Teaching K-12 students STEM-C related topics through playing and conducting research

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***Abstract*—Living in the world that is rapidly changing and is strongly interconnected with digital technologies puts a lot of pressure on K-12 students' teachers. Although, today's K-12 students are surrounded by technology and computers from the day they are born, they also must learn the basic principles of computer science in order to be adequately equip for their future jobs. However, Science, Technology, Engineering, Mathematics and Computer Science (STEM-C) fields are too wide and too complex for only K-12 schools to participate in the teaching process. In this paper we thus present how high education institutions can cooperate with elementary and secondary schools in STEM-C education process of K-12 students. We will share two good practices for allowing K-12 students to learn STEM-C related topics that have been implemented in Puerto Rico and Croatia. The objective of both projects is to establish a pipeline for K-12 students to go to colleges, and from colleges to graduate schools. The paper will present the impact of the program on the pre-college and university community of Puerto Rico, as well as the results of outreach activities conducted in Croatia.**

Keywords*—*K-12 students, early research experiences, STEM-C fields, learning programming through "playing" computer games

I. Introduction

According the U.S. National Academy of Engineering and National Research Council the Science, Technology, Engineering, Mathematics and Computer Science (STEM-C) fields are too wide and too complex for one single educational institution to cover all areas [1]. It is thus of vital importance to combine the strength and knowledge of various institutions in order to achieve successful education of students in STEM-C fields. The academia and other high educational science institutions, as well as research laboratories, have the knowledge and resources that elementary and secondary schools lack of. In this paper we will show how K-12 students can benefit from simultaneously combining both "sides" of education.

As opposed to elementary and secondary schools that have very firm schedules and clear learning outcomes, after-/out-of-school STEM-C settings (i.e., informal education) can contribute towards K-12 students' development of interest and identity in STEM-C fields. In that way, already jam-packed elementary and secondary school curricula do not have to be extended or reorganized, and students can have a boost they need to consider STEM-C fields as an important part of their lives. Here we do not only want to make an impact on K-12 students that will work in STEM-C fields in future, but also on every K-12 student as this knowledge will help them to cope with the challenges that will await them in their everyday lives.

Informal STEM-C education can be either a long term or a short term one. Both approaches have its advantages and disadvantages. For example, when K-12 students are involve in a long term after-/out-of-school STEM-C program then they get better understanding of how things work in this particular case and gain more extensive knowledge. However, they can experience only a limited number of opportunities as this approach is time consuming. Moreover, time constraints also affect educators who can provide these opportunities to only a limited number of K-12 students. On the contrary, when K-12 students are involved in short term programs then they can explore different types of programs and since they are short, more students can benefit from participating in them.

In this paper we will present both approaches and compare them in cases of K-12 students involved in programs run in Puerto Rico and Croatia. Namely, in Puerto Rico K 10-12 students are mostly involved in STEM-C long term research projects: (1) 16 weeks out-of-school program on Saturdays, (2) research mentoring process by undergraduates, (3) pre-college research symposium, and (4) 7 weeks summer research program at the US mainland research institutions. In Croatia K-12 students and their teachers are involved in shorter term programs: (1) K-8 students visit our research groups and departments where they play and learn how to code, (2) K 9-12 students do their own specific mini projects with their school teachers during a school year and then present them at our university, and (3) K-12 school teachers learn how to improve their approach to teach STEM-C concepts in a fun way.

The rest of the paper is organized as follows. In Section II we present related work and Section III describes two frameworks that are used to carry out STEM-C outreach activities: "SUZA - from school to science and the academic community" in Croatia and the Student Research Development Center (SRDC) in Puerto Rico. The SUZA program started in 2012, while SRDC has served as STEM-C outreach activity center in Puerto Rico for almost 15 years now. Furthermore, Section IV present short term out-of-school STEM-C activities, while Section V emphasizes our efforts made in long term outreach programs. Finally, Section VI comments on results that are obtained from our STEM-C outreach activities and Section VII concludes the paper.

II. Related work

Changes in STEM-C formal education are a "hot topic" across different countries in the world, although discussed differently by nations. Differences can be mostly seen in a case of level of integration of STEM-C and other fields. Some scholars are more keen on STEM-C taught using an integrative subjects approach, other consider STEM-C education to be the improved teaching of the separate subjects of STEM-C and many believe that it should be a combination of both of these approaches [2]. There are also some efforts made towards understanding challenges in developing a global curriculum [3]. However, no matter what their opinion on the level of integration is, it is widely accepted that STEM-C formal education needs to be complemented with the education activities conducted in informal STEM-C settings.

There is an extensive body of related work how universities and other research institutions can contribute to K-12 student's STEM-C education. Recently Steinmeyer has shown how to increase the reach of STEM-C exposure and education programs for high school students through the use of online environments [4] and Granchelli and Agbasi-Porter showed how intensive classroom lectures and hands-on activities can be used in their experiential STEM-C programs also for K 10-12 students [5]. Moreover, it has been shown that research is not only important on undergraduate level [6], but also on the high school level [7]. However, most of the studies are only concentrated on one STEM-C outreach activity (e.g., Kinect sensor [8], robots [9] or Arduino [10]) and are rarely focused on building pipelines [11].

In that sense, the contribution of this paper is threefold: 1) we propose a pre-college pipeline in which K-12 students participate at different stages of their pre-college education, 2) we introduce case studies of our STEM-C outreach activities in which we compare long and short term out-of-school STEM-C programs and 3) we distinguish among different goals for informal STEM-C education depending on student group ages.

III. Frameworks for STEM-C outreach activities

All activities that are organized in Croatia are a part of a program called "SUZA - from school to science and the academic community" [12]. This program is the official popularization program of the University of Zagreb Faculty of Electrical Engineering and Computing in Zagreb, Croatia. We partner with the Institute of Electrical and Electronics Engineers (IEEE) Croatia Section and the student organization eSTUDENT with the support of two Croatian agencies: Education and Teacher Training Agency (AZOO) [13] and Agency for Vocational Education and Training and Adult Education (ASOO) [14]. The aim of SUZA is to increase interests of K-12 students and their school teachers in STEM-C fields by organizing different educational and popular science talks, presentations, workshops and organized tours.

All activities organized in Puerto Rico are grouped within Student Research Development Center (SRDC), which is a part of Ana G. Mendez University System (AGMUS) in San Juan, Puerto Rico. AGMUS became the model institution for excellence institution when received the first National Science Foundation (NSF) grant in 1985, following by others grants totaling over 30 million USD. One of the main objectives of these grants was to establish a pipeline for pre-college from high school to college, and from college to graduate school for young economically disadvantage minority students from Metropolitan San Juan, Puerto Rico, interested STEM-C fields.

IV. Short term out-of-school STEM-C programs

This section presents three short term out-of-school STEM-C activities, two of which were organized in Croatia and one in Puerto Rico. As mentioned earlier, activities organized in Puerto Rico are mostly, although not exclusively, a longer term and aimed to K 10-12 students, while activities in Croatia are mostly a shorter term ones and aimed mostly to K-8 students. Namely, as the vision of SUZA program is to ensure the feasibility of the mutually entangled priorities of high science and industrial leadership defined by the Horizon 2020 program through ensuring quality learning outcomes and professional guidance for the top students [15], in SUZA we want to (1) start early (i.e., include K-8 students), and (2) reach out to as many students as we can (i.e., in form of short term outreach activities). On the contrary, STEM-C outreach activities in Puerto Rico are more oriented towards pre-college students (i.e., K 10-12 students) helping them with their transition from a high school setting to a university life.

A. Scientific visits for K-8 students

K-8 students should be first introduced to the basic concepts in STEM-C fields in order to understand that this is an important part of our everyday lives [16]. Applying the described concepts, we organize K-8 student short visits to our research groups and departments followed by a programming class similar to the Hour of Code [17]. These short term visits are usually 2-3 hours long and follow the same format: K-8 students are first introduced to simple theory concepts that are behind things they are going to see (see Fig. 1) and then they can even try simple examples by themselves (see Fig. 2). Finally, they participate in a short programming workshop where they write their first codes (see Fig. 3).

Fig. 1. Our volunteers explaining basic theoretical concepts before showing the real-world examples of their research.

At our university in Zagreb, Croatia in total we have 12 departments where each department has different focuses and things to explain and show to K-8 students. For example at Department of Electroacoustic K-8 students learn about physical phenomenon related to sound propagation, visit so-called "deaf chamber" and experience a professional audio equipment in a controlled environment. They also learn about how dangerous it is to hear music very loudly and can "play" with some sound equipment.

Fig. 2. Experiencing ”deaf chamber” and playing with sound equipment.

Last part of the visit is a programming workshop where K-8 students do a pair-programming with help of our volunteers and learn basic concepts of computer science with drag and drop programming [17]. Using this game-like approach, they learn repeat-loops, conditionals and basic algorithms.

Fig. 3. Learning basic programming concepts in pairs with help of our volunteers and earning certificates for successfully finishing the workshop.

B. Science fairs for K 9-12 students

K 9-12 students should have a basic knowledge about: (1) STEM-C in the modern world, (2) STEM-C concepts and practices, and (3) specific topics in STEM-C. They should first learn how to appreciate the breadth of computing and its influence in almost every aspect of modern life and should be aware of social and ethical impacts of their choices when using computing technology, both in their work and personal lives. Then, they should also learn how to clearly understand the application of computational thinking for tackling the real-world problems and how to work collaboratively to solve various problems using modern collaboration tools. Finally, K 9-12 students should be involved in projects-based work focusing on a single problem [16].

In contrast to short term programs that we organize for K-8 students where we want to make a first impact on student lives, by organizing short term programs for K 9-12 students we hope to help students to continue their interest in STEM-C fields. With that goal we help K 9-12 students to present outcomes of their work at a scientific fair. Fig. 4 shows a student fair that was organized at our university for two years in a roll and where more than 60 students and teams from almost 30 technical and vocational secondary schools in Croatia presented their work in front of their future professors and colleagues. Their work was judged by external team of university professors and research assistants and the best of them got awards for their achievements.

Fig. 4. Defending their work in front of judges.

C. Research symposiums for K 10-12 students

In Puerto Rico twice a year (i.e., in December and May) we organize AGMUS pre-college research symposium with the goal of emphasizing the importance of conducting research work starting already in pre-college years. Namely, at this event K 10-12 students present their research results in forms of professional posters or oral presentations. By doing so, K 10-12 students gain experience of communicating their scientific results using PowerPoint presentations and computer-generated posters (see Fig. 5).

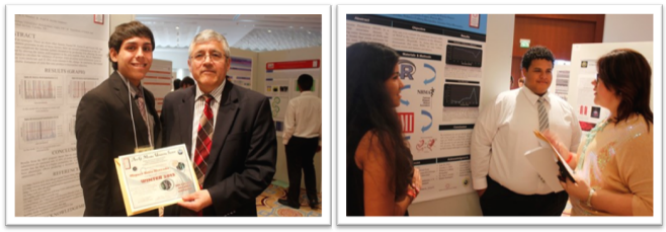

Fig. 5. K 10-12 students at the poster session.

A typical structure of AGMUS pre-college research symposium includes: a poster session set up, breakfast, registration followed by an opening ceremony with a keynote speaker presenting motivational and state-of-the-art talk every time with a different topic (e.g., topics from robotics, computational chemistry, computational biology, modeling and simulation, software development, visualization and astronomy). Moreover, during the symposium K 10-12 students have opportunities to attend workshops for example in ethics, English and STEM-C fields.

The efforts of the students that showed the most outstanding performance are recognized at the end of the symposium during the closing ceremony when they are awarded the certificates (see Fig. 6). By presetting in this research symposium, pre-college students not only gain knowledge and practice how to present their work in front of others, but also do get feedback on their presentation performance as they are evaluated by professional judges (e.g., faculty members and/or specialists within the area).

Fig. 6. The awarded K 10-12 students.

All posters and oral presentations are in English, which is not their mother tongue, so they practice to present in a foreign language as well. Finally, in addition to the pre-college students who present their research work, other K 10-12 students who do not have any prior research experience are also invited to attend the symposium. By just attending, these students have the opportunity to see posters and presentations done by their peers that can give them a push to try the same in the following years.

Once when AGMUS pre-college research symposium finishes, we publish a special post symposium proceedings in which we include all presented posters and given presentations. Although this event can be seen as a short term one, it has long term positive effects on lives of students who participated in it as we encourage them to continue with their research activities and to participate in national and international research conferences. We also support them in their future years as young scientists by providing them with more information about the process of publishing in peer-reviewed journals [18].

D. Short term programs for K-12 school teachers

Within SUZA program we also offer K-12 school teachers in STEM-C fields educational workshops where they can learn how to present STEM-C topics in such a way that is understandable, interesting and attractive to "ordinary" people, especially youth (see Fig. 7). Namely, during their studies, future K-12 school teachers usually learn how to present the required content in a traditional ex-cathedra way. However, times have been changed and nowadays K-12 students want and expect more out of their education.

Fig. 7. Teachers listening to presentations.

This is also recognized by AZOO and ASOO agencies that are encouraging K-12 teachers in their life-long learning process. Not only school teachers are encourage to take additional "classes", but attending certain programs is even mandatory. That is why the aforementioned workshops entered the calendar of professional teacher conferences and are now a part of the lifelong learning education and professional education offerings for K-12 school teachers in Croatia.

V. Long term out-of-school STEM-C programs

In this section we will present two types of longer term outreach activities designed for pre-college students. Both activities are organized in Puerto Rico. The first one is a pre-college research program organized in a partnership with institutions in Puerto Rico and US Virgin Islands during the school year, while the second one is a summer research program for pre-college students, undergraduates, and graduates organized in collaboration with some of the best universities and research institutions from US mainland and abroad (e.g., MIT, UCLA, UC Berkeley, University of Texas-El Paso, Carnegie Mellon University, Spanish Research Council).

A. K 10-12 student research program on Saturdays

The AGMUS pre-college research program is developed with NSF support who awarded us with the three grants: Modeling Institutions for Excellence, AGMUS Institute of Mathematics and Caribbean Computing Center for Excellence [19]–[21]. The main objective of the program is that K 10-12 students by attending Saturday research-oriented activities become more interested in STEM-C fields and afterwards enroll more easily to universities in the same fields. This is a longer term program that is run twice a year (i.e., during both fall and spring semesters) with total load of on average 64 hours per semester (see Fig. 8).

Fig. 8. Students involved in research programs run on Saturdays.

Students, while participating in research activities in STEM-C fields, are guided by their research mentors who are mainly undergraduate and graduate students. Research mentors provide students with knowledge and skills that they need to conduct their research. Namely, training that they get comprises of basic steps how to do research starting with how to make a literature review, format research hypotheses, what methods to use, how to get results and finally how to draw conclusions from their research.

They also learn about research protocols and safety, how to make a good plan for dissemination activities and the most importantly what the ”real world” application of their research/science can be. Some of the examples of the previous projects are: (1) extrapolation of stock market data using MATLAB, (2) a study of Newton’s law using Maple, (3) simulation of the Lorenz equation using an RK4 algorithm in C++, and (4) gamma ray burst associated with Supernova: a highly correlated physical sample.

B. Summer pre-college research program

Every summer for the last five years we have been organizing 7 weeks summer research program in which our partners were institutions in the US mainland and abroad (see Fig. 9). The list of partner institutions includes: MIT-Haystack, University of Vermont, University of Texas, El Paso, National Center for Atmospheric Research, North Carolina State University-Raleigh, Vanderbilt University, UCLA, UC Berkeley, Lawrence Berkeley National Laboratory, Lawrence Livemor National Laboratory, and Jagsellonian Observatory in Krakow, Poland.

Fig. 9. Summer pre-college research program flyers for 2012, 2013 & 2014.

The participants for this program are selected among the best performing students who attended our research programs on Saturdays during the given school year. The selected participants travel in groups of five, supervise by a chaperone, to one of the partner institutions where their mentors provide them education in the following core areas: (1) hands-on laboratory research, (2) computer-based research, (3) mentor/modeling, (4) career counseling and orientation, (5) professional growth, and (6) English language enhancement. A list of previous projects includes:

- Leg design for a praying mantis robot
- Visualization of molecular-dynamics simulations
- Tekkotsu support for the calliope platform
- An ontology on algorithms for high spatial resolution image interpretation
- Graphical display of search trees for transparent robot programming
- Teaching robotics in a three-dimensional visualization environment
- Development of educational data mining environment for the analyses of Moodle data
- Robot for support teaching parabolic trajectories
- Dog simulation behavior through the game of ”catch”
- Effectiveness of a sensor-based video game system in the therapy of students with special needs.

During the program students spend on average eight hours per day, five days per week doing research-related activities under their mentor supervision. On weekends and holidays a chaperone, who is usually an undergraduate student, organizes cultural and social activities for them. Selected students are prepared and trained during a spring or fall semester prior to the summer one participating in research methodology seminars, English courses, and other professional development activities. Moreover, we help them with their travel and housing arrangements. Finally, as they move forward with their research we monitor their progress either via e-mail either by having weekly meetings on Skype or by telephone.

At the end of the summer experience, students have to make their posters and prepare oral presentations that they present both at their research sites while still there, and later one during a local research symposium held in Puerto Rico early in fall of the same year (see Fig. 10). The AGMUS research symposium is a two days event organized with the goal of bringing together pre-college, undergraduate and graduate students presenting their research projects in STEM-C fields [22], [23]. In addition to student research presentations, future participants can get an insight into summer research internship opportunities offered by major US research institutions such like MIT, UC Irving, Carnegie Mellon, University of Vermont, Princeton, University of Colorado, Boulder, UCLA, Washington University, St. Louis. The AGMUS research symposium finishes with an award ceremony where the best students are recognized for their posters and oral presentations and where they receive prizes from local industries and commerce.

VI. Results of out-of-school STEM-C programs

We achieved great results both in short and long term outreach activities in STEM-C fields. Activities that we have organized in Croatia during the last two years made impacts on more than 500 K-8 and K 9-12 students all together. Our university was visited by K-8 students from 4 different elementary schools in Croatia: (1) more than 60 students visiting from elementary school ”Kralj Tomislav”, (2) more than 20 students from elementary school ”Pavel Miskin”, (3) more than 20 students from elementary school ”Tin Ujevic”, and (4) more than 10 students from elementary school ”Stenjevec”. On top of that we had more than 100 K-8 students participating in Hour of code workshops.

Fig. 10. An example of a scientific poster made by a pre-college student.

Fig. 11. A K-8 student giving us her feedback.

In addition to K-8 students, we also supported different activities for K 9-12 students. By organizing student scientific fairs and mini hands-on workshops, in total we hosted more than 210 K 9-12 students, where the full statistic is as follows: (1) more than 20 Swedish secondary school students, (2) more than 90 students participating at Student fairs 2013 and 2014, (3) more than 30 students visiting from Technical school "Ruder Boskovic", (4) more than 40 students participating in Scientific Saturday, and (5) more than 10 students visiting from Electrotechnical school. Finally, in collaboration with other popularization groups, initiatives and organizations in Croatia, we made impact on more than 540 not only students, but also other individuals interested in STEM-C fields.

In order to improve our program after each event that we organize we collect students' feedback. We rarely give to them specialized questioners, but rather support their creativity to express their opinion in a nonstructural and for them the most preferable way. In that sense, K-8 students expressed their opinions through their paintings (see Fig. 11), while K 9-12 students provided us with their feedback in form of a short written summary of their visit along with things that they liked or did not like. We took their feedback very serious and tried to improve our further activities based on the things that they did not like as much. Although our main goal is not only to promote our university, we are proud when students before leaving say: "See you in ten years!".

In partnership with public and private high schools across Puerto Rico and the US Virgin Islands for the last fifteen years we have impacted more than 4,550 K 10-12 students from 225 schools. The partnership with the Department of Education of Puerto Rico, and the Municipalities of the major cities and town of Puerto Rico and US Virgin Islands helped with the recruitment and selection of pre-college students for the research agenda. The model has a very successful track record of transferring almost 100% of the participants into college, and a rate of 85% of them into STEM-C fields. Fig. 12 shows outcomes of our activities that we organized for the last fifteen years. The blue colored bar denotes the number of project per year, while the orange one denotes the number of students participating in those projects.

The most important outcome of our long term project in Puerto Rico is the establishment of a pipeline from pre-college to college and from college to graduate school for STEM-C minority students from Puerto Rico and the Caribbean. During the last fifteen years we have witnessed to numerous successful examples of students who were involved in our projects. It can be either a short term success when for example technical papers that students write as a part of their summer pre-college research program are published in scientific journals or a longer term success when our students finish good universities and build a successful scientific career. In the rest of this section, due to the lack of space, we are going to mention only a few of them.

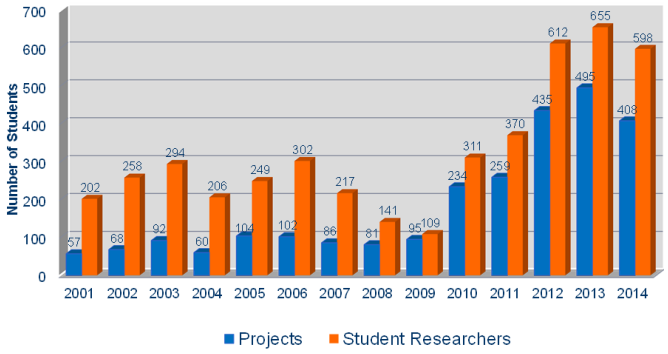

Fig. 12. Outcomes of outreach activities organized in Puerto Rico.

One of the successful short term outcomes was when the technical paper written by a student Andrea Boria who worked in the research project "Gamma Ray Burst Associated with Supernova: A Highly Correlated Physical Sample" under the mentorship of Dr. Maria Dianotti from the Jagsellonian Observatory in Krakow, Poland was published as a journal paper. Other longer term successful stories are in cases of Dr. Dalvin Mndez and Dr. Joshua Martnez, who are both from Puerto Rico. Namely, Dr. Dalvin Mndez, who entered our program as a 10-K student, finished an undergraduate program in Chemistry, Ph.D. in Computational Chemistry at Arizona State University and now is a Postdoc at Yale University. Dr. Joshua Martnez, who also joined our program in grade 10, finished his undergraduate program in Material Sciences at MIT, Ph.D. in Bio-Materials at Johns Hopkins University and now is a Postdoc at Oxford University, UK.

The list of universities where we successfully implemented our pre-college pipeline includes: the University of Puerto Rico-Mayagez, MIT, the University of Texas-El Paso, Universidad Metropolitana, Universidad del Turabo, the University of Puerto Rico-Ro Piedras, the University of Puerto Rico-Humacao, Polytechnic University of Puerto Rico, Universidad del Sagrado Corazn, UC Irvine, UC Berkeley, the University of Virginia, Charlottesville, Howard University, Universidad Central del Caribe, Universidad Interamericana, the University of Vermont, Syracuse University, Tuft University, Cleveland State University, Boston University, Ohio State University, Georgia Tech University, the University of Maryland, Johns Hopkins University, the University of Kentucky, Pontificia Universidad Catlica de Puerto Rico, the University of Puerto Rico-Cayey, and the University of Puerto Rico-Bayamn.

To gather information about the outcomes of our activities, our students are always asked to complete an anonymous evaluation questionnaire. The evaluation questionnaire is usually a modified version of the Student Assessment of their Learning Gains instrument [24]. Due to lack of space, we are going to show only results from research program run on Saturdays in 2014. Of 65 participants who participated and completed the online survey, 24 (38%) were males, and 39 (62%) were females. In relation to education level, 21 (33%) were high school seniors, 18 (29%) were juniors, 8 (13%) were sophomores, and 12 (19%) were freshmen, and 3 were college students (5%). Most participants, 56 (90%) were Puerto Rican, 2 (3%) were White, 1 (2%) were African American, 3 (4%) reported "Other" race/ethnicity and one student did not report his/her race/ethnicity.

After finishing our program, participants reported substantial knowledge in relation to numerous scientific research-related variables. As illustrated in Fig. 13, over 70% of participants reported "great deal of knowledge/a lot of knowledge" in relation to all of the scientific research related-variables.

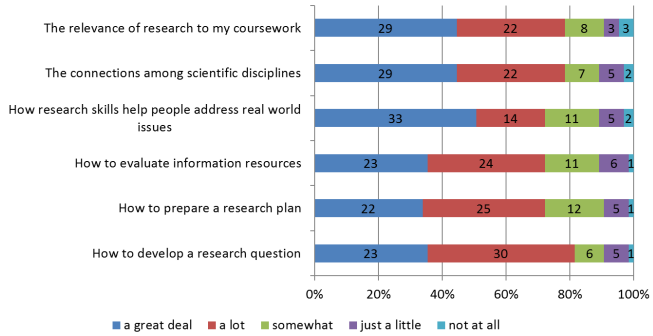

Fig. 13. Students' scientific knowledge and understanding of research.

Moreover, as expected, most participants (about 70%) reported "great/a lot" of skills in relation to many research/scientific related skills as shown in Fig. 14.

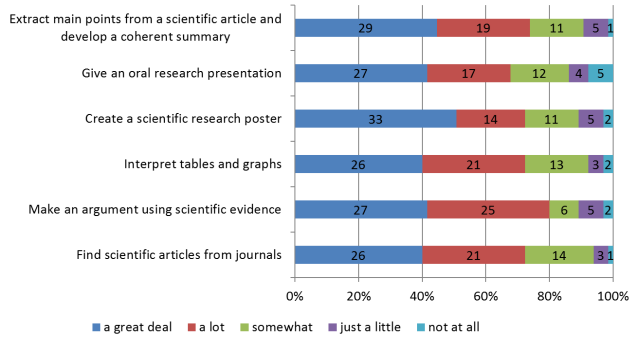

Fig. 14. Students' skills related to higher learning and scientific research.

Finally, as displayed in Fig. 15, over 80% of participants reported "great/a lot of interest" in relation to educational opportunities in STEM-C and over 80% of students reported interest in majoring in STEM-C and enthusiasm for research.

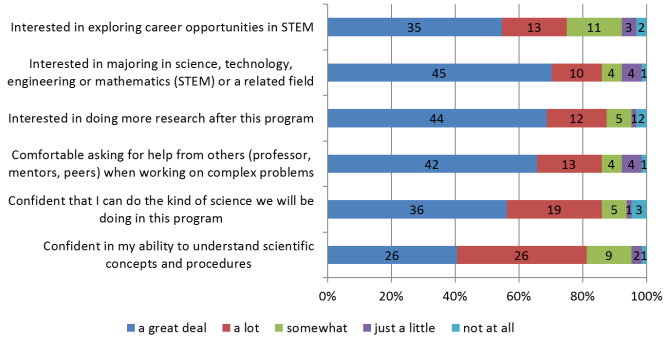

Fig. 15. Students' attitudes and interests in higher learning (Ph.D. in STEM-C), science, and research.

VII. Conclusion

As today we are facing very rapid changes in the way we are living (e.g., crowd-sourcing, crowd-owning), it is very hard to predict what future is going to look like. However, the thing that is very obvious is that jobs people (i.e., today's K-12 students) will have in 10-20 years are going to be more and more connected with digital technologies. In that sense, it is of vital importance to prepare today's students for the future challenges in the best way we can, i.e., by teaching them basic concepts of STEM-C fields. Without any doubt, this knowledge is going to be needed not only for people working in those fields, but also for other professions.

In this paper we presented two ways of introducing K-12 students to STEM-C fields: by involving them into short and long term programs. With the goal of promoting STEM-C fields, we have been organizing different scientific events both in Croatia and Puerto Rico. We showed that both approaches have their own advantages and disadvantages. Unlike the longer term activities, in cases of short term activities, we are able to include more students. However, with longer term activities we are able to establish a pre-college pipeline through which we are able to achieve more concrete results.

In our future work, we will try to benefit from both approaches by combining them together and by merging our two programs into the one. Namely, in two settings that we have today in Croatia and Puerto Rico we have either a pipeline that starts at a pre-college level or disconnected activities at lower levels (i.e., for K-8 students). In order to get better results, we would need to establish a pipeline that starts in elementary school and continues until the college level. However, to successfully implement this model, we would need every entity in the pipeline supporting lower levels. That would for example mean that high schools would need to be involved in outreach activities for elementary schools, and elementary schools would need to participate in STEM-C popularization activities for kindergarten students. Once when fully established, students who enter this pipeline will have a lower level risk of dropping along the way. Consequently, this would mean that we would have more students educated in STEM-C fields. Finally, by having more people educated in STEM-C fields, in future we will hopefully live in a more advanced and safe world.

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