Technological Ecosystems in Citizen Science: A Framework to Involve Children and Young People

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Abstract: Young people are distinguished as a social group with the capacity to drive new behaviours and understandings in today's society. However, most young people consider that people in charge of decision-making processes are not addressing their concerns. The WYRED project proposes a framework for citizen science based on a technological ecosystem to promote the transfer of perspectives, ideas, and knowledge among young people and decision-makers on issues related to the digital society. The work goal is to analyse the model proposed through a citizen science case study centred in identifying the ideas and opinions of children and young people between 7 and 30 years old, concerning gender stereotypes on the Internet. A total of 69 children and young people from Belgium, Italy, Spain, Turkey, Ukraine, and the United Kingdom have interacted for two weeks in a private space guaranteed by the defined ecosystem. The results of the analysis of the interaction between young people and facilitators (with different profiles: educators, researchers and decision-makers) demonstrate that the use of technological ecosystems to sustain the development of citizen science projects allows for the improvement of knowledge transfer processes between children and young people with stakeholders, as well as the analysis of these processes.

Keywords: citizen science; open science; digital society; gender stereotypes; decision making; young people; technological ecosystem; knowledge management; virtual communities

1. Introduction

The origins of citizen science go back to the beginnings of modern science, where scientists were citizens, whose source of income was in other professions [1]. At present, citizen science is associated with the voluntary participation of citizens in scientific research in different fields, although it is especially linked to the field of natural and physical sciences, whether environmental data, astronomy or biochemistry [2–5]. There is no a clear definition of citizen science accepted by researchers and politicians. According to European Union, citizen science is "general public engagement in scientific research activities where citizens actively contribute to science either with their intellectual effort, or surrounding knowledge, or their tools and resources" [6]. A large number of authors consider a citizen science approach focused on involving a dispersed network of volunteers to assist in professional research using methodologies defined by professional researchers [7]. On the other hand, some authors propose a citizen science approach in which citizens are not only focused on the collection of information but also participate more closely in the different stages of research [8]. In particular, Shirk et al. [9] present an approach of citizen participation where the role of the citizen scientist can vary from defining the need to designing and executing the whole project. According to the review carried out by Kullenberg and Kasperowski [5], in many cases the citizen science projects are instead targeted to specific issues of concern, initiated by local communities, which may incorporate

experts and scientists, but originate outside the academic (or research) institutions and, consequently, most of their funding structures [10,11].

Furthermore, citizen science is linked to the open science movement. Fecher and Friesike [12] identify the public school that advocates the idea that science should be accessible to all people, as one of the five open science schools of thought. Open science is a movement that aims to make scientific research accessible to all citizens. It is closely related to or based on the idea of eScience or science 2.0, which is defined as the application of social web technologies to the scientific process [13].

In this sense, technological development over the past decades has been vital for the emergence of citizen science [14]. Emerging technologies influence the scientific research process by streamlining data collection, improving data management, quality control automatization, and streamlining communication [15]. Likewise, the popularisation of Web 2.0 and the advances related to mobile devices have facilitated the participation of citizens in scientific projects [3]. Moreover, information systems research can involve the citizen in scientific processes, improving scientific knowledge and creating a more informed citizenry on science and technology [16]. These collaborative processes also foster the exchange of knowledge and a spirit of collaboration that helps societies to become more sustainable [17].

Organizationally, many local governments are beginning to realise that they need the input of their citizens to govern their cities. Starting to work with critical citizens is not an easy step, but once citizens participate in the production of knowledge for decision making, they are more likely to accept the results and resulting actions [18]. In this participation and collaboration, citizen science can make significant contributions that deserve the attention of funding agencies and policymakers [19]. Likewise, the direct involvement of the public in research projects exposes them to the scientific process, so it is also a way to face public scepticism of science when confronted with debates in areas such as climate change or the use of technology in our lives [20].

In this context focused on decision making and the improvement and sustainability of societies, most assume that young people have limited power or impact; they cannot vote or do extensive volunteer work, generally do not put pressure on policymakers, and do not make important decisions about buying a home [21]. However, in the last century, young people have distinguished themselves as a distinct social group, as drivers of new behaviours and perspectives [22,23]. Young people have the power, the ability and the will to contribute as a group to the sustainability of their environment, as well as the knowledge to participate in decisions related to the digital society, that is, to use technology in the different areas of today's society. Despite this, according to the work "Focus on: Empowering Young People to Participate in Society" [24] many young people in Europe feel that their concerns are not addressed by politicians, leaving them aside in the economic and social life of their countries. Moreover, the last Eurobarometer survey dedicated to European youth shows that 57% of the young feel that "in their country young people have been marginalised and excluded from economic and social life" [25].

The European project WYRED "netWorked Youth Research for Empowerment in the Digital society" focuses on involving young people in international social dialogues in order to know their ideas and opinions, and to promote the design and development of participatory research projects that allow them to address issues related to the impact and use of technology in today's society [26]. European society faces myriad challenges. Many of the challenges faced by the European society are influenced by digital technologies, and they affect the lives of those who are young at present. It is natural and ethical to ensure their participation in reflection on the issues that affect their future. The WYRED approach aims to help young people to explore their concerns and voice their perspectives in relation to the digital society. This is not however an easy undertaking; the current marginalisation and disengagement that young people feel is partly due to the fact that their views have not been taken sufficiently into account [25]. The ways in which research is carried out also can contribute to the lack of involvement. Frequently, the research process is owned and framed by others.

The WYRED project proposes a framework for citizen science based on a technological ecosystem that makes possible to establish transfer cycles between young people and decision-makers on issues related to the digital society. This framework aims to engage and involve young people in the definition of sustainable models for future society, not only to express their views, but also to be directly involved in the framing and design of the research process, in order to ensure that the issues explored are relevant to them apposite. Most citizen science projects offer minimal possibilities for communication and interaction between researchers and citizen scientists [27]. Generally, the communication support is focused on the interaction between the volunteers. Technological ecosystems allow establishing learning ecologies in which access to information is unrestrained, experiments and failures are tolerated as part of the innovation process, and knowledge is shared and transparent, allowing for co-creation and recreation by others [28].

The present work aims to demonstrate that the use of the WYRED framework based on a technological ecosystem and a validated methodology sustain the development of international citizen science projects and supports the knowledge transfer processes between children and young people with stakeholders. In particular, the work addresses the analysis of the framework for citizen science through a case study supported by a technological ecosystem focused on facilitating communication between the different profiles involved in the process. This case study tackles gender stereotypes in digital society from the perspective of children and young people between the ages of 7 and 30. According to the results, the framework has facilitated the process of defining and initiating a large number of research projects that serve as seeds for establishing larger projects, either by the participants themselves or by other young people interested in continuing the work, thus facilitating an open science process mediated by the WYRED methodology and ecosystem.

2. Related Works

The goal of the WYRED framework is to involve children and young people in international social dialogues in order to know their ideas and opinions through the definition and development of citizen science projects that allow them to address issues related to the impact and use of technology in today's society.

According to Kullenberg and Kasperowski [5], citizen science has gained an unprecedented presence in scientific literature during the past decade, although the practice itself is much older. They carried out an analysis of 1935 papers retrieved from Web of Science focused on citizen science. Also, Follet and Strezov [20] carried out an analysis of 1656 works about citizen science extracted from Scopus and Web of Science. Both studies provided an overview of the current situation of citizen science from a research context point of view. Regarding the aim of this work, Follet and Strezov [20] analyse the classification of [29] who identifies a type of citizen science projects developed as education projects that are often performed in the classroom or school grounds as part of the science curriculum, such as [30–33].

There are works about citizen science projects with children and young people at school level in which the projects involve several schools in the same region. For example, Locritani, Merlino and Abbate [34] involved students aged 16–17 years from four different high schools located far from the coast in Northern Italy. Also, in Europe, [30] involved 16 schools from Vienna and Lower Austria for two years. Other experience in Australia involved students aged 9–12 years from six primary schools; the students did not interact between schools; they only were involved as volunteers to collect data [33]. On the other hand, Trajber et al. [35] propose an approach based on citizen science and participatory action research in which scientists, researchers, teachers and young people from different schools in a Brazilian region work together to articulate and act upon the complex processes that characterise social, political and environmental issues.

Although there are several works related to involving young people in citizen science projects, the research questions and objectives are defined by scientists, researchers or teachers; the students do not choose the activities [30,33,34,36]. In other cases, they involve the students in some parts of

the research definition, but not in the research objectives definition. For example, Frigerio et al. [37] both the pupils and their teachers were directly involved in generating the questions of the survey applied in the second phase of the citizen science project. Moreover, according to the review carried out by [33], the school-based citizen science projects fail because the science was not tailored to engage students to collect quality data, or the educational and engagement aspects were over-emphasised at the expense of data integrity.

Regarding the topics covered by the analysed words, most of the school-based citizen science projects are focused on natural science - climate change, wildlife, marine litter, pollution–[30–37]. Only Magnussen, Hamann and Stensgaard [38] are focused on projects related to improving the quality of life in the neighbourhoods in which the school is located. None examples are focused on issues related to technology.

3. Materials and Methods

3.1. Technological Ecosystem Metamodel

Technological ecosystems [39–44] are considered a variant of software ecosystems [45,46] in which people are an inherent part of the ecosystem. Users are part of the processes of definition and development of ecosystems, not only in the phase of obtaining requirements [47] or as final users, but as a critical component in complex systems [48,49]. According to Mens et al. [50,51] the technological ecosystems share some characteristics with the natural ecosystems. In particular, García-Holgado and García-Peñalvo [52] define the technological ecosystems as a set of users and software components connected between information flows in a physical environment that provides support to those flows.

This type of solutions allows supporting knowledge management processes in heterogeneous contexts, from companies to organisations and public institutions. The ecosystems that establish among their main objectives to support learning processes, regardless of whether it is formal, non-formal or informal learning, allow the establishment of learning ecologies, learning environments with a strong interactive component that allows the exchange of knowledge both formally and informally.

The definition of this type of solution poses a set of challenges that have been addressed from software engineering through the definition of two metamodels that encompass the knowledge acquired through the definition, implementation and evolution of a wide range of technological ecosystems focused on knowledge management and building learning ecologies. First, a metamodel that provides the necessary guidelines to define the technological ecosystem from a conceptual point of view (available at http://bit.ly/2X1h4YD) and, on the other hand, a metamodel that supports technological and methodological decision-making when implementing the ecosystem in a real context (available at http://bit.ly/2WhOaXf). Both metamodels have been validated through a process based on automatic checks in order to avoid possible biases introduced by the researchers [53]. Likewise, from the point of view of Model Driven Engineering (MDE), the quality of both metamodels has been validated using the framework proposed by López-Fernández et al. [54].

3.2. WYRED Ecosystem

This proposal is part of the WYRED initiative, a European project funded under the Horizon 2020 programme whose main objective is to involve young people in issues related to the digital society, so their opinions and ideas are taken into account by decision-makers at all levels of society, with particular emphasis on technology-related issues. For this purpose, during the three years covered by the project-November 2016 to October 2019-the definition of a framework has been considered in which young people can express themselves and explore their ideas and interests related to the digital society through social dialogues, both face-to-face and online, and research projects based on the citizen science approach that involves participants in all stages of research [9].

The WYRED ecosystem was born as a solution, not only from a technological but also from a methodological point of view, to build a learning ecology that allows the transfer of knowledge

between young people, researchers and decision-makers. The main objective of the ecosystem is to provide the necessary tools for supporting the communication and interaction between stakeholders ubiquitously and asynchronously, which facilitates the development of citizen science projects at an international level, so that young people, educators, researchers, and decision-makers from different countries are involved in such projects.

The definition of the WYRED ecosystem was based on the proposal of metamodeling for the definition of technological ecosystems focused on knowledge management. In particular, the developed ecosystem is composed of a set of Open Source software tools [55] connected through information flows to provide the necessary support to the people involved in the project. The WYRED methodology allows defining the interaction between the different components of the ecosystem where components are both the technology and the human factor.

The WYRED Platform, the tool for surveys and evaluation, and the project's public portal are the primary services offered by the ecosystem and where most of the interaction related to the definition of citizen science projects takes place (Figure 1). On the one hand, the Platform provides a fully private space for interaction with strict privacy policy and robust security measures which aim to allow children and young people to express themselves freely and openly on issues related to the digital society. On the other hand, the public portal gives visibility to the citizen science projects developed within the Platform and, besides, provides the ways for other young people interested in the issues addressed in the project to join the activities developed within it.
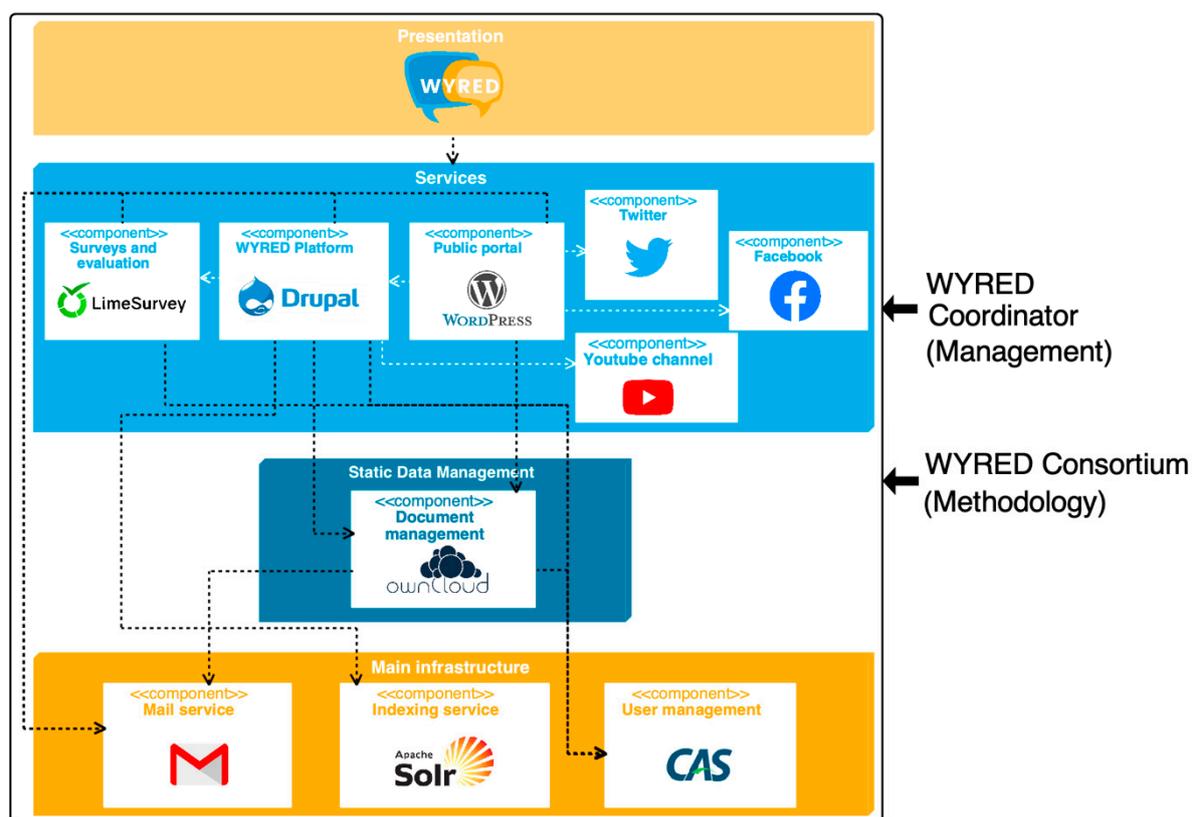

Figure 1. WYRED Ecosystem components and relationships. Based on [56].

3.3. Methodology

The WYRED methodology is based on the Action-Research methodology [57]. Specifically, it is structured in three Action-Research cycles, or research cycles according to the nomenclature used in the project, one per year of the project. An infographic of the WYRED methodology is available on [58]. The aim has been to improve the transfer process between young people and interested persons from

different backgrounds. During each of the cycles, the WYRED ecosystem has evolved according to the changes introduced in the methodology. Each cycle consists of four phases:

- Phase 1. Preparation. It begins with a consultation phase involving outreach and participation and a process of social dialogue. In this initial step, children and young people are brought together and facilitated to discuss the issues and concerns of the digital society, using age-appropriate facilitation techniques and tools.
- Phase 2. Dialogue. The results obtained in the previous phase lead to the second phase of the research definition. Through the articulation of research questions, children and young people are again supported to consider key issues in greater depth.
- Phase 3. Research. The next stage in the process is focused on action. The research questions are articulated as research projects. These projects, developed within the framework for citizen science, can cover different methodologies and formats when presenting the results.
- Phase 4. Evaluation. In the last phase of the research cycle, the analysis of the projects is carried out. Children and young people seek to interpret their work, their answers. At each stage, children and young people have the opportunity to present their analysis and critique of the online environment in which they interact and develop projects.

Within each of the phases that make up the WYRED research cycles, different methods and techniques have been used to achieve them. During the first phase, a set of social dialogues with children and young people to identify their issues and concerns of the digital society. The results of the social dialogues were used as an input to carry out a Delphi study to identify and prioritize key areas of interest for children young people, and to provide additional insights regarding their involvement in decision making related to their concerns, attitudes and perceptions [59]. In particular, two instruments were used, one for children and young people, and another one for relevant stakeholders. At the end of this phase, fifteen topics were selected: self-image, self-confidence; tolerance to different cultures/opinions; necessary changes in education; causes of stress among young people; employment prospects; cyber-bullying, shaming; internet safety & privacy; gender stereotypes/discrimination; integration of migrants/refugees in schools and in the society; adult misunderstandings of young people; reliability of information on the Internet and social media; roles of parents, friends and peer groups; environmental problems (e.g., pollution); crime; mental wellbeing. According to the recommendations of the external experts who evaluate the WYRED project, a subset of these topics was selected and reorganized into subthemes to validate the framework under the scope of the theme "life in the digital society". In particular, the subthemes were: (1) self-image and its presentation online; (2) gender discrimination and differences online; (3) internet safety, cyberbullying and online abuse; (4) living on social media, living with stress; (5) fake news and media literacy; (6) digital participation and activism.

Regarding the second phase, the dialogues are conducted face-to-face (local dialogues), fully online (international dialogues), or a blended version in which the dialogue starts in person and after online to interact with people from other places. In this phase, the facilitators, both face-to-face or online, define activities to engage children and young people in the definition of the research questions to be answered during the third phase. The techniques and methods used during the research phase are selected by the children and young people involved directly in the project, with the advice and support of the facilitators. Finally, the evaluation phase uses qualitative methods to collect feedback from children and young people involved in the citizen science projects. In particular, participant observation and focus groups. Moreover, the facilitators also conduct interviews with their stakeholders, including principals, teachers, youth workers and others acting as gatekeepers in the formal and informal sectors, where WYRED is applied.

Furthermore, inside each research cycle, several case studies were conducted to test the different phases with children and young people from different countries, ages, cultural backgrounds, working in different topics related to the digital society. Through all the case studies during the three research

cycles participated more than 1700 children and young people. The case study approach offered additional insights into what gaps exist using the framework in different contexts [60]. Moreover, the case study method was used previously with children and young people as a way of involving them in the research [61,62], as well as being part of the process of citizen science that the WYRED framework proposes.

The case study presented in this paper is developed during the dialogue and research phases in the third cycle of WYRED research, and it has been selected to exemplify and demonstrate that the framework works and that it enables the objectives of the framework to be achieved. During the first two research cycles, the dialogue phase was conducted in person, so that social dialogues involving young people, researchers and decision-makers were organised in each of the participating countries. Later, they accessed the WYRED Platform, where they continued the dialogue and carried out the development of their citizen science projects.

On the other hand, the third cycle of research proposed a change aimed at establishing dialogues at an international level and promoting the development of projects through the collaboration of children and young people from different regions and social and cultural contexts. Furthermore, participation in the project is open to young people from all over Europe, Israel and Turkey, not only those belonging to the networks of the partners involved in the project.

A programme of international conversations on the different subthemes identified during the preparation phase was proposed (http://bit.ly/2HUxtIb). Each international conversation was defined as a case study, so the presented in this work is one of the eight international conversations carried out from January to September 2019. In particular, authors selected the case study about gender stereotypes on Internet, because it was the international conversation in which more young people was involved at the same time, and also because it was the conversation in which the authors were in charge of its definition. Each international conversation consists of three stages. Firstly, a stage focused on the definition of the conversation. At this stage, a coordinator and a team are assigned to define the details of the conversation. In particular, they have to provide the title, a brief description for dissemination, a set of reference materials, and a series of action points that are used to guide the dialogue and the project development.

Secondly, once the conversation is defined, dissemination materials are developed to invite children and young people to participate. The conversation is published using the tools provided by the WYRED ecosystem, the project's public portal and the social channels of the project on Twitter, Facebook and Instagram. Young people, who wish to participate, use a contact form available on the project's public portal. After verifying their identity with an email conversation, they receive an invitation to access the WYRED Platform. This informal validation process is necessary as an additional measure to keep WYRED Platform as a safe space. In addition, during this stage, the project partners looked for groups of young people in order to involve them.

The last stage covers the development of the international conversation, which lasts about two weeks, although the development of the citizen science projects is extended once the guided dialogue is over. It is important to note that the language used is English.

Regarding the ethical issues, the project protocol was approved by the Ethics Committee of the University of Salamanca. Furthermore, an Ethics Advisory Board was set up to ensure the application of the WYRED Participant Protection Policy [63]. In particular, a set of policies were implemented in the WYRED Platform to manage the informed consent of the participants. The following are the main measures, although not the only ones:

- Access to registration in the Platform is by invitation and linked to the informed consent procedures.
- The personal data is stored in an off-line database to which only the administrator have access. It will be only used in cases where abusive or unacceptable behaviour in the Platform.
- Parental consent managed by each institution involved in the project is needed to finish the registration process of children under 14 years old.

4. The Case Study

The following case study highlights a typical example of the delivery of the research work phases within WYRED. Among the issues identified by children and young people during the preparation phase are issues related to the gender gap and stereotypes in the digital society. In contrast to biological gender (sex), social gender refers to socially or culturally determined gender roles and gender relations. These are general ideas and expectations of how women and men are or should be, such as gender-specific behavioural attributes, interests, competencies or attitudes that are intertwined with social power relations and hierarchies. Gender stereotypes refer to everything that is considered typical of a particular gender in a culture, and it is criticised that such stereotypes leave no room for variety or individuality.

Within the international conversations programme, a conversation has been developed focusing on sharing opinions and ideas on gender stereotypes on the Internet from the perspective of young people. This conversation was scheduled to be part of the worldwide activities being held in connection with International Women's Day on 8 March. A day to celebrate the social, economic, cultural and political achievements of women while making visible the need for action to accelerate gender balance in any field.

The conversation took place within a space configured on the WYRED Platform, a community, where children, young people, social educators, community managers and facilitators interacted through forums that allow a combination of text, audio and video. The conversation, coordinated from Spain with the collaboration of institutions from Italy, Austria and Turkey, was organised in three actions. First, an exploration activity to identify examples of gender stereotypes on the Internet, both positive and negative, and share them in the forum "Exploration: gender stereotypes". Emphasis was placed on respecting copyright and licenses when sharing images and other contents, so the link to the original content should always be indicated. Secondly, the young people had to comment and reflect on the contents shared by other participants in order to establish a dialogue between people from different social and cultural backgrounds.

Finally, the conversation moved to the forum "How the way we use Internet or technology influence in gender stereotypes?" to discuss how technology influences gender equality, in the perception of stereotypes; if the use of technology and Internet is different depending on gender; if there are differences between the stereotypes found on the Internet and those that can be perceived in everyday life beyond social networks. Figure 2 shows the open community inside the WYRED Platform in which the three actions were conducted, and the research projects generated through the conversation were published.

Regarding the participants, several of the institutions involved in the conversation facilitated a group of young people in order to achieve a high level of internationalisation. In Turkey, the institution that is part of the project is a network of private schools that have integrated the WYRED methodology as part of their academic activities. The teachers and the corresponding educational centres are responsible for managing the legal permission for children to have access to the WYRED ecosystem. Parental consent was collected for each child involved in the conversation.

On the other hand, in the case of Spain, the project and the international conversation were presented to a group of university students of the degree in Social Education at the University of Salamanca, specifically in a subject focused on qualitative methodology.

Figure 2. Open community in the WYRED Platform for the international conversation about gender stereotypes and equality on Internet.

5. Results

A total of 79 people from Belgium, Italy, Spain, Turkey, Ukraine and the United Kingdom participated in the conversation, of which 69 were children and young people aged 10–28, and 10 were facilitators of different ages focused on managing and facilitating the dialogues and activities within the WYRED Platform. All participants communicated in English, using automatic translators when their English level was not enough. In terms of gender, 91.3% identified themselves with the female gender, 8.7% with the male gender and no one with non-binary gender or another choice.

Regarding the activity generated by the participants, all developed within the WYRED Platform in spaces similar to forums, 215 comments were published during the period that the facilitators guided the development of the conversation (Figure 3), although the activity was extended to three weeks later, reaching the figure of 274 comments. Besides, the comments not only contain text, but there are 72 comments containing images, videos and external resources such as news or scientific publications [64–66].
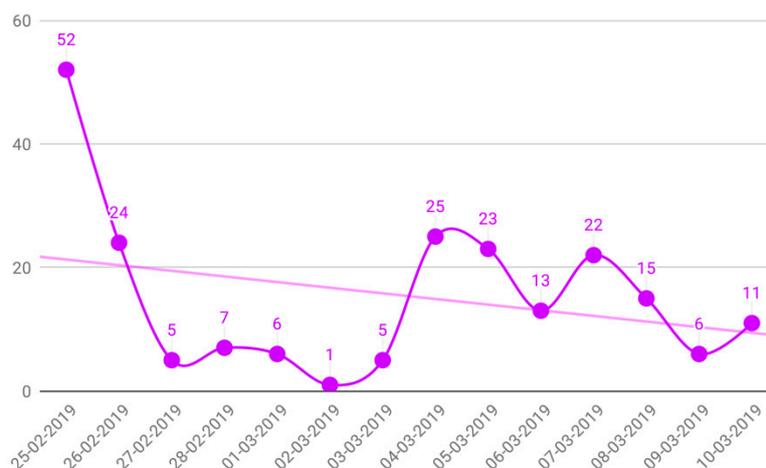
Figure 3. Conversation activity during the guided period.

In terms of the ideas and reflections shared by the young people during the conversation, there is a shared view that the media, especially social media and the Internet, not only reflect social gender stereotypes but also increase them massively through the permanent and global availability of the web. They have provided many examples of this, such as the ideal of the female or male body, often sexualised, promoted by influential people on YouTube or on Instagram. There has also been an interesting discussion about the connection between these stereotypes and cyber-bullying and hate publications. In general terms, as a group, they reject restrictive gender categories and support the dismantling of stereotypes and respect for people's differences and diversity.

Regarding the research projects, the conversation has laid the foundations for the development of 62 research projects, seven developed by children from Turkey, and 55 projects grouped in eight topics developed by young people from Spain. The projects try to answer the following research questions, addressing gender stereotypes from different perspectives:

(1) Do social networks promote the stereotypes?
(2) Do teaching learning processes an impact in the stereotypes?
(3) How young people deal with pressure about self-image?
(4) Does Internet influence in sports?
(5) Does social media support the gender gap?
(6) Do stereotypes have an impact in the current society?
(7) Do stereotypes only related to gender or there are stereotypes related to sexual orientation?
(8) Are there gender stereotypes during childhood?

The projects were developed and presented in different formats, from documents to artistic works or videos. For example, the project entitled "Don't stay silent! Investigation of the impact of a patriarchal society on women's social lives" is a scientific article based on 20 interviews with people in a Turkish region. On the other hand, the project entitled "Cars for boys and dolls for girls" carries out an analysis of all the comments made during the conversation in order to obtain relevant conclusions that can be useful to researchers, educators and people with profiles related to decision-making. The project "Gender equality on Internet" presents a report in which it analyses different stereotypes that directly affect equality between men and women. Also noteworthy is the project developed by young doctoral students under the theme of International Women's Day, "Balance for Better", a video focused on making gender equality in science visible. Likewise, a large group of young people have produced different posters, both artistic and scientific, to make visible some of the gender-related stereotypes identified.

The most relevant insights from the analysis of the different projects are:

(1) Gender stereotypes are part of our lives from the beginning, also when technology is not part of our lives.

(2) Internet could help to identify stereotypes although also it is a way to strengthen them.

(3) Teachers should aware about stereotypes and they can use the examples available on Internet to analyse them in the classroom.

(4) There are gender stereotypes associated to the uses of Internet.

6. Discussion and Conclusions

6.1. Contributions to Theory

The literature review conducted about young people involved in citizen science projects shows that there is a lack of proposals in which young people define the projects and conduct the research [30, 33,34,36]. Moreover, the studies and experiences described in the works published in the last five years are focused on natural science - climate change, wildlife, marine litter, pollution–[30–37]. Only one study covers another kind of problems, such as urban problems in a deprived neighbourhood [38]. The WYRED framework is focused on the issues that concern to children and young people, based on their answers, with a particular focus on technology. Furthermore, citizen science projects with children and young people only involve one or more schools in the same region. No proposals were found in which there is international collaboration in the development of citizen science projects, where children and young people collaborate at a distance employing technology to achieve their research objectives. In this sense, the WYRED framework allows the involvement of children and young people in the definition and development of international citizen science projects based on their own concerns. The combination of the technological ecosystem and the methodology defined and validated during three years seed the bases to establish a network of children and young people participating actively in the digital society, providing their own perspectives and ideas through research projects that can be used by the stakeholders in decision making processes.

6.2. Implications to Practice

Citizens have valuable knowledge that is often beyond the reach of scientists [67], are knowledgeable about what is happening in their communities and can tell which stakeholders should be involved [18]. Although young people are part of society and in the last century have distinguished themselves as a social group, their needs, experience, learning and knowledge have been neglected [68]. They do not feel involved in setting research agendas or formulating policies that affect the society of which they are part.

WYRED proposes a learning ecology to promote the transfer of perspectives, ideas and knowledge, between young people and decision-makers on issues related to the digital society. Young people take an active part in the research process through a series of cycles in which priority is given to communication support and interaction between participants–children and young people between 7 and 30 years old, facilitators, educators, researchers, decision-makers.

According to [15], citizen science makes it possible to create a link between science and education which, when combined with emerging technologies, expands the frontiers of research and public commitment. In the present proposal, the case study developed on the WYRED ecosystem to find out the opinions and ideas of young people concerning gender stereotypes in the digital society has made it possible to analyse the use of technological ecosystems to support a framework for citizen science focused on involving young people in society.

The results obtained during the case study reflect the methodological changes made over two years through the Action-Research cycles. It is important to note that the WYRED framework validation involved more than 1700 children and young people between the different phases and cycles of research. Regarding the international conversations carried out during the last cycle of research, more than 300 children and young people were involved as participants to validate the framework. The described

case study was selected because it was the international conversation in which more young people was involved at the same time, and also because it was the conversation in which the authors were in charge of its definition.

6.3. Key Lessons Learnt

The results obtained from the case study, mainly the analysis of the interaction between young people from different regions of Europe and Turkey, and the set of research projects developed from the online discussions, affirm that the framework has facilitated the process of defining and initiating a large number of research projects that serve as seeds for establishing larger projects, either by the participants themselves or by other young people interested in continuing the work, thus facilitating an open science process mediated by the WYRED methodology and ecosystem. Moreover, a set of findings emerge from the case study:

- It illustrates that within a group of children and young people, they find a wide range of research topics to explore, as well as creative means to presenting their research results.
- As identified in previous work focusing on co-creation processes [69], the proper development of international conversations requires the participation of facilitators - educators or scientists - who guide the group dynamics.
- The asynchronous communication tools provided by the WYRED ecosystem facilitate communication in a single language, English, by allowing the necessary time to prepare the interventions, as well as allowing the use of automatic translators as support in cases where the written level is low. The facilitator plays a key role in facilitating conversation and avoiding problems associated with written expression.
- The participation of children between 7 and 14 years old requires the support of their teachers and, to a lesser extent, of the educational centre, in order to manage the legal permission of the tutors to register in the WYRED ecosystem and to develop the citizen science projects at an international level.
- Research projects carried out by children and young people involve a learning process as well as providing ideas to researchers and decision-makers. Besides, the ecosystem allows giving visibility to the projects so that other young people can get ideas for future projects.
- The ecosystem provides the context and tools necessary to establish a methodology based on communication between people involved in research projects in order to achieve international projects, involving people with different points of view, from heterogeneous social and cultural contexts.
- Language is a barrier in the development of international citizen science projects, but the use of asynchronous communication based on the WYRED Platform allows children and young people use translate tools and other resources to collaborate with people from other countries.

6.4. Limitations of the Research

There are some limitations related to the sample of the case study. Although a wide range of ages was covered in the selected case study, the description and analysis of the other case studies carried out during the WYRED projects provides a larger number of children and young people to cover ages from 7 to 30. On the other hand, the number of men who have participated in the case study is low, but this problem is repeated during the different phases and cycles of research, so it is also necessary to balance this figure to know how the proposal works with heterogeneous groups.

6.5. Future Research Directions

Further research might explore the low participation of men in citizen science processes focused on sharing their opinions and perspective about the (digital) society as a way to involve them in the decision-making processes. Moreover, the WYRED framework will be tested in other contexts, not only

in Europe. In particular, another study is being conducted in Latin America to adapt the framework to different dynamics and cultural contexts, as well as to analyse the development of the research projects without the language barrier.

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