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SCIENCE AT HIGH SCHOOLS – COLLABORATION BETWEEN RESEARCHERS AND STUDENTS

Abstract

In the text, high school students involvement in research activities is explored. The paper contains three parts. The first part presents the theoretical backgrounds of the relationship between science and civil society, and the concept as well as concrete examples of the Citizen Science. The second part reports the results of a pilot study (sondage) in which the students from five (Slovenian) High Schools expressed their views regarding the meaning and significance of the ecology and sustainable development. In the third part, so-called group-feedback analysis with the participation of students is considered, regarded as a contribution to the concept of the Citizen Science Experiment. The results show that the students are getting solid knowledge on ecological and environmental issues, especially in biology courses, however there is a certain lack of more integral didactic approaches while students' interests seem to be rather declarative and pragmatic (school-centric).

Keywords: citizen science, high schools, ecology, sustainable development, civil society, environmental studies, biology, sociology

Introduction

In order to fully understand the effects of techno-scientific applications, we have to motivate the active citizens (non-scientists) to include in research teams. The period we are currently living in is marked by scientific discoveries and technological innovations in all fields, on all levels. The natural and technical sciences in particular are included in this. It is very important that part of the humanities and social sciences are given the opportunity to reflect on and monitor the effects of technical/scientific applications on society and the environment.

Two processes have been encountered recently. The first is called the scientification of society and the everyday life of the individual. The second may be denoted the socialisation of science. The first, the scientification of society refers to the "small but well-organised community of scientists and specialists who are persistently and worthily linking two seemingly separate worlds – science and the public" (Sopta 2013: 60). Mostly these well-organised communities are established as science organisations, scientific organisations, scientific institutions and international scientific organisations.[3] Besides their role in shaping the public policies, they remain the important actors of knowledge transfer. Secondly, we

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[3] See: https://en.wikipedia.org/wiki/Category:Scientific_societies (Accessed August 27, 2018)

can talk about the socialisation of science when science becomes the subject of wider reflections. Important foundations for it are interdisciplinarity and ensuring the inclusion of all interested and well-informed citizens in scientific research and technological applications.

But what is the true meaning of such inclusiveness? It cannot be related to the politicisation of science but, on the contrary, to greater respect for people, namely those who are directly affected by scientific discoveries and technological applications. Inclusiveness in this respect presupposes an organised civil society and active citizens; active not only in a social but also in a cognitive sense and in the sense of long-term strategic policymaking. What needs to be emphasized here is the popularisation of science and technology through the media and spreading the network of non-governmental organisations dealing with this type of popularisation and knowledge transfer.

The main concern and orientation of our paper that emerges from two research projects is how to make young people familiar with the scientific way of thinking and problem-solving.[4] We decided to focus on ecology, environmental aspects and the challenges of sustainable development. These topics form part of both the social and natural/technical sciences. Moreover, they also serve as an inspiration for personal growth and social engagement (Shirk et al., 2012).

The paper consists of three parts. The first presents the theoretical backgrounds of the relationship between science and civil society, and the concept of the Citizen Science Experiment (CSE), which has proven to be a successful instrument for the socialisation of science and participation of non-scientists from civil society. The second part reports the results of a pilot study of young students from five high schools (grammar schools), which also involve other activities such as group discussions with young students and teachers. In the third part, so-called group feedback analysis is applied, regarded as a contribution to the concept of the Citizen Science Experiment. At the end, we provide a short summary and a conclusion.

Civil society and the socialisation of science

In reference to the socialisation of science, the proliferation of civil society organisations (CSOs) as bearers and generators of knowledge and expertise should also be viewed in connection with the emerging knowledge-based society, or the learning society and learning organisations. Only in such an environment is there a possibility of deliberative democracy which brings about new actions and a new understanding of the role of civil society. It is quite clear the deliberative democracy model itself presupposes meritocratic characteristics,

[4] This paper is mainly based on research in a project called STEM (Science, Technology, Engineering, Mathematics) for Youth within the Horizon scheme funded by the EU Commission, where IRSA is one of the partners (see www.institute-irsa.si). In addition, the small project “Pioneers: Citizen Science Experiment in High Schools” has to be mentioned. It was funded by the American Embassy in the framework of calls for projects for NGOs. In this connection, the collaborators Nick Vovk, Barbara Tomšič, Francesca Lori and the late Toni Pustovrh who contributed to these two projects should be acknowledged.

such as articulated knowledge, the ability to enter into public dialogue, and well-informed actors.

CSOs can play an important role as a mediator between politics, business, science and the rest of society and thereby help to establish a new developmental discourse and in the making of more carefully considered political decisions. Conversely, new approaches to the sociology of science underline the distinction between 'reliable science' (scientification) and 'socially robust science' (socialisation), meaning a new social contract between science and society with an emphasis on wider stakeholder inclusion and policy deliberation on the long-term implications for implementing scientific and technological innovations (Nowotny et al. 2003).

CSOs can also play a vital role as a mediator and 'translator' between scientific expertise and the broader public. It must be taken into account that: "Since expertise now has to bring together knowledge that is itself distributed, contextualised and heterogeneous, it cannot arise at one specific site, or out of the views of one scientific discipline or group of highly respected researchers. Rather it must emerge from bringing together the many different 'knowledge dimensions' involved. It's authority depends on the way in which such a collective group is linked, often in a self-organized way" (Gibbons 1999: 6). In this connection, the paradigm of the Mode 2 production of knowledge highlights socially distributed, application-oriented and trans-disciplinary knowledge which is subject to multiple accountabilities (Nowotny et al. 2003). The participation of citizens and stakeholders is an essential part of the research process and reflexivity.

In the last decade, the growing distrust of the general public in developed countries in the objectivity and reliability of scientific expertise, especially concerning the societal benefits, risks and unintended consequences of new developments in science and technology has led to the forming of tentative mechanisms to enable the inclusion of a broader range of knowledge and opinions from various stakeholders in the scientific and technological research, development and deployment process, ideally creating a two-way channel between scientists and various publics. This has become especially salient given the extensive implications of existing technologies, such as nuclear technology and biotechnology, and the new and emerging technologies like nanotechnology (Roco et al., 2011), synthetic biology (Schmidt et al., 2009) and human enhancement technologies (Savulescu et al., 2011).

The report of the Expert group on the Global Governance of Science, for example, proposes several new exchange mechanisms on the interfaces between the "society of science" and general society that could maximise the societal good and minimise the risks and negative consequences of scientific and technological processes and products, possibly even allowing some degree of societal control over what kind of innovations and resulting social changes will be introduced (Mitcham and Stilgoe 2009). This approach has also been further elaborated under the concept of "responsible research and innovation", which seeks to foster the 'right' impacts of science and technology, that is, socially desirable innovation in a broad sense, by enabling the establishment of deliberative mechanisms that on one hand inform experts such as scientists and policymakers about public opinions, preferences and debates and, on the other, inform other stakeholders and the public about proposed scientific and technological funding, research and development directions (von Schomberg 2011).

These approaches strive to take account of both the serendipitous nature of scientific discovery and the need to steer scientific and technological development into socially desirable and beneficial applications, as well as towards society's pressing problems. In the scope of 'socially responsible innovation', approaches that include deliberations with a wide range of stakeholders and especially various segments of the public as key elements, CSOs could perform important functions, especially as mediating agents between the society of science and policymakers on one side and the civil society and other stakeholders on the other.

As is evident, all these requirements regarding knowledge production systems in modern knowledge societies point to a strong need to develop "hybrid forums" (Callon et al. 2009) where experts, policymakers and citizens discuss and create new approaches for the social regulation of science and technology. Currently, best placed among the institutions that could feature mechanisms and channels for stakeholder and citizen inclusion in science and technology deliberations are National Ethics Committees (NECs), expert bodies that provide policy advice on ethically and socially contentious technologies at the level of individual nations. However, a recent overview of NECs in 32 European countries (Mali et al. 2011) shows that less than half of these feature distinct mechanisms for public involvement.

Further, a majority feature passive mechanisms, meaning one-way channels of knowledge flow from experts to the public for the purpose of informing and educating, and only a minority feature active mechanisms, meaning two-way channels that enable the exchange of knowledge, preferences and opinions between experts on one side and stakeholders and the general public on the other. Among the latter NECs are those of Germany, with its open meetings for a public exchange of views, the Netherlands, with its enlarged special thematic committees, Portugal, with its Citizenship Forum, and the United Kingdom, with its consultation papers and deliberative workshops. In the USA and some EU countries, different forms of Citizen Science or Citizen Science Experiment (Projects) can be noticed.

A closer look at Citizen Science

In this subchapter we present several definitions of the complex category of citizen science and several examples of projects where this concept is put into practice.

Recently, many attempts have been made to define Citizen Science. The term itself refers to a broad concept which includes many different aspects ranging from the observation of natural events to the democratisation of science. One of the first definitions appeared 14 years ago (Lewenstein 2004) and constitutes of three parts:

1. the participation of non-scientists in the process of gathering data according to specific scientific protocols and in the process of using and interpreting that data;

2. the engagement of non-scientists in true decision-making on policy issues that have technical or scientific components; and

3. the engagement of research scientists in democratic and policy processes.

It can be noted that in Lewenstein's definition (also see Lewenstein 2016), the broadness characterising the concept of Citizen Science persists as each part refers to a distinct scientific branch (i.e. scientific research, scientific policy-making and science advocacy). Another definition is offered by the Green Paper on Citizen Science where Citizen Science refers to the general public's engagement in scientific research activities when citizens actively contribute to science either with their intellectual effort or surrounding knowledge or with their tools and resources (Shirk et al. 2012).

Other authors use citizen science to describe a situation in which people employ scientific techniques to investigate a phenomenon of interest without any institutional cooperation (Heiss and Matthes 2017). However, we find the cooperative aspect to be crucial in Citizen Science. This is well emphasised in the Oxford Dictionary where the term is referred to as scientific work undertaken by members of the general public, often in collaboration with or under the direction of professional scientists and scientific institutions.

The above mentioned collaboration enables professional researchers to gather large-scale or hidden data they could not access otherwise. In this sense, although Citizen Science projects have primarily concerned and flourished in the natural sciences[5], nonetheless recently Citizen Science projects have also been initiated within the social sciences. As Heiss and Matthes explain, the rise of certain favourable conditions is responsible for that. They not only include more attractive funding programmes for citizen engagement, but also the increasing willingness of societal actors to actively contribute to scientific research. Further, public engagement has been favoured by new technologies. One example is the Austrian Citizen Science project Young Adults' Political Experience Sampling (YAPES). In this project, school students are asked to send comments and pictures from their smart phones, and this engagement enables researchers to collect data on young people's political participation.[6]

Nonetheless, Citizen Science goes beyond the mere collection of data. It also has an educational value, insofar as it can be responsible for increasing knowledge and scientific

[5] In this sense, the American colonialists who recorded changes in the weather may be considered the first citizen scientists. We owe credit to Thomas Jefferson and Benjamin Franklyn for the birth of a network of weather observers that provided, and still does, the National Weather Service with data. Other examples of Citizen Science pioneering experiences include fields such as ornithology and astronomy.

[6] The YAPES project (Young Adults Political Experience Scoring) is taking place at the University of Vienna. Interested young adults were invited to collect their political experiences on a daily basis and send them to the research team via e-mail or WatsApp. Everything that was politically interesting and important for them was invited to photo, document and comment. In this way, it was possible to understand which political topics are important for the youth and how the politics could address them. See: https://citizenscience.univie.ac.at/projekte-an-der-universitaet-wien/yapes-young-adults-political-experience-sampling/ (Accessed August 31, 2018).

interest among its participants. This is witnessed by a project underway at Michigan State University to address the issue of students' attraction to STEM sectors. For instance, one of them is addressing climate change to classes to maintain students' interest in STEM fields.[7]

Ultimately, these Citizen Science experiments are found to lead to more positive attitudes and aspirations, as well as a more active interest, concerning science. Moreover, the experiments contribute to the certain STEM-related skills being acquired (i.e. responsibility, critical-thinking and problem-solving). These "interdisciplinary process skills [...] are paramount to solving 21 century problems."[8]

Climate change is definitely one of the 21 century problems, being a complex scientific and social problem. Therefore, incorporating climate change to the curriculum is an important aspect of citizen science. Interdisciplinary approach is the prerequisite to fully understand climate change. Dealing with it requires knowledge from biology, chemistry and physics.[9] In the paper, the authors[10] offer three examples of climate change-related STEM education projects that are interdisciplinary in nature:

-The "hockey stick project" in which students work in groups to teach their classmates about a topic related to it. The hockey stick graph is a visual that illustrates how global warming has dramatically increased over the last 100 years.

-"Climate change week" in which first- and second-year college students sit in on a variety of STEM courses to learn about the relevance of several disciplines for understanding climate change.

-"Climate change semester or year" in which a long-term course is team-taught by instructors from many disciplines.[11]

Defining the complex category of citizen science or the citizen science experiment, and continuing definitions from above, having in mind the co-creation (co-design)[12] nature of the citizen science, the citizen science projects are also defined according to the type of voluntary participation:

-contributory projects: participants take part in data gathering, analyse the data at certain points in the project and help disseminate the results

-collaborative projects: as well as the above, the participants analyze the samples and, on occasions, help design the study, interpret data, draw conclusions or disseminate the results

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[7] See: https://msutoday.msu.edu/news/2013/attracting-more-students-to-stem-by-teaching-climate-change/ (Accessed August 31, 2018).

[8] https://msutoday.msu.edu/news/2013/attracting-more-students-to-stem-by-teaching-climate-change/ (Accessed August 31, 2018), introduction by Tom Oswald , Aaron M. McCright.

[9] See: https://msutoday.msu.edu/news/2013/attracting-more-students-to-stem-by-teaching-climate-change/ (Accessed August 31, 2018).

[10] Promoting interdisciplinarity through climate change education
Aaron M. McCright, Brian W. O'Shea, Ryan D. Sweeder, Gerald R. Urquhart & Aklilu Zeleke
Nature Climate Change volume 3, pages 713–716 (2013)

[11] See: https://www.nature.com/articles/nclimate1844 (Accessed August 31, 2018).

[12] …co-design is defined from an understanding of the co-created modality of citizen science as »participatory science« or »civic science« (Wylie e tal., 2014 in Senabre, Ferran-Ferrer and Perello 2018, 30).

-co-created projects: the participants collaborate in all stages of the project, including the definition of the questions, development of hypotheses, discussion of results and response to further questions that might arise (Follet and Strezov 2015 in Senabre, Ferran-Ferrer and Perello 2018, 30).

The millennium is the era of technological breakthroughs, of everything digital, and the job market goes in the same direction: the highest expected salaries are in fact those of future graduates in science and technology, and the current job market demands for more digital professionals than higher education can supply.

Experiences with Citizen Science pilot experiments

As part of the European project STEM4YOUTH, the University of Barcelona is carrying out three Citizen Science experiments. They involve a total of 96 high school students from three schools in the Barcelona metropolitan area. The schools were chosen for their different socio-economic backgrounds, whereas the students taking part in the project are in the same age range[13]. The students are gathered in small-scale working groups and each working group includes the following profiles: two early-stage researchers, one post-doctoral researcher, one final-year undergraduate student, one senior researcher, one researcher and up to three teachers involved in the pilot experiment, making a total of seven teachers for the three schools. The working groups are in charge of the design and implementation of research projects which aim to study behavioural traits in a given community.

The originality and value of these Citizen Science experiments consist in the degree of student engagement in the projects. In fact, students and members of the research team collaborate in every single stage, giving birth to a 'co-created' project. This implies an active partnership with the research team in defining research questions, developing the hypotheses and discussing the results. For this purpose, the University of Barcelona collaborates with the Digital Commons (DIMMONS) group of the Internet Interdisciplinary Institute (IN3) from the Universitat Oberta de Catalunya (UOC).

From January to March 2017, three different Citizen Science experiments were co-created within a span of 8 hours. To do that, a set of complementary educational tools (i.e. learning via experiments/gamification, hands-on activities, inquiry-based learning) were designed and adopted to make the students familiar with the process. The co-creation phase was

[13] Institut Enric Borràs is in the La Salut neighbourhood of Badalona (220,000 inhabitants). Its population is characterised by low income and high cultural diversity. The Collegi Sant Gabriel lies in Viladecans, a smaller area of 65,000 inhabitants. The area faces deep changes regarding the use of public space as well as a rapid demographic increase. The third school, Jesuïtes de Casp, is in the centre of Barcelona where issues like inequality and the over-exploitation of resources due to tourism converge. In the first two centres, the students involved were attending the final year of secondary school and were on average 15/16 years old. In the third one, the students were attending the first year of the Baccalaureate and were on average 16/17 years old.

accomplished as a collective problem was identified, the research questions were formulated, the scientific experiment was represented through a diagram and tasks were planned. An analysis of the co-creation phase showed that students from different schools prioritise different social problems (i.e. inequality, common good, respect, community problems at Institut Borràs; self-esteem, sustainability, public space and common good at Collegi Sant Gabriel; common good, inclusion, mobility, tourism at Jesuïtes de Casp). This phase was followed by a 3-hour informal workshop to work on minor details. The workshop proved highly relevant for increasing the students' engagement before the experiment took place.

There were some important outcomes of these experiments. The research team detected an increase in the sense of motivation and engagement of the students. These feelings emerged when the students and research team worked together to build the experiment's structure and invited passers-by to take part in the experiments. Also, the innovative way of addressing scientific notions fostered the motivation and participation of female students. The perceptions of the scientific team were further verified by way of an anonymous online questionnaire for which 81.4% of the students answered all the questions. The answers generally showed high levels of motivation, commitment and satisfaction. Further, 45% of the participants considered their contribution as essential for the co-creation process, this measure pointing to a high degree of empowerment. It is worth noting that the high degree of perceived engagement (82%) appears to relate to the extent the students consider the co-creation environment as trustworthy. As far as the environmental context is concerned, some aspects appear to influence the students' levels of participation and inventiveness. In particular, the extent to which students share daily experiences and concerns proves to be more important than their education level.

The second positive outcome concerns the volunteers participating in the experiments. The volunteers affirm they had changed their mind about STEM learning, their conception of scientific research and the relative possibility to contribute to it. Finally, the project is responsible for launching collaboration with local institutions and associations, which may support further discussion of the findings emerging from the experiments and deploying them when designing new policies.

Survey on the meaning of ecology in Slovenian high schools

Below, the field work at five high schools in Slovenia, conducted in 2017/2018 by IRSA is outlined with special attention to one class of students who commented on the findings of the survey and other activities conducted at their own and other schools.

The project was run at five high (grammar) schools, four in Ljubljana and one in a rural area outside of Ljubljana. Contacting the high schools, some were responsive, but it later emerged that the young students have little interest in ecological themes. Therefore, in these three high schools we only conducted short surveys (sondage). In the given project timeframe, only in the case of one high school – thanks to the natural sciences teacher – could we also engage in a more profound discussion with the young students involved in the survey. In total, 215 young students were respondents, mainly from Grades 3 and 4. In this period, the communication with teachers and meetings with them were intense. We also gathered information from the high schools' webpages.

At two high schools we held lectures on social aspects of ecology and sustainable development for a group of young students who had chosen sociology as their optional exam subject. We also conducted a group discussion with these young students but – at least during these activities – none of them decided to become acquainted with the mentioned topics in greater detail and further develop it into a research or project agenda as part of the final examination (matura) or in another aspect.

The research in this project is exploratory in nature. This means the hypothesis was not defined at the beginning but formulated during the research process. We also used elements of action research and a quasi-experiment besides other qualitative methods, such as group discussion, presentation with discussion and content analysis.

The questionnaire involved ten open questions addressing three thematic parts. The first part was cognitive/informative. Here we wanted to establish the high school students' level of knowledge of ecology, where this knowledge stems from, and how they estimate it (self-estimation). We found the young students acquire the greatest knowledge and information about ecology from the subject of Biology, followed by Geography and Environmental Studies (the last being an optional subject not implemented in all high schools). To a small extent, Sociology and Chemistry are also mentioned here. In the framework of Biology as a subject, there is a textbook entitled Ecology for High Schools (Gaberščik et al., 2013), although we could not determine the actual degree of its use in the classes. Biology and chemistry teachers referred to the use of the interdisciplinary curriculum entitled environmental education as education for sustainable development.[14] More than half the young students who responded discuss these topics at home, a little less so with their peers. More than half follows media reports and websites on these topics. Most (around 60%) believe their level of knowledge of ecology is very good and consider their level of knowledge is sufficient for them to form and express their own opinion.

Table 1: Sources of information on ecology issues[15]

	First group	Second group	Third group	Fourth group
1	School	School (Geography)	School (Biology)	Media
2	Ecology symposium at the Faculty of Social Sciences	Home (family)	School projects and workshops	School
3	Web media	Media (web and TV)	Web (articles, documentary	Out-of school activities

[14] See: http://www.mss.gov.si/fileadmin/mss.gov.si/pageuploads/podrocje/ss/programi/2008/Gimnazije/K_OKOLJ_VZGOJA_gimn.pdf (Accessed August 31, 2018).

[15] 1 means the most frequent, 4 the least frequent; data analysis from grammar school 1, where participants were from 16 to 19 years old, from 3rd and 4th class of secondary (grammar) school.

			movies)	
4	Classical media	/	/	/

The results show that the students get information on ecology issues mostly at school, particularly in geography and biology class (chemistry is rarely mentioned), whereas one group refers to the media. They are more likely to use the media (be it web or TV), than to actively engage in interest circles or civil organisations.[16]

The second part relates to the significance and the meaning the young students assign to ecological topics. We asked them about this meaning in an intellectual and personal sense. Their answers show the topic is relevant for almost two-thirds of the young students. Answers are divided in response to the question of whether their attitude to this topic is likely to change. To this question the answers are divided.

The third part relates to an active approach and a concrete interest in dealing (research/analytically) with ecological topics. This thematic part also incorporated the interest of young students in personal and social engagement. The question of whether they would choose an ecological topic in the framework of an optional (research) seminar for an examination-based degree (matura) was met with a modest response. About ten young students (5% of all respondents) answered that they are thinking about this option. One young student from Grade 3 referred to a plan to research the topic of media reporting on preservation of the environment, but we could not determine if he/she is willing to pursue this.

On the contrary, almost half the young students responded positively to the following question: Are you willing to collaborate with a research project led by a team from scientific institutions?

In relation to involvement with groups, interest circles and NGOs, about 20 young students are active (less than 10%). The reasons for such low level of civic engagement should be further analysed.

The survey results may be summarised as follows:

- the young students acquire most information from Biology and Geography;
- knowledge and acquaintance with ecological problems is estimated to be at a relatively high level;
- ecological and the related issue of future sustainable development is estimated to be high in importance;
- students' activity in both cognitive and social-engagement sense are low; engagement that extends beyond school subjects is weakly expressed.

[16] See: https://www.dropbox.com/s/a8qwqd932ipfz3p/Analiza%20anketnih%20vpra_alnikov%20in%20skupinskega%20dela%20na%20temo%20ekolo_ke%20problematike%20%281%29.docx?dl=0 (Accessed August 31, 2018).

If we combine the above conclusions from the short questionnaire (sondage) with other data (conversations with pupils at High Schools 1 and 2 as well their teachers, especially the study of sustainable development and ecology in high school programs (Kos and Pavlin 2017), the following picture emerges:

- young students obtain a lot of information at school but their synthetic and interdisciplinary level of knowledge is quite poor;

- a passive and partly declarative attitude to ecology prevails;

- the social sciences in this context are mostly inactive and do not play the expected knowledge transfer role;

- there are huge differences among high schools regarding knowledge transfer, optional subjects and study programmes (curriculum); and

- young students with a natural sciences orientation are more likely to deal with ecological topics.

The gap between the self-estimated and declarative levels of knowledge (and its importance) and the readiness to devote more time and use ecological topics as a seminar or research task subject is quite obvious**.** In order to explain this we sought an opportunity to have a discussion with students from one high school. It was believed that such discussion would contribute considerably by adding to the final interpretation of findings. At the same time it would make it possible to include students in some variant of the Citizen Science engagement.

Group feedback analysis as part of the Citizen Science Experiment – A case study

This year we met young students from Grade four (the last year) who have taken part in the previous phases of the survey (at High School 4). Our purpose was to present the survey results and other collected data and to receive their feedback. We presented the young students with the whole research process and the results based on the acquired data. We then asked for their comments. We divided the class into small groups of five and instructed them to discuss the results, especially the question: How to explain the gap between the high levels of self-estimated knowledge of ecology and its importance on one side and the low level of readiness to adopt an active approach to this topic, on the other? We also instructed one member of each team to write down the answers and form a final opinion on whether the group had achieved a total consensus or the answers were divergent.

The groups started the discussions and after twenty minutes delivered their records. The group member who wrote the answers down had reported on the discussion process. From their feedback we can see the young students are highly concentrated on their school work and dealing with ecological topics is part of their school obligations. This means the young students are quite well informed about ecology topics but have no time or desire to deepen this type of knowledge. Concerning their choice of topics for examination or research at the end of Grade 4 they act pragmatically. We may assume that, in this sense, ecological topics are marginal and it is more likely they will choose topics or subjects where they are assured of meeting their obligations. Some expressed the view that »you can't change anything in our country" and active engagement therefore makes no sense or does not lead to any results.

One group expressed the view that their knowledge of ecology is more school-based and theoretical. »... All this theory comes from school and is 'forced' while no one is willing to deal with this outside from school". The other group stated: »... we don't internalise our knowledge«. In relation to social engagement, it holds no meaning: »... people are aware of problems in general but do not deal with them unless they are directly affected«.

We may conclude from these comments that the young students are »school-centric« and pragmatic in relation to their engagement with ecological issues. What we know from conversations at other high schools (namely Grammar Schools 1 and 2) is that even those young students oriented towards the social sciences show little interest in global and (macro) social problems. Of the topics in sociology suggested for the final exam (*matura*), they have mostly chosen (micro-level) topics related to youth subcultures, lifestyle and family relations. These topics are common, although the students should be more strongly encouraged to connect them with macro and global societal issues.

Conclusion

We will start with the conclusion of the citizen science pilot experiment in high schools in Slovenia. During this project we gathered different types of qualitative and quantitative data. In conversations with the teachers we realised that huge differences exist among high schools in terms of their openness or closedness regarding the environment and initiatives from the outside. The same is true of their study programmes. In some schools, students acquire most information related to ecology or sustainable development from traditional subjects like biology. In others, they have the opportunity to choose the study of the environment or eco-school as optional subjects

However, despite the high level of self-estimated knowledge, the interest in dealing with these topics in any more profound way proved to be low. By using the method of group feedback analysis where the students of one class deliberated on the research results for the five high schools, it turned out that they are acquiring 'theoretical' knowledge that is relatively disciplinary fragmented and disorganised.

On the other side, social engagement is also weakly expressed. The CSE revealed that the high (grammar) schools are in a cognitive and social sense quite closed systems, despite some teachers being willing to experiment with new methods, due to their study programmes (curricula) being determined on the basis of a mono-disciplinary approach. Such a constellation requires the full attention of pupils, leaving very little room for manoeuvre for other learning/teaching options parallel to a lack of incentives for a more creative approach to practise alternative methods of learning and doing research.

Secondly, these results denote the need for innovative educational approaches to successfully address the interdisciplinary nature of the addressed topics. Innovative educational methods, such as hands-on activities, inquiry-based learning (IBL), learning via experiments, gamification and multimedia have been developed in connection to STEM fields (science, technology, engineering, maths and medicine) to rise interest of young students for studies in STEM fields.[17]

Besides innovative approach to learning and interdisciplinary approach to school curriculum, in the broader sense, knowledge transfer is the hottest issue when speaking of open communication channels between science and society. Scientification of society has thus become the current concept and the new approach of connecting the two: the citizen science experiment. As the prominent author of the CSE Josep Perello with his collaborators states:

“In particular, co-creation is perceived as a fundamental factor in participants’ motivation and commitment, a key aspect in citizen science projects.” (Senabre, Ferran-Ferrer, Perello 2018: 32).

Co-creation, meaning the inclusiveness of participants in scientific research, as well as data interpretation and conclusion making, has been part of the presented CSE project in high schools which was part of the STEM4Youth[18] and Pioneers[19] project, conducted by IRSA[20], as well.

The future steps would involve high schools open for external cooperation with scientific institutions, (interested) teachers with the opportunity to spend every few years at a scientific institute and participate in its research activities. In class, the curricula should be re-defined, with greater attention paid to:

- combining individual performance with teamwork (an amalgamation of competition and cooperation – ‘co-opetition’);
- organised discussion and reflection in small groups;
- a problem-solving approach by employing knowledge from different disciplines;
- scientific methods with a special accent on a synthetic approach (meta-analysis); and

[17] See: http://www.stem4youth.eu/ (Accessed August 31, 2018)

[18] http://www.stem4youth.eu/

[19] https://pioneerscse.wordpress.com/

[20] http://www.institut-irsa.si/

- ethical issues of research.

We believe that students will be more productive and creative in such a cognitive and social climate. Our analysis of the results of using CSE reveal this method of intervention is worth applying in high schools. We also believe we have added to understanding of scientific research and its role in broader society as well as to the current trends of the complex relation between science and society.

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