Scientific Literacy through co-inquiry for non-formal and informal learning

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Abstract

This paper presents a collaborative research on scientific citizenship developed by the Open University UK (OU) through the weSPOT project for inquiry based learning and the Universidade do Estado da Bahia (UNEB) responsible for coordinating the Telecentros.BR training programme for Digital Inclusion in Brazil. The European weSPOT project (2013-2015) is a working environment with social, personal and open technologies for inquiry based learning (IBL). The Telecentros.BR training programme (2013-2014) is a non-credit online course supported by the Brazil Government, whose participants are more than 2000 young educators in diverse areas with low access to digital technology. The role of these young educators is to promote better use of ICT and support the Telecentro.BR's projects created by the communities for their development in various dimensions. The objective of this research is to create a framework for applying collaborative inquiry to scaffold citizen's scientific skills through digital technologies. This framework, drawn on qualitative and quantitative study, synthesizes key abilities

related to multiple literacies to foster scientific skills in the digital age of open education, open science and open citizenship.

Introduction

Scientific literacy is a key competence for social inclusion and active participation towards social scientific citizenship in the digital age (Okada, 2008; 2014). Through the support of government and educational institutions, new projects have been emerging to foster citizen's capability of decision making, taking action and judgment on socio-scientific technological and ethical issues (e.g. weSPOT 2012, Engage 2014). New studies have been developed, then, to better understand how these projects can facilitate citizen's basic understanding of scientific concepts and processes as well as scientific argumentation. Scientifically literate citizens, who understand the role of science and technology in their lives, are more capable to discuss science in the media, evaluate public policies, analyze risks and benefits of scientific advances and make evidence-based decisions (AAAS, 1993; Bell & Lederman, 2003; Holbrook & Rannikmae 2009). Scientific skills, however, are promoted basically through formal education where teachers help students design and evaluate inquiry, interpret data as well as communicate scientific explanations (PISA 2015). This research argues the importance of promoting scientific literacy through not only schools and Universities (formal learning), but also open online courses and projects for community of practice (non-formal learning) as well as open educational resources and social networks (informal learning).

In order to increase opportunities for widening participation towards the development of Scientific Literacy it is necessary to provide citizens with meaningful learning materials, easy-to-use technologies as well as interesting projects and communities of practice that can support scientific thinking skills, particularly the quality of scientific argumentation. Learning how to argue with evidence is essential for citizens to understand how scientific knowledge is constructed and validated. This requires adopting a more inquiry-based methodology, which provides people opportunity for self-expression and responsibility for coming to informed decisions. Collaborative inquiry aims at developing the skills of scientific thinking collectively, so that learners can interpret evidence, weigh up technologies, make informed judgements, and argue their views together (Okada, 2008, 2014).

The rapid advances of Science and Technology encompass issues that should not be handled solely by the scientific community. As scientific issues continue to dominate public policy that impacts our lives (e.g., food safety, environment, genetically modified organisms, artificial enhancements of the human body and so on) citizens need to have the skills to assess the reliability of information, the soundness of arguments, and the ethical implications. In order to be "scientifically literate" citizens need to know how to put together arguments coherently (Hodson, 2003). Citizens need to be equipped with the ability to evaluate claims about science in the media. Previous studies (Okada 2008; 2014) point out that learning scientific argumentation is not an easy task. Scientific argumentation skills do not come naturally. Debating controversial socio-scientific issues is not sufficient on its own to foster good argumentation skills (Kuhn, 1991; Newton, Driver & Osborne, 1999). Facilitators need to assist communities in making their thinking explicit, helping them to clarify and shape their reasoning around the norms and criteria which underpin scientific discourse (Hogan and Maglienti, 2001:683). Scientific reasoning is a special form of discourse that needs to be developed and appropriated by learners through suitable tasks, and through "structuring and modelling" (Simon, Erduran & Osborne, 2002). In order to help citizen scaffold scientific argumentation facilitators need to show how to set out arguments and establish good connections between questions, statements, knowledge and evidence (Okada, 2008).

A good scientific argument is constituted by both domain knowledge and argumentative knowledge, "*scientific rationality requires a knowledge of scientific theories, a familiarity with their supporting evidence and the opportunity to construct and/or evaluate their inter-relationship*" (Simon et all, 2002:2). Subject knowledge and personal experience to elaborate arguments are also two important components for argumentation (Means and Voss, 1996). Citizens need to use both scientific concepts and their own arguing skills to ground their reasoning. The more knowledge is integrated in their arguments, the richer is their argumentation (Schwarz and Glassner, 2003:230).

This paper describes a collaborative research on scientific citizenship developed through weSPOT project for inquiry based learning and the Telecentros.BR online course supported by the Brazil Government. Its participants are more than 2000 young educators in diverse areas with low access to digital technology whose role is to promote better use of ICT through communities' projects. The objective of this research was to create a framework for applying co-inquiry - collaborative inquiry to scaffold citizen's scientific skills through digital technologies. The preliminary phase of this project focused on contributing factors for, and challenges to engage participants in collaborative inquiry as well as scientific argumentation.

Methodology and Initial Results

Based on semi-structured interviews and surveys, Telecentros.BR participants' interests, competences and needs were collected and analysed for drawing a co-inquiry framework whose purpose is to bring diverse citizens together (learners, educators and academics) for collaborative investigation in the communities through weSPOT (figure 1).

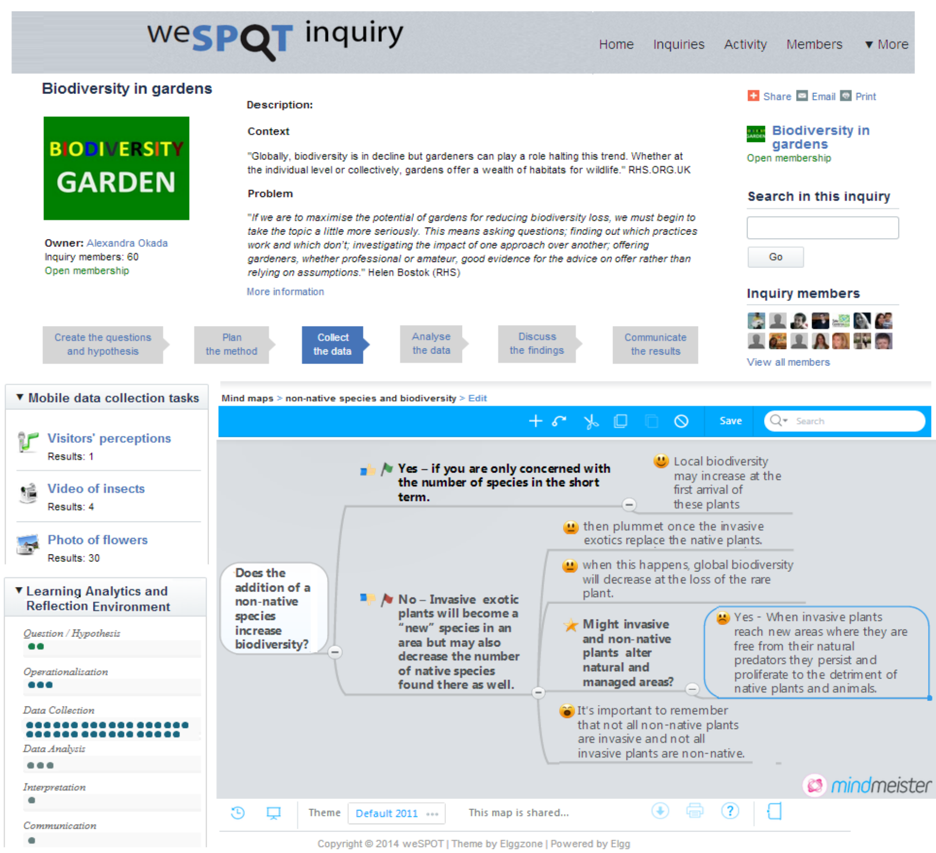

Figure 1 – weSPOT Biodiversity in Gardens

The weSPOT project (Working Environment with Social, Personal and Open Technologies) focuses on propagating scientific inquiry as the approach for developing scientific literacy through different scenarios related to formal, non-formal and informal contexts. Its aim is to provide learners with the ability to build their own inquiry-based learning space, enriched with social and collaborative features. Smart support tools can be used for orchestrating inquiry workflows, argumentative mapping, mobile apps, learning analytics and social collaboration on scientific inquiry. Learners can interact with their peers and discuss their inquiry projects, receive and provide feedback, mentor each other, thus develop meaningful social networks that will help and motivate them in their collaborative inquiry projects. Co-learners are encouraged to take the role of scientific explorers, which are motivated by their personal curiosity for developing personal knowledge and collaborative scientific reasoning.

The training programme on Digital Inclusion for Telecentros.BR project, supported by the Brazil Government offers a non-credit online course for more than 450 young people from 16 to 29 years old who work at Telecentro.BR in different locations (Figure 2). Most of participants, however, are from 16 years old to 20 years old. They are students of Secondary schools or initial graduates in the Universities.

Their role is to promote better use of information and communication technologies, promote training activities through online projects in various dimension (e.g. social, cultural, professional). Their most interested themes for supporting projects for their communities are Biodiversity, ICT, new jobs and innovation as well as food, literacies and health.

Fig2. Location of the participants of Telecentro.BR

The quantitative and qualitative data from the questionnaires and interviews, which were applied to a random group of 20% of the Telecentro.Br's young educators, indicate that those participants have key digital technology skills (figure3). They are able to manage files, folders, use software tools and applications, create multimedia file, install new tools and devices and a small group are also able to use open source software as well as programming language. A small group of these participants - 15% - do not have computer at home, but all of them access internet from cyber cafés or Telecentro.BR building. Many of them are users of Youtube and FaceBook. All of them have mobile phones and most of them (70%) with Internet.

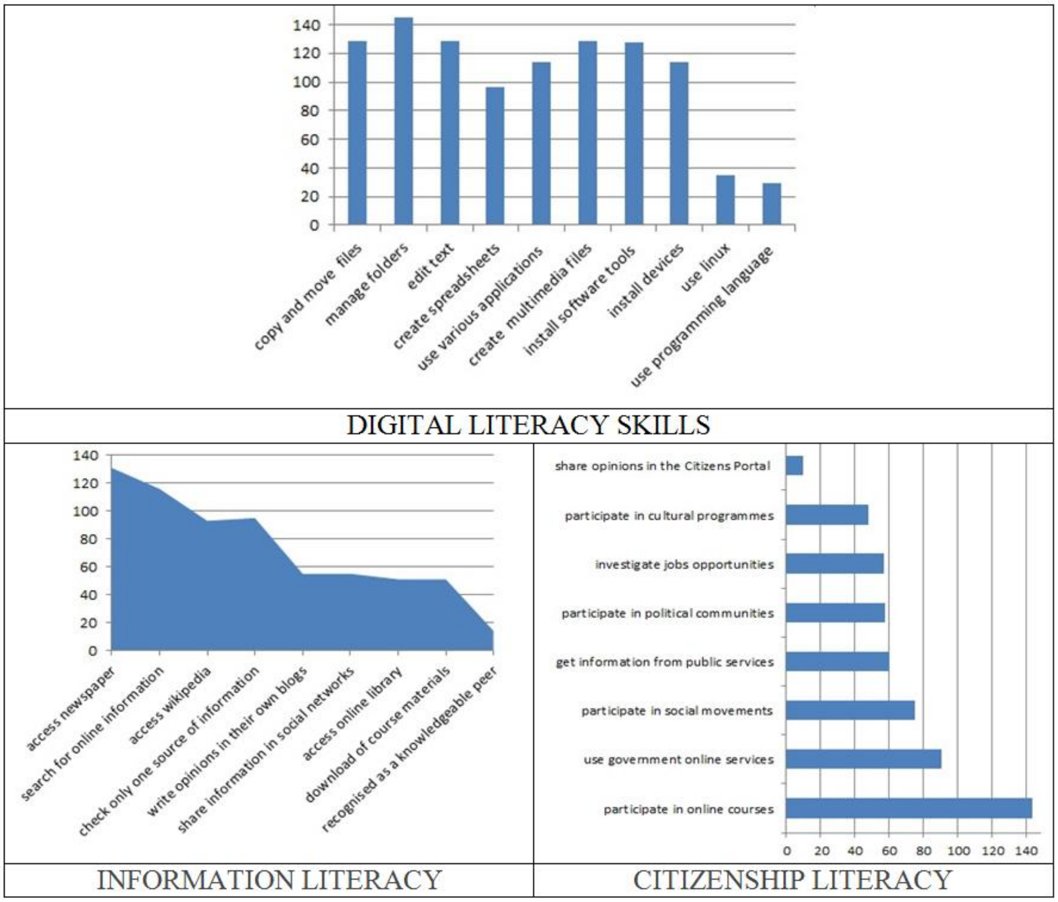

Figure 3 – Digital, Information and Citizenship – Literacies

Regarding to information literacy (figure3), more than 80% access online newspaper, and search for online information. More than 65% access Wikipedia, but consider only one source of information. A small group (approximately 30 %) share information in their social networks, access online library and are able to download their course material. However a smaller group (less than 10%) is recognised in their networks as a knowledgeable person in their virtual community. Related to Citizenship Literacy(figure3), the majority are participating of the training course supported by the Brazilian Government. Approximately 60% use government online services, and participate in social movements. A small group, around 40% gets information from public services such as job opportunities and cultural programmes, or participate in political movements. Less that 10% share their opinions in the Brazilian Citizens Portal.

Based on qualitative data, it was noticed that some of these young educators can initiate an inquiry based learning project with their community. They elaborated the following research questions collaboratively with feedback of researchers:

- "*What is main cause of environmental degradation in our community?*
- *What would be the most effective environmental actions in our community?*
- *What are the most* relevant *environmental inquiry projects for our Community?*
- *How does environmental project support citizen engagement through co-inquiry?*

Based on their online activities and F2F discussion, it is also possible to identify key issues that might engage participants to develop their inquiry project as well as initiate argumentative thinking:

1. **Common interests:** *"we realized that our communities have many common characteristics and interests related to environmental protection".*
2. **Enjoyment:** *"It will be fun to increase our network with participants from other cities and University abroad (OU UK)".*
3. **Perceived usefulness:** *"It will be useful to learn a new application that we can use in our mobile devices and carry on discussions about our project."*
4. **Collective Purpose:** "*the quality of life through a good relationship with natural environment is important for our communities*"
5. **Co-authorship: "***Our project was built collaboratively through the debate with participants interested in environmental issues including biodiversity*."
6. **Existing Knowledge:** *"manufactured products made from combinations of natural resources cause significant environmental damage, affecting biodiversity and human life in long term.*
7. **Awareness:**. *Awareness of environmental degradation caused by human activities is essential to avoid profound negative consequences* "
8. **Relevance:** *"on rainy days, flood and waste in local area increase the proliferation of insects and other animals, causing diseases (dengue, yellow fever and leptospirosis)"*
9. **Opportunity for Argumentation:** *"This is a good topic for argumentative debate. There is no agreement on the extent of the environmental impact of human activity. Protection measures, even occasionally criticized, would*

benefit our communities."

10. **Contextualisation:** The methods, procedures, activities should be contextualised according to the characteristics of each community and interests of groups to promote opinion-forming and scientific understanding.

Discussion

Based on the Telecentro.Br surveys with young educators, it is possible to observe that their digital, informational and citizen literacy might help to support their community's scientific literacy. An initial barrier identified in the online interactions and some of the interviews reveal that they are not familiar with inquiry based learning methodology nor with strategies for facilitating argumentative thinking within their communities. Although multiple literacies would enhance the development of scientific literacy, just providing communities scientific or controversial socio-scientific issues to discuss is insufficient to develop argumentative thinking and inquiry based projects (Osborne, 2011). For the next phase of our project, our research will analyse the meaningfulness of training materials and relevance of interaction with experts to support communities of practice for applying scientific argumentation to their inquiry based learning.

Based on the Telecentro.Br online course, participants' inquiry activities and discussion forum, it is possible to identify ten features that might engage participants to facilitate community's inquiry projects: commons interests, enjoyment, perceived usefulness, collective purpose, co-authorship, existing knowledge, awareness, relevance, opportunity for argumentation and contextualization. All these features will be applied to analyse participant's engagement during the implementation of communities' inquiry projects.

Conclusion

Innovative projects and technologies to promote Scientific Literacy have been developed recently for formal education, which might be applied to informal and non-formal context. The first phase of this research investigated preliminary results on contributing factors for, and challenges to engage Telecentro.Br's young educators in collaborative inquiry projects for promoting as communities' argumentative thinking in the weSPOT working environment. This case study identified key skills and factors that might promote public engagement for widening up Scientific Literacy.

Further studies will also integrate the European project ENGAGE (Equipping the Next Generation for Active Engagement in Science) whose aim is to help educators develop the beliefs, knowledge and practice for RRI (Responsible Research and Innovation). This project also focuses on adopting inquiry based methodology to provide learners opportunity for coming to informed decisions through scientific thinking and awareness of Responsible Research and Innovation.

The 21st century education has primarily the challenge of equipping citizens with science knowledge, skills and attitude for developing scientific literacy. Collaborative inquiry projects might be useful for increasing learners ' engagement and understanding through software tools, mobile devices, and different resources offered in the European Projects weSPOT and Engage.

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