Abstract – Education in science usually is related to diverse science activities undertaken in schools and at universities. School and university students have mostly unobstructed access to scientific knowledge and instruction in scientific methods as part of their daily educational activities, while citizens outside the domain of formal education are in less favorable position. As a result, they seek scientific content and activities online or in libraries, including public libraries, which are by their definition accessible to all citizens regardless of their age, education, gender, religion etc. and offer diverse learning opportunities to their users. Public libraries in Croatia have been helping citizens to become familiar with recent developments in science and to become informed individuals who will be able to make important decisions in their lives based on their knowledge about the world that surrounds them. This paper aims to introduce public libraries in Croatia as places at which science education is not only possible but it is already done rather intensive and widely accepted by the different generations of library users.

Key words – science education, public libraries, Croatia

I. INTRODUCTION

Science is one of the most prominent and most favored human endeavors in society. During the development of the human civilization, people have developed many interconnected ideas about the physical, biological, psychological, and social worlds they investigated [1]. They tested their ideas mainly by applying different scientific methods, and these scientific methods helped them prove their ideas true (or false). Today, after centuries of successful scientific research resulting in many important discoveries and their application in education, medicine, engineering, space exploration, business etc., there are still individuals who have doubts in science and outcomes of its activities. This happens because of the lack of knowledge about the world we live in, but also because science is sometimes applied in very closed communities which occasionally tend to be elitist and do not communicate enough or communicate at all with the wider public. We have now entered a new era of development of science – open science. Open science is here to enable better and open cooperation between scientists, better insight into scientific activities to science funders but also to enable better insight into the world of science to all individuals in schools and universities and those who are enthusiastically interested in sciences but their education was completed recently or long time ago so now they seek additional scientific knowledge outside the classroom and formal education to understand changes and phenomena happening in today’s world. This paper aims to explain what open science is and how important it is for an individual to have access to results of scientific research without obstacles (for instance, in public libraries) in order to become scientifically literate and to understand effects of science on everyday life.

II. OPEN SCIENCE

“Open Science represents a new approach to the scientific process based on cooperative work and new ways of diffusing knowledge by using digital technologies and new collaborative tools. The idea captures “a systemic change to the way science and research have been carried out for the last fifty years: shifting from the standard practices of publishing research results in scientific publications towards sharing and using all available knowledge at an earlier stage in the research process” [2]. The OECD defines Open Science as making “the primary outputs of publicly funded research results – publications and the research data – publicly accessible in digital format with no or minimal restriction” [3]. The EU sees open science as an important developmental driving force. The EU/EC suggested the five points of potential policy actions [4]: 1. fostering and creating incentives for open science, by fostering open science in education programmes, promoting best practices and increasing the input of knowledge producers into a more open science environment (citizen science). This area is also concerned with guaranteeing the quality, impact and research integrity of (open) science; 2. removing barriers to open science: this implies, among other issues, a review of researchers’ careers so as to create incentives and rewards for engaging in open science; 3. mainstreaming and further promoting open access policies as regards both research data and research publications; 4. developing research infrastructures for open Science, to improve data hosting, access and governance, with the development of a common framework for research data and creation of a European Open Science Cloud, a major initiative to build the necessary open science infrastructure in Europe; and, 5. embedding open science in society as a socioeconomic driver, whereby open science becomes instrumental in making science more responsive to societal and economic
expectations, in particular by addressing major challenges faced by society”.

What is most important both to scientific professionals (researchers) and to scientific nonprofessionals (enthusiasts and students) is to acquire access to results of scientific endeavor without obstacles. Open science enables public insight into results of work of professional scientists and, what is also important, it enables civic engagement in science. To be able to understand results of scientific research, a person must be scientifically literate.

III. SCIENTIFIC LITERACY

Science is the driving force of the development of society, so those who are professionally involved in science as well as citizens should possess knowledge about world that surrounds them and understand how science is changing that world. Of course, the quantity of knowledge about scientific methods and facts based on scientific research differs between professional, citizens enthusiasts and layman. Main problem in case of citizens enthusiasts layman is that they are not all educated enough or educated at all in science or are able to keep up with the latest scientific developments.

In contrast to citizens enthusiasts whose knowledge about a certain world phenomenon does not need to be detailed (but it could be, and sometimes is), the professional researcher should possess a number of competencies such as “knowledge, skills, attitude, and characteristics which are conducive to research, must have an ability in critical thinking, synthesis, capable of criticism, well predicted an answer, knowledgeable in the use of the scientific method and logic, able to criticize with logic, good interpersonal contact with others, as well as using the information as a basis for decision making” [5].

In addition to enthusiast, school and university students should develop such skills to a degree which will prepare them to become at least informed citizens and to answer challenges at their future workplace. The world itself is changing fast and old knowledge and skills are not good enough for future world.

Science does not happen in vacuum, but it is integral part of the 21st century society. The 21st century requires new set of skills, which include basic, scientific, economic, and technological literacies; visual and information literacies; multicultural literacy and global awareness [6].

Aita, Rannikmäe, Soobardc, Reiskab and Holbrookd [7] made a step further and suggested that new standards related to expected student capabilities in the 21st century necessary to replace the existing basic skills and knowledge expectations of the past and to succeed in this six major criteria areas: “1.) transformation of schools through science education, students need to develop an understanding of big ideas about objects, phenomena, materials and relationships in the natural world 3.) individuals need to be nurtured who are able to appreciate diversity of values and culture sensitivities surrounding issues, to have compassion for others, collaboratively construct values for the larger welfare, and ultimately take action 4.) an increasing urgency needs to be recognized for skills such as analyzing the credibility and utility of information, evaluating its appropriateness and intelligently applying it 5.) skills are needed to infer meaning from science texts which relates to the ability to recognize the standard genres of science, their appropriate use, and, in the case of argument, to evaluate the claims and evidence advanced 6.) metacognitive knowledge is also an important need for science learning which is related to positive attitudes and knowledge gains”.

To become an active and a responsible citizen, one should possess “necessary knowledge and understanding of the problems faced by mankind” [8]. In case of science, knowledge and understanding are usually perceived as science literacy.

In the past several decades, the goal of science education globally has been achievement of scientific literacy [9]. However, the term scientific literacy is understood differently in different environments, and it is not equally accepted in all educational institutions. “Scientific literacy represents the ability to use evidence and data to evaluate the quality of the information and arguments presented by the scientists and, in mass media” [8]. It also means “knowledge and understanding of the scientific concepts and processes required for personal decision-making, participation in civic and cultural affairs, and economic productivity” [10]. Scientific literacy can be divided into four categories: “1.) cultural scientific literacy - means understanding the science by a person with average intelligence and education of a culture; 2.) civic scientific literacy- represents the level of scientific understanding necessary a person to make informed decisions with regard to legislation and public policy; 3.) scientific literacy practice - refers to scientific knowledge that a person needs to solve practical problems (expl. determining the most efficient way to heat home); 4.) aesthetic literacy and consumer science - indicates to what extent the understanding of scientific laws” [8].

As a result of being educated or acquainted with science, a scientifically literate person would require competencies to: “1.) explain phenomena scientifically; recognize, offer and evaluate explanations for a range of natural and technological phenomena; 2.) evaluate and design scientific enquiry: describe and appraise scientific investigations and propose ways of addressing questions scientifically; 3.) interpret data and evidence scientifically: analyse and evaluate data, claims and arguments in a variety of representations and draw appropriate scientific conclusions” [11].

IV. EDUCATION IN SCIENCE

Generally speaking, education in science starts at an early age and it continues throughout the entire life of a person. “Education contributes to the development of the ability of understanding of the most effective way to use science in daily life and social responsibility” [8]. The PISA report from 2015 indicates that the Croatian students fell behind the OECD average in science related performance [12]. To improve this situation the current educational system in Croatia must change to introduce newly discovered science related knowledge, skills and
teaching methods in schools and at universities in such a manner, which would benefit students. During their education in schools and at universities, students develop their research competencies by participating in scientific curricula which includes the logic, critical thinking and integration, creating description and argument, the communication, and the use of mathematics [5]. While many of these skills are included in academic curricula at all levels of education, formal education must end at some point in time and after that moment individuals are left on their own to continue their science education in years to come. Currently, Croatia does not have developed system of life-long learning, which would facilitate and guarantee continuing education to every individual interested in it. So, students should learn two things during their formal education. First, they should acquire as much knowledge about science as possible during their formal education. The opportunities for this are enormous as students have many ways in which they can access scientifically related knowledge offline in academic libraries or online in many other information resources available to them. Second, their knowledge and experience in finding scientifically related knowledge should be applied once their formal education finishes to continue their education in science which progresses perpetually. As the access to university information resources ceases to exist, former students should focus their search to other institutions, which offer insight into current scientific knowledge to the wider public.

Luckily, such institutions exist as schools and universities are not the only places where science education happens. According to Rennie, informal science education can happen in various non-school environments and they remain catch-all term “for science-related activities that are not part of a formal, assessable curriculum offered by educational institution” [13]. One such environment is library in general and public library in particular.

V. EDUCATION IN SCIENCE IN LIBRARIES

Public libraries in Croatia are very busy places offering a variety of activities including science related activities. It is now a common knowledge that libraries (in general) have been closely related with education in general for centuries. Their positive involvement in education include referral services, information and teaching resources, individual tutoring programs and educational classes, outreach to specific people’s groups with educational handicaps, distribution of resource materials to institutions, including hospitals, prisons, homes for the disabled and aged, rehabilitation centers and groups with education related problems and adolescents involved in crime, unemployment and the like [14]. Public libraries play “the role of a nodal point in assimilating informal or formal information of local learning content and co-relating it to knowledge and information from global resources” [14]. During their activities in education in science, public libraries in Croatia cooperate with individual scientists and scientific institutions to acquire new information about the latest scientific discoveries and also to acquire new knowledge for themselves as “librarians don’t always have all the skills needed in order to satisfy the digital learning needs of all groups, but they have the ability to connect people” [15]. The result of this cooperation is quality science related library programs and cooperation in scientific projects.

No matter how good public libraries are in helping people to get informal education in science, they are often neglected or even invisible when media search for scientific activities outside schools and universities. To improve this situation, public libraries use Web pages and social media to promote their science related activities.

The following part of the paper presents selected examples of science related activities in public libraries in Croatia. This list could be longer, however, information about science related activities are not systematically archived on the Web pages of public libraries so it is sometimes difficult to find such information after the completion of such activities.

Zagreb City libraries presented a series of lectures for public called “Eppur si muove.” [16]. The first lecture was held on March 26 2014. Lecturers were scientists in different fields of science, philosophers, sociologists, theoreticians and journalists.

The lectures covered a wide spectrum of topics presented by dozens of scientists and journalists. There is no entrance fee to the lectures, which take place in the attic of the Zagreb City library – a place well chosen as an open forum for exchange of knowledge and ideas.

“Bogdan Ogrižović” library introduced the public round table on different topics including scientific topics and this round table is broadcast on the Croatian national radio every time it takes place, which helps in even wider availability of the content of the round table [17]. Due to the limited capacity of the library facilities, the listeners sometimes stand on their feet instead of sitting on chairs.
In 2017, the library at the University of Rijeka [18] was part of the national Festival of Science during which dozens of institution like schools, universities, libraries and museum participate in popularization of science. Although it is not a public library, the library at the University of Rijeka participated by organizing a series of lectures in different scientific topics. By participating in the lectures, audience was acquainted with selected scientific topics.

Figure 2. Public round table

Figure 3. Science festival at the Library at University of Rijeka

Zadar city library also organized a number of science related public lectures, which enabled audience to become acquainted with the relevant discoveries in science [19].

Another science related event in Zagreb City Libraries are workshops for children in the library department for children and youth [20]. Children will be introduced to topics in biology, ecology, environment protection, health, nutrition and other similar topics which promote science fight ingorance and help in cooperation with scientists.

Figure 4. Zadar city library

Figure 5. Small scientific workshop

Zagreb City Libraries offer science related programs even for pre-school children [21]. They organized the smallest scientific workshop in which pre-school children are acquainted with topics related to exploration of Universe.

Figure 6. Small scientific workshop
City library in the Croatian town Đurđevac organized scientific workshop for children [22]. The activities included use of magnifying glass to observe one’s hair and skin, collecting material for inspection under the microscope and design of a volcano.

The City library in the town of Metković organized a workshop for children as a part of the project “Scientific magic” [23]. The project was original idea of the Croatian chemical society with aim to popularize science among children of pre-school and school age. The aim of the workshop is to present natural laws and phenomena to children.

The city library Sisak organizes a series of lectures and workshops as part of the project “Jump into science”. Aim is to attract children of pre-school and school age as well as children with needs. The lecturers will be experts, university and school students.

All these examples demonstrate active involvement of public libraries in Croatia in education in science outside the classroom (of a school or of an university). Education outside the classroom generally comprises of three domains: knowledge, attitude and skill. These three domains have the following objectives: “first, to reinforce student understanding of concepts taught in class; second, to provide learning experiences in real-life situations; third, to make learning more meaningful and enjoyable; fourth, to enable students to think and master knowledge through contextualised experiences; fifth, to increase student interest and attitudes to learn; sixth, to expand teamwork and social skills; seventh, to develop skills in the collection, processing and analysis of data and information; and eighth, to cultivate wholesome values among the students themselves” [25]. All three domains could be acquired in schools, at universities and in libraries.

While this paper mentioned school and university students in some of its parts, it must be noted that the
content of the science related activities are intended for wide variety of library user groups and individuals like special age groups like pre-school children, but also schoolchildren, university students and adults of all ages. This makes library activities truly universally accessible to different users, which is the original idea of existence of every library.

VI. CONCLUSION

Science helps our society develop better and faster. Scientific activities can most frequently be found in educational institutions and commercial companies which plan their development on research and development. However, science is not carried out exclusively in educational institutions, but they can also be found in other environments and institutions like libraries. Libraries have central role in society of information supplier and facilitator of different educational and cultural activities. As such, they have enough experience in organizing science related activities that otherwise immanent to educational institutions. Their role is extremely important in the changing environment and in time when pressure is put on libraries to change their role in society: “New business infrastructures, healthcare, academic research, economic development and social interaction have sprung from the arrival of networking, data storage, new innovative software and microprocessors, thus providing for direct access to all information, eliminating the legendary intermediary, and thus gaining on space and time” [14]. However, libraries, and especially public libraries are regaining space and time taken by technology offering unique personal and group approach to support the learning process especially in learning about science. The proof that they are doing this job well is the number of interested library users who attend science related activities in public libraries (as presented in Figure 2.). Unfortunately, so far there hasn’t been no special evaluation of the outcome of these activities and their influence on students and other categories of library users but that is something that remains to be done in future. Until then, the number of science related activities in public libraries will continue to depend on financial means, number of librarians who can participate in organizing such activities, space capacity in library etc. Because of that, some library activities are carried out less frequently and in more modest environment. However, public libraries will not give up on education in science for user groups who are seeking such activities in their premises.

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