OPEN SCIENCE SCHOOLING – RETHINKING SCIENCE LEARNING

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Abstract

An ongoing trend shows young students in K12 develop resistance towards science learning and science careers. Tackling this issue to bring back the interest and motivation of students in science and technology learning, we present here the progress of the open science schooling project. The project proposes that science-learning processes should be strongly linked to the students' participation in real-life science challenges in society and to participation in real research and innovation circles. We present here the results of the 1st year deployment of these ideas with students in Poland as well as our views on how this hands-on science learning approach could further benefit from the integration with digital fabrication and making activities.

Keywords: K12 education, science pedagogy, hands-on learning, students' motivation.

1 INTRODUCTION

Constructivism is based on the proposition that knowledge is generated from the interplay between ideas and experience and on the reflections on this process [1]. This puts the learner in the centre of the learning experience as an active information and knowledge constructor instead of a passive recipient of knowledge. Based on these ideas, Constructionism as an educational theory is inspired by the Constructivist ideas of learning. Hence, Constructionism argues that learning is most effective when people are involved in the making of tangible objects in the real world [2, 3].

In our work, the concept of open science schooling (OSS) tries to contextualise science meaningfully for students, using experiential learning (ideas of constructivism) and practical, hands-on activities with the aim of building or manipulating actual objects in order to generate knowledge (constructionism). The aim is to bridge science learning and students through the practical identification of science as it is used in the students' environment and context (e.g., local community). To achieve this end, OSS envisions to engage students in real-life science challenges in society and create a solid link between schools and the community. With that in mind, OSS involves students into cross-subject immersive mission-style learning activities, so that personalised learning is attainable through a variety of practice-oriented work.

In this paper, we present our development in the deployment of the OSS approach to science learning through the preliminary experimentation bringing this concept to the school curriculum in a junior high school in Poland.

2 BACKGROUND

As early as a decade ago reports started to show the decline of students' interest in science and technical subjects in Europe [4] and elsewhere [5]. An identified problem has been the gap between what is taught in science lessons and its relevance to students' lives, which makes their motivation diminish [5]. Key global stakeholders, such as the OECD [6] and the European Commission [7], jointly agree that the disengagement in science takes place in secondary school and typically when the students are from 12 to 15 years old, indicating that science resistance is strongly linked to the development of the students' identity and personality. Therefore, the call is for a re-thinking and development of new science learning didactics. This context brings to live the OSS approach, in which science learning processes are strongly linked to the students' participation in real-life science challenges in society and to participation in tangible research and innovation circles.

Open science schooling (OSS) refers to learning undertaken outside the formal classroom in order to generate alternative and deep learning experiences. This form of learning is meant to be an attractive way to gain competences and life skills as well as to ensure a holistic approach to learning in partnership with society. This approach to science learning can be especially valuable for young people who may be at risk of low levels of attainment with traditional learning approaches, or those who have dropped out of school or are in a situation of unemployment where achieving new skills might increase their opportunities in the labour market.

Because OSS has yet to be implemented broadly, it is very difficult for secondary schools and science teachers across EU to engage in the practical experimentation this concept. This is a strong motivation for implementing, investigating and evaluating the OSS approach to science learning. The practical experimentation and collaborative work alongside secondary school students should bring at the end of the OSS project useful guidelines on the successful implementation of the approach, representing one of the first systematic contributions for evaluating OSS in Europe.

3 SETTING OPEN SCIENCE SCHOOLING

The idea behind implementing OSS is that young people conceive the science projects that they will be working on and running as a group. The successful implementation of a project developed through OSS is based on the all the group members' active contribution. As a starting point, young people are immersed in the project design with the aim of steering, carrying out tasks and taking initiative towards the fulfilment of their selected project. The expectation is that through this process the students' interdisciplinary competencies and skills develop. OSS is a learner-centred approach that engages and allows them to try out new activities. Furthermore, OSS encourages students to find connexions outside schools in order to understand science contextually in society, creating strategic partnerships between schools and relevant stakeholders, notably experts in different fields that could collaborate with the students, contributing their knowledge and bringing forth innovative ideas and solutions. In our work, the students chose participating in this type of non-traditional learning freely.

Here we present the steps taken to understand the need of a new didactical approach to science learning, taking into consideration the perspectives of the students alongside the preliminary implementation of OSS in a local junior high school in Łuków, Poland.

3.1 The Teams

Science learning through OSS was set up as an optional biology course for students to participate voluntarily. Before starting the optional course using OSS learning approach, a questionnaire of 17 items was provided to a group of 16 students (12-16-year-olds, mixed gender) participating in the project (experimental group) and to another group of similar size taking traditional science classes (control). The aim was to have students describing their general understanding and their views on science as well as their self-identification with science. A set of questions related to the influential drivers keeping students interested in science, how they feel about science and whether they consider that the school's curriculum develops their interest in science was also administer after the course. An eForm was used as the tool to collect the questionnaires data.

3.2 Students' Views on Science

According to the answers in the questionnaires, the students that chose science learning through OSS were the ones already motivated and interested about science learning (see Fig. 1). However, the answers also highlight that students generally do not show a high interest in science and that they feel unsure about its importance. This is also pinpointed by a student's statement *"nowadays, science is considered a difficult and boring subject and not many kids are interested in learning it"*. Furthermore, both groups of students did not consider the school and its curriculum help them to understand science or motivate them to learn science, neither now nor in the future. Moreover, other competences gained at school (e.g., creativity, digital and social skills) were ranked rather low by the group participating in the traditional science learning approach (e.g., lectures and exercises from books).

Teachers in some cases might be real factors enabling students reach better understanding, keep their motivation and achieve higher grades, according to the students' opinion, though this does not always happen. Students participating in the OSS approach also reflected the positive influence on science through their personal involvement in a collaborative project, finding solutions while experimenting, the number of experiments, workshops or well-equipped classrooms. From the students' perspectives, teachers' everyday traditional practice to science learning does not allow students to increase their digital skills, social competence or creativity, however. Students also indicated that the social context in their classes is important, an aspect that is fostered in OSS through cross-class and cross-subject work.

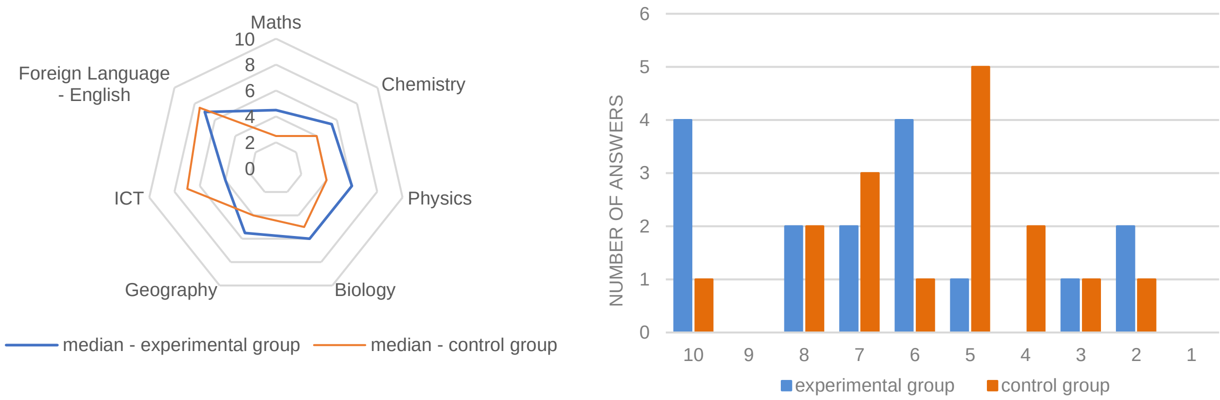

Figure 1. Students views on science. Left) answers to 'how much does the school curriculum motivate you to understand particular branches of Science?' (before the OSS intervention). Right) answers to 'how much does the way the Science subjects are taught at school is relevant to your expectations and needs?' (after the OSS intervention). Scale 0 = not at all; 10 = completely; N=16 respondents in each group

On the other hand, students did not think of science as a way of life. They did not understand the beneficial influence that it can have on local and national development. These responses confirm the need of implementing a different science learning approach in everyday school practice to make science a real experience instead of an additional theoretical input. Students recognised that the traditional science learning in the classroom is very rigid and does not respond to the challenges of society and the interests of students participating in our research. These perspectives of students provided strong grounds for the preliminary implementation of OSS in practice.

4 PRELIMINARY PRACTICAL IMPLEMENTATION

The OSS didactic approach is imbued in a science pedagogy implemented through the following processes:

- Problem identification and contextualisation. Students are engaged in understanding what are the real problems that affect their local community and how science can offer support to understand and meliorate the situation. In order to understand the problems students are prompted to involve the local community as collaborators in their investigations, including research and innovation centres, industries, NGOs, and other social stakeholders.
- Knowledge and competences acquisition. Once a problem has been selected to be tackled, students receive training and information on demand from school teachers and other stakeholders from the local community as well as from their own investigations. This invites the acquisition of digital literacy skills, cross-subject matter and cross-disciplinary knowledge as well as the development of self-regulation, collaboration and communication skills, cultural awareness, creativity and problem-solving efficacy. Here the students benefit from learning through a variety of practice-oriented work forms that support different learning styles.
- Documentation. The students are encouraged to keep a record of their process and involvement on their projects. This serves the students as a tool for self-reflection on the work accomplished and provides them with a narrative of their experiences.
- Sharing. The students are also encouraged to share their experiences and solutions with peers in their schools and also with their local community. The sharing can take place online, e.g., through websites and social media, at scientific conferences, through ebooks, etc.

The processes of the pedagogical framework can be carried out by the students simultaneously. That is, as students advance in their learning experience, they could work on the problem identification and contextualisation while at the same time acquire knowledge and competences about relevant topics, for instance. The group of 16 students participating in the course carried out through OSS organised their activities by gaining digital competence through a series of workshops offered in the school's computer classroom. Students gained skills that enabled them to set and provide a web page to share and to document the important events or results of their work through storytelling narratives.

To involve the local community in their science learning, the students explored the question *'where is science in society?'* For this, students carried out a dozen interviews with municipality officials, teachers, peers and family members in order to build a general picture of science and its understanding and implementation in locally set business. They also went to observe the process of creating cloth in a factory that they contacted with the assistance of a teacher. Before that visit, they had to familiarise with the business and prepare the set of question, which were to be asked to the business owner during an interview. Students had the opportunity to observe the production process of that local business, from the very beginning to the final products, with particular attention on the need of science and its implementation in the process. This facilitated students' access and contact with a community resource involved in a variety of science activities. In this way, an abstract understanding of science was transformed into a real-life and real-time experience, which increased the relevance of science learning for the students. Importantly, the students discovered the complex interrelationships between different branches of science in one place, outcomes of which were presented by them in the local TV as well as in online platforms (e.g., local media, posts, school web page, and project web page).

After their concept of science was created, the students decided to get involved into real outdoor research provided by Faculty of Biology and Environmental Science, Cardinal Stefan Wyszynski University. This work took place in a local forest reserve and the subject of investigation was ecological relationships of moths (Lepidoptera) and other fauna related issues. Students were engaged into every step of research process. At the beginning of the research, in spring 2018 they were working on identifying the moths, measuring and scaling them, and putting the data into a database. For this, they worked extracurricularly, with workshops held every week on Saturdays for 3-5 hours. In summer 2018 students visited several times the reserve for 1-3 days, were the hands-on investigation (night catching moths in light traps) was carried out. This activity was followed by identification, measuring and scaling of the specimens. The students finished their working according to scientific method and prepared several posters for the National Biopotential Conference 2018 and for the Yong Scientists Conference in 2018 and 2019. The students decided to continue their research during 2019. The impact of this process could be appreciated in the students' answers given after the course, shown in Fig. 2. Students expressed excitement about being involved in new activities and in new ways of thinking about science education and science learning.

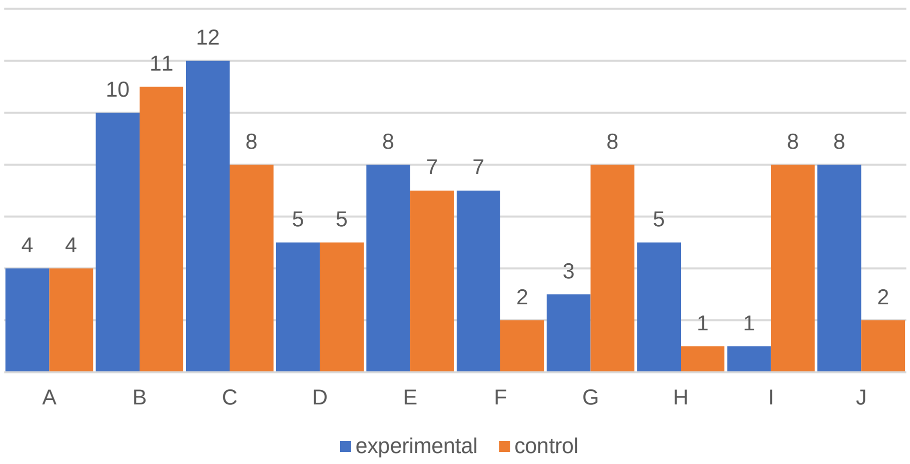

Figure 2. Answers to 'The highest influence in the interest in Science is provided by (match the three most important)'. Answer types: A - the number of hours on particular school science subject; ***B - the methods of teaching; C - the teachers charisma;*** *D - well equipped classroom;* ***E - the number of experiments, workshops; F - the personal students' involvement;*** *G - the number of students in the classroom; H - the students personal discoveries while working on science; I - when teachers give students solutions;* ***J - when students find out solutions by themselves.***

5 DISCUSSION

According to our preliminary deployment experience, OSS is suitable to various learning contexts (e.g., formal, informal and non-formal) depending on the actual tasks to develop. In our deployment, we facilitated the process by providing the students a scheme with sub-tasks that they could perform in order to understand ‘science in society’. Although such activities were difficult to implement within a rigid established curriculum and with a large classroom, the activities proved to have the potential to enrich the school’s routine and facilitate a deeper understanding of science for the students. A suitable solution that we considered was to divide the classroom into smaller groups, so that they could carry out their search for science in society. The implementation of the activities, nevertheless, required the direct participation and/or support of the managerial staff at school as well as the students’ parents at home. Allowing flexibility and openness in the curriculum is fundamental, as it is the parents understanding of the process and consent to the activities since students are realising them in the community outside the school grounds.

Looking at established approaches, it is well-documented that science is better learnt through ‘hands-on explorations’ [8]. Similarly, STEAM (science, technology, engineering, arts and math) education has also benefited from the integration of a hands-on, constructivist approach to learning [3]. The OSS teaching and learning approach with its diverse activities has strong potential to develop STEAM education also integrating the use of digital fabrication and making technologies, since the digitalisation of society is ever present nowadays and the benefits of digital fabrication and making in education are widely acknowledged for providing meaningful and practical hands-on learning [9]. For example, we observed that during one of the missions outside the school involving a visit to a local clothes factory, students observed the work of 3D scanners as well as laser fabric cutter machines both operated by a computer. Students engaged deeply in knowing the details of such controlled process although the purpose of their visit was interviewing the head of the company about how science was implemented into the firm’s activities. Bringing digital fabrication tools such as 3D modelling and printing software as well as 3D printers to the reach of the students will certainly benefit their engagement with science learning as the students could already appreciate the real application of these tools in society.

We can expect that through the OSS approach, teachers and students make significant progress towards enhancing their digital competence, considered as a very useful and on demand skill on the labour market, education and life. Through this kind of approach, we believe that students not only develop their cognitive skills but also develop their cross-cutting 21st century skills such as cultural awareness and communication, needed in the digital societies that we are creating. This could better qualify them to embrace their own future as digital citizens while at the same time providing students and teachers innovative learning and teaching approaches in the present [10].

Additional research on the practical implementation and development of OSS in different educational context could provide further insights on the ecosystem (e.g., collaboration between school, local community, home) necessary for this approach to thrive.

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