both the percentages of people in our region (26%) and also in Spain (40%) with college degrees. Similarly, and focusing now on STEM degrees, 68% of MSYS students at university are pursuing STEM degrees, while we find only 24.4% in Spain.

This latest value can be also compared with the preliminary analysis described in [4]. There, a 47% of students at university ages were found to be enrolled in STEM degrees. A similar conclusion can be reached as with high school rates: the best model found in that previous analysis, the one that has been extended in the last five years, have provided this dramatic increase of STEM interest, that provides and increase of 21 points over that preliminary analysis.

Finally, a summary of results, including University, high school and professional degrees, are shown in table X.

A. Discussion

To the best of our knowledge, these remarkable results have never been reported for a STEM project before. Yet, the correlation between the project methodology and results obtained could be questioned, considering previous interest of families in having their children attending MSYS. We have also taken this issue into account, and have thus analyzed two music schools that have been operating for long in our region: the ones offered in Castuera and Almendralejo, two of the towns where MSYS is working.

After talking to their heads, they reported a 10% of students finally attending High Music Conservatories in the case of Almendralejo, and nobody yet in Castuera. The reason maybe due to the period of time both schools have been working -much longer in Almendralejo, and also for the possibility of attending a professional music conservatory in Almendralejo, that allows students from the music school to perform a transition towards high music conservatories. In this case, students are similarly motivated by their families, but results are quite different from the ones we are reporting for MSYS. Certainly, the main goal of music schools is not to ”create vocations” towards music, but to provide a music background to students. However, they also encourage students to continue studying music if they want to. Interestingly, this results are aligned with some reports dealing with low rates of students becoming professional musicians [10].

Anyway, even when families are similarly interested in encouraging their children to attend the schools in both cases,

TABLE III
WHERE STUDENTS ARE TODAY.

College	Prof. Dg.	High S.	Mid S.	other	total
37	12	35	9	7	100

TABLE IV
WHERE STUDENTS COULD BE TODAY.

College	High School	Mid School	total
54	37	9	100

TABLE V
DROPOUT RATE.

Where	Studying	Job Market	total
University	37	5	42
High-Mid School	44	2	46
Prof. Degrees	12		12
TOTAL	93	7	100

results provided by MSYS are much better, and this could be related to the unique model it develops.

However, despite these results, the spread of MSYS in new towns are quite slow. Table VIII shows the number of villages and towns invited every year, those that accepted the invitation, provided resources and joined the project, and the total number of towns where MSYS has been operating for the last 6 years.

We may pay particular attention to what happened in 2019: 21 mayors were met so that the project was shown, but only 3 joined MSYS. So, only 14% of the mayors really understood the need for this STEM activity and decided to launch it in the town. Moreover, given that 2019 was an election year with changes in mayoralties in several cities, and considering that in some of this cities the new mayors decided to cancel MSYS, we see that the project is not valued by its results but by which political party implemented it first in the town. Along the period considered, we may notice that 122 villages and towns have been invited, 38 (31%) accepted to launch the first year the initiative, and only 16 (13%) have been working in 2019-2020.

And so we arrive at a sad situation: despite the success achieved, and the fact that a number of mayors who believe in this project, implement it, they are still a minority, and we usually found barrier in policy-makers, that keep us from working with students in every town of the region.

Summarizing, this is the sad situation we are facing: even when MSYS is attaining their goals, providing a dramatic increase in STEM interest in all levels of education, most mayors are the main problem for extending the project: only 13% have really backed the project along the years. We are still analyzing the reasons for this behavior and hope to find in the short term how to overcome this drawback that keeps more students in our region to increase interest in STEM areas.

TABLE VI
PERCENTAGE OF POPULATION WITH (OR PURSUING) COLLEGE DEGREES

Where	University	STEM degrees
Spain	40%	24.4%
Extremadura	20%	26%
MSYS	(37/54) 68%	(24/37) 68.5%

TABLE VII
PROFESSIONAL DEGREES AREAS SELECTED.

STEM related	Other	total
8 (66.7%)	4 (33.3%)	12

TABLE VIII
EVOLUTION OF YSLS ALONG THREE YEARS

Year	Towns invited	New YSLS	Number of YSLS	Students
2014	10	8	8	150
2015	25	11	15	200
2016	21	9	19	270
2017	15	3	21	402
2018	10	4	18	399
2019	21	3	16	366

TABLE IX
TOTAL (SCIENCE/HUMANITIES) AT HIGH SCHOOL AGES -

Science	Humanities	Job Market	total
23 (23/35 = 65.7%)	10 (10/35=28.6%)	2 (2/35 = 5.7%)	35

TABLE X
STEM STUDENTS AT EVERY LEVEL SUMMARY.

MSYS	Stem	No-Stem	Rate
University	24	13	68%
Prof. degree	8	4	66.7%
High School	23	12	65.7%
TOTAL	55	29	65.5%

V. CONCLUSIONS

This paper analyses the impact of a STEM project working over the past five years in Extremadura, Spain. Although other analysis had been reported for single workshop actions, to the best of our knowledge this is the first time that a long term activity is analyzed to understand how it affects students decision over university STEM degrees they may follow. Results have also been compared with the preliminary analysis that a couple of years ago MSYS already performed.

The analysis has allowed us to notice a dramatic increase in students interest for STEM related areas, particularly in the number of former MSYS students attending university degrees: an increase of 42% over the average results for Spanish students at university level. MSYS students show 68% enrollment in STEM degrees, while only 26% are in the average for Spanish universities. Considering all the ages and

levels that MSYS alumni may be attending, an overall rate of 65% are found for STEM areas.

To the best of our knowledge, this is the first time such a long-term STEM project provides these remarkable results. Unfortunately, we are facing a problem we did not expect when the project was launched: difficulties for extending the model in our region. During the period analyzed, and after meeting mayors to tell about the project, only 31% decided to initially launch MSYS, but in the end, only 13% support it over several years. And thus we reach a sad situation: despite the success attained, a barrier is found in local governments, that keep us from working with students in every town of the region. This lead us to question whether scientific research, new methodologies and results obtained are really taken into account by policy-makers in our region or a different approach is required to convince them about the need of STEM actions like the one described.

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