Strong cooperation between schools and universities can inspire the young people to study physics?

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Abstract. In order to identify what are the strategies and actions implemented by the universities in cooperation with schools carried out in Horizons OPE European project a research focused on the topic. In the first phase of the research were held preliminary meetings with several members of the project, with teachers from schools and universities to draft a first form of questionnaire. In second stage during the meeting with secondary schools teachers were carried out SWOT analysis of most known activities based on school university cooperation that was used to refine the draft of Questionnaire. In the third stage the quest was applied to a control group of 20 teachers from secondary schools and 10 academ. The results served to refine and clarify the final form of the questionnaire. The questionnaire was organized in 25 items, on a scale with five levels in four categories of interest. The present work is a detailed discussion on strategies that universities have in cooperation with schools, degree of involvement of staff, logistic and financial support of stakeholders.

1. Introduction
At the end of 2016, the results of the PISA tests carried out in 2015 on a sample of over one million 15-year-old students were published [1]. The test focused on competences in science, mathematics and reading and understanding a text. As stated in the introduction, "science is not only the domain of scientists. In the context of massive information flows and rapid change, everyone now needs to be able to "think like a scientist": to be able to weigh evidence and come to a conclusion; to understand that scientific "truth" may change over time, as new discoveries are made, and as humans develop a better understanding of natural forces and of technology's capacities and limitations".

Many pedagogical and social research has been conducted on the factors that can influence or maintain the interest of students in middle and high school students to pursue a career in science, engineering, engineering, mathematics and computer science. One of the latest studies is the one published in the Hope project [2].

One of the conclusions of this study was that much closer cooperation between all stakeholders is needed to increase the young generation's interest in the in-depth study of science, technology, engineering and informatics. Cooperation between universities and schools is very important in the process of attracting students in these “hard topics”. In the surveys undertaken the importance is expressed by the respondents in various ways such as:

- The visit of scholars at University;
- University professor's visit to the schools;
- Participation in a public event organized by the university in cooperation with the school;
- Participation in a school competition involving university students;
- Etc.
In order to identify the strategies and actions that universities implement in collaboration with schools, it was decided in WG 1 Working Group ”Inspiring Young for Physics Study” of Horizons of Physics Education Erasmus Network project to conduct a focused research on this issue.

2. Research hypothesis, methods and instruments

The research hypothesis was: “Majority of the universities have a long term cooperation with schools based on confidence that activities addressing STEM can rise the interest of students to pursue science at technologies studies at university level”. In the first research phase several preliminary meetings were held with members of the working group, with teachers from the schools and academic staff from involved in collaborative actions. These preliminary research was done in 6 universities of different countries of the partners involved in HOPE. During the meetings with the secondary education teachers, SWOT analyses of the most used paternal collaborative activities were carried out and was formulated a second research hypothesis: “A lot of initiative of cooperation in between schools and universities are good practice in inspiring youth to choose a career in STEM”.

Another important result of these brainstorming activities was the design of a draft of questionnaire surveying best practices. The draft of the survey was distributed to a group of 20 secondary school teachers and 10 university professors. Analysis of the results of this initial test served to refine the questionnaire and establish the final form. (see ANEXE 1).

The questionnaire was organized in 25 items, on a 5-level Lickert scale, in four categories of interest (collaboration between schools and universities).

The first category looked at general aspects of collaboration between schools and universities, and sought to identify whether universities have a long-term strategy in co-operation with schools, whether academic staff are involved, whether the university is investing logistically and financially in collaboration with schools and teachers. The rest of the items in the first category were centred on collaborating with students' parents, the local community, and whether the overall atmosphere of possible collaborations has a significant impact on students' motivation to study physics in universities.

The second group of items was centred on one of the collaborative categories bringing together teachers from universities and schools, such as Physics competitions or Science contest. The SWOT analysis with secondary school teachers found that these competitions have issues that are being discussed by the two communities involved. Teachers are divided into several categories of supporters. Some of them want school competitions such as International Olympiad in Physics that are focused on problem solving, while others appreciated competitions to strengthen pupils' skills to solve experimental problems or interdisciplinary issues [3]. Among the competitions that were considered in the early preliminary stage for pupils were competitions that encourage students’ creativity, teamwork or even competitions that are dedicated to encouraging the use of visual arts and multimedia products to increase students' performance in scientific literacy.

The third category of collaborations between schools and universities that has been the subject of the investigation was delineated by joint events: actions to popularize science and technological progress, demonstrations and interactive activities conducted in public space, hand on laboratory for scholars or visits in companies and research institutes [4].

Another aspect considered to be of great importance by both university teachers and school teachers is to work together to develop training programs that meet the needs of the latter. Brainstorming in teacher discussions has shown that training programs and activities offered to teachers play a very important role not only in the professional development of the latter, but also in building collaborative relationships. An atmosphere of trust between the two categories increases the involvement of teachers in the activities offered to students. For this reason 7 of the items attempted to surprise the opinion of the university teachers and teachers about the
training activities that should provide important support to teachers in improving their teaching strategies, teaching in an interdisciplinary context, using the new information technologies and communications and Internet resources. An agreed work hypothesis by all those who participated in the SWOT analysis has been involved in designing the questionnaire. It was that university teachers should be involved in delivering training programs and activities to meet the expectations of teachers.

In closing the questionnaires, to the respondents were given the opportunity to identify in 50 words the activity they considered the most effective or a good practice that should be disseminated and implemented by universities in order to bring pupils and the teacher closer to the common goal of inspiring students to study physics in universities.

The response scale was a Likert type, with the following steps: 1. Strongly disagree; 2. Disagree; 3. Neither agree nor disagree; 4. Agree; 5. Strongly agree; 0. Do not know

3. Discussions and results
In the introduction of the questionnaire, data were asked about the respondent such as: university and country, age and sex, years of university experience and function held. The questionnaire was sent on a list of addresses of people involved in the activities of working group 1 active in the HOPE project. The address list contained 24 addresses. 18 respondents answered, meaning a 75% response rate. The high value of the response rate was justified by the interest of respondents in the subject: cooperation between schools and universities in activities that would increase the young people's interest in the in-depth study of Physics in universities. A look at the distribution chart of the respondents, Figure 1, shows that the interest of the universities is uniformly distributed in all the European countries involved in this working group, with special attention being paid to the collaboration between schools and universities which, even if they have a satisfactory level, for improvements.

Austria (1)
Bulgaria (1)
Estonia (1)
Finland (1)
France (1)
Germany (1)
Greece (1)
Italy (1)
Latvia (1)
Portugal (1)
Romania (3)
Spain (1)
Switzerland (1)
Slovakia (1)
United Kingdom (2)

Figure 1. Distribution by country of the respondents

By age group the respondents were distributed as follows: 1 was under the age of 25, 2 was between 25 and 30, 1 was between 30 and 40, 6 between 40 and 50, 5 between 50 and 60, and 3 over 60 years. It can be noticed that the majority of the respondents had advanced ages corroborated with years of professional experience: 2 had 5 to 10 years of experience, 1 between 10 and 15 years, 1 between 16
and 20, and the over 20 years of experience. 10 of the respondents were male and 8 female, which can be considered a relatively balanced distribution. Of the respondents, 10 were full professors or permanent teachers, 2 were readers, and 6 were lecturers or associate professors. Can be considered that the targeted group of the questionnaire are experienced in collaboration with schools. The results on the general aspects of cooperation between schools and universities have shown that in most cases (see histogram in figure 2), respondents' perception of the involvement of academic staff in collaborative activities is placed at the upper level of the scale: 4. Agree; 5. Strongly agree. There are only three respondents who consider their institution does not have a long-term cooperation policy. In many replies, the statement "My institution has a long term strategy for school-university cooperation" is associated with opinion 4. Agree for the "My colleagues and I are deeply involved" variable.

It should be noted that 4 of the 18 options for the variable "My institution has a long term strategy for school-university cooperation" are 4 answers of 1 (figure 2). Strongly disagree. An interesting polarization appears between options 4 and 1 of the scale, suggesting an exaggerated perception of the present, rather than the absence of a long-term strategy in school-university cooperation. We believe that the four responses strongly disagree rather with the frustration of the respondents who would like the involvement of universities in cooperation with schools to be more active and more efficient and to produce evidential results in the number of admission candidates in the Physics Departments they represent. These disagreements are also found in polarized responses to the item "We have logistical where 8 Agree options are counterbalanced by 9 neutral answers (no agreement/disagreement) or disagreement.

The answers to the "We have financial support from our institution" variable with 2 Agree and 8 Neither agree nor disagree suggest that there is no significant financial support from the department or institution. Some polarization between the perception of agreement with the institutional support received, ie the neutral position (no agreement/disagreement) with this variable. In the item "We are strongly supported by parents of students in our activities" the first 2 options as a frequency are 1. Strongly disagree; and 2. Disagree; with 6 or 5 options, clearly indicating the absence of support of the students' parents. This perception is also reinforced by 47% of responses that believe that the local community is not actively involved in cooperative activities between schools and universities. It is just a strong agreement and three of Agree that show that the university thinks that they are left alone to solve the problem of raising the interest of young people for the in-depth study of Physics.

The results of the second category of "good practice" school subjects have proved to be very interesting. Contrary to the results of the SWOT analysis undertaken with secondary school teachers, university professors believe that "Theoretical problem solving competitions" should be encouraged. Only three answers are neutral, the other 14 being distributed in agreement 8 and strongly agree 6. This polarization shows that universities consider "serious" only contests as Olympiad opposed to the school teachers who would rather like to encourage competitions of the interdisciplinary subjects or based on experiments or group projects.
At the item "Competitions based on solving experimental problems should be encouraged" there are 14 responses in the agreement area and strongly agree but this time reversed what demonstrates a small yield and acceptance of the role of experiments in maintaining the interest of young people for Science in general and for Physics in particular. It draws attention and moves from a neutral position to the variable "Theoretical problem solving contests should be encouraged" (3 options. Neither agree nor disagree), to a net rejection, position for the variable "Competitions based on solving experimental problems" encouraged "(3 options 1. Strongly disagree). It is thus confirmed the hypothesis that respondents are people who do not like competitions based on hand on and prefer the Olympiad of Physics. This polarization probably is due to the very traditional way of thinking about teaching and learning Physics based on solving theoretical problems.

The analysis of responses to the variable "Competitions based on interdisciplinary topics should be encouraged" only three options are noted: 4. Agree; 5. Strongly agree; 2. Disagree; with 7, 6 and 4 options out of the 18 cast. The interdisciplinary approach is validated by 13 of the 18 options and is not very categorically rejected by the other four options.

The attempt to find a correlation law between the "Competitions encouraging teamwork should be organized" and "Competitions encouraging student creativity should be organized" did not yield any noticeable results, suggesting that both are perceived to be virtually identical. Encouraging teamwork and encouraging student creativity have the same perception for respondents.
Figure 8. Cooperation enables students to acquire a positive attitude towards physics studies (Q7)

Figure 9. Theoretical problem solving competitions vs. Q9 Experimental problems (Q8)

Figure 10. Teachers should use computers and the Internet more as learning resources (Q19)

Figure 11. Demonstrations in public spaces, universities and schools are a useful activity (Q14)

Figure 12. Responses to questions: Competitions based on interdisciplinary topic (Q9), student creativity (Q10), teamwork (Q11) and arts and multimedia productions (Q12)
Concerning the third Category of items, the School-University cooperation for outreach activities and events organizing the interpretation of correlations that can be established shows that the options are 5. Strongly agree and 4. Agree on the variable "Universities should permanently open a special laboratory for secondary school students" are associated with option 5. Strongly agree with the variable "Demonstrations in public spaces, universities and schools have is an inspiring activity", which indicates the common perception of the two aspects suggested by the variables. It can be said that this questionnaire reveals that the variables:

1) Popularization of science events in schools and community are needed;
2) Demonstrations in public spaces, universities and schools are a useful activity;
3) Students should visit research institutes and enterprises

are more "linked" to each other than it is variable Universities should permanently open a special laboratory for secondary school students versus any of the three variables quoted above.

A chapter considered important by academics but especially by secondary school teachers is the cooperation between School and University in offering training programs. This has also been reflected in the large number of items that analysis is based on.

The histogram of the frequency distribution of options at item 18. "Strongly disagree is the higher frequency of any response option." There are no extreme options, Option strongly agree is dominant, representing 11 of the 18 responses. The transfer of competencies for implementing formative strategies in teaching physics is a net option, and the intensity of "Strongly agree" shows the desirability of such pedagogical support to the in service teachers.

At item 19. Higher frequency with 10 replies out of 18 is again Strongly agree. The extreme options 0 and 1 do not appear. There is some fear of surrendering in traditional contexts. Perhaps university professors are thinking about the students’ competences to become good physics teachers and less about their competence to teach from an interdisciplinary perspective.

A careful look at the frequency distribution of options at item 20. "Teachers should use computers and the Internet more as learning resources" shows an interesting distribution of options in the sense of
no less than 3 modal values, those corresponding to the frequencies of options 3, 4 and 5 of the scale. These 3 options in one place hold 15 cases out of 18, ie they record equal weights with just 5 cases. Histogram of the distribution of the frequencies of options at item 21. "University staff should be involved in the implementation of new programs in schools". It is noted that the highest frequency of any response option is 4 in the scale 1. The second weight between the options of item 21 is the options 3 and 5 (with 4 out of 18 cases), being a little different from the item 20, meaning that there is a polarization between two favorable / extremely favorable options 4 and 5) of the pedagogical support described by the item under investigation, as opposed to a more reserved option represented by Neither agree or disagree.

Evidence of the fact that respondents consider very important the support offered to teachers in the continuous professional development is the fact that in item 22, "the universities should offer help and training for teachers". 5. Strongly agree are the majority. 12 of the 18 respondents strongly agreed. When it comes team teaching in the schools with the secondary school teachers, however, a neutral attitude is mostly observed, but there are 8 of the respondents who are willing to provide support even in the classroom.

From the answers given in item 24: "Training programs for teachers should be designed and implemented by universities in cooperation with teachers and schools addressing their needs", it is noted that university professors believe that training programs should be designed and implemented to meet the needs of their professional development.

4. Conclusions

The questionnaire on co-operation between universities and secondary schools in order to strengthen the inspirational factors of young people to deepen the study of physics in universities has confirmed the studies undertaken by HOPE project group 1 [2]. Here are some general recommendations:

- Physics departments in universities need to build long-term collaboration policies with schools and teachers in secondary schools;
- It is preferable to nominate a person who is responsible for such co-operation and is needed a prioritization of action;
- Equally important is the allocation of material resources (budget, spaces, employees, etc.) and time;
- If the interest of young people in the study of Physics in Universities is to be increased, they should use a very wide range of actions that the most appropriate respondents believe are the involvement of university teachers in organizing school competitions and events targeting secondary school students at all age levels;
- In the opinion of the secondary school teachers, resulting from the SWOT analysis, the competitions must be interdisciplinary, based on experimental problems and encourage students to be inventive and team-based;
- It is recommended to evaluate the school competitions organized by Universities and to promote, in cooperation with the secondary schools, the innovative competitions;
- As far as public events are concerned, university professors and school teachers consider that they cooperate effectively and that many types of events are provided as inspirational factors for students;
- It is recommended to overcome the teachers' reserved attitude regarding the opening Hands On or Learning by Doing Laboratory in their own department. More than positive experiences that students have during university-level visits and the desire expressed by secondary school teachers should be sufficient arguments for the heads of physics departments to set up such units;
• As regards teacher support, teachers recommend more openness to meet their needs and even targeted visits in schools where teachers feel the need to teach in team with experienced mentors.

It turns out that university co-operation has good practices, but there are many elements that could make it more effective and more responsive to the needs of secondary school students and teachers. The presence of teachers in schools and events promoting Physics as a school discipline and that science can make a significant contribution to inspiring young people in schools to make a career in STEM.

5. References

[1] PISA 2015 Results in Focus (2016) OECD 2016 http://www.oecd.org/pisa/
[2] Michelini M 2017 Preliminary Data Analysis of SSQ-HOPE Questionnaire on Factors Inspiring Secondary Students to Study Physics. In: Greczyło T., Dębowska E. (eds) Key Competences in Physics Teaching and Learning. Springer Proceedings in Physics, vol 190. Springer and Cham pp. 129 – 140
[3] Kelly A M 2013 Phys. Rev. Special Topics – Phys. Ed. Res. 9 010122
[4] Hempelmann R 2014 Science Education Research and Education for Sustainable Development; I. Eilks et al. Eds. Shaker Aachen, Germany, pp. 189–197

ANEXE 1

Questionnaire for University staff about joint School - University activities To inspire young people to pursue a career in Physics

Please read carefully the questions and choose the desired response in the column adjacent question. Please fill the 24 item space within your opinions that were not addressed by the questions. Save the file with the name Quest Opinions P XY (xy the number of partner).

Respondent Institution
University of
Country
University staff
Age
Gender
Years of Teaching experience
Years of Professional experience
How strongly do you agree with the following statements related to inspiring and motivating high school students to study physics at university?
Please use the following scale and choose the answer you consider that best fits your belief or situation: 1. Strongly disagree; 2. Disagree; 3. Neither agree nor disagree; 4. Agree; 5. Strongly agree; 0. Do not know

School - University cooperation in general
1. My institution has a long term strategy for school-university cooperation
2. My colleagues and I are deeply involved
3. We have logistical support from our institution
4. We have financial support from our institution
5. We are strongly supported by parents of students in our activities
6. Local community support all of our activities
7. Cooperation enables students to acquire a positive attitude towards physics studies

**School - University competitions for students - good practice**
8. Theoretical problem solving competitions should be encouraged
9. Competitions based on solving experimental problems should be encouraged
10. Competitions based on interdisciplinary topics should be encouraged
11. Competitions encouraging student creativity should be organized
12. Competitions encouraging teamwork should be organized
13. Competitions encouraging visual arts and multimedia productions of physics concepts should be organized

**School - University common activities and events**
13. Popularization of science events in schools and the community are needed
14. Demonstrations in public spaces, universities and schools are a useful activity
15. Universities should permanently open a special laboratory for secondary school students
16. Students should visit research institutes and enterprises

**School - University training programmes**
17. Universities should contribute activities (e.g. in-service training) enabling teachers to improve their teaching strategies in the classroom
18. Universities should contribute activities (e.g. in-service training) enabling teachers to teach physics in an interdisciplinary context relevant to daily life
19. Teachers should use computers and the Internet more as learning resources
20. University staff should be involved in the implementation of new programs in schools
21. Universities should offer help and training for school teachers
22. Academics may teach in joint teams in schools
23. Training programmes for teachers should be designed and implemented by universities in cooperation with teachers and schools addressing their needs
24. Please describe in approximately 50 words your idea of a School - University cooperation activity that you consider to be good practice.