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Integrating Open and Citizen Science in Higher Education

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ABSTRACT

Integrating Open/Citizen Science in Higher Education is a great way to engage students and general population and help them feel empowered. Open/Citizen Science is a powerful tool for teaching science, but it must be made accessible and easy to use by both faculty members and students.

As the world becomes increasingly more connected, how can higher education be prepared to meet the challenges of a new era? One answer might lie in citizen science and open science. Citizen scientists are volunteers who make contributions to scientific research without having a formal position in the field or being paid for their work. Open science lab projects provide students with hands-on opportunities for scientific inquiry and discovery in different areas of research. The purpose of this study was to find out to what extent Open/Citizen science has been integrated in higher education and what are the impacts and challenges regarding to Open and Citizen Science in higher education. The findings of the study suggest that Open/Citizen science has been integrated into higher education in a limited way and there is a need for further development of this field. There are also different challenges faced with Open/Citizen Science in Higher Education such as lack of policy to guide on how it should be implemented.

Keywords: Citizen Science, Open Science, Higher Education.

Contents

Introduction

Open science (OS) is an approach based on a scientific concept which allows bi-directional scientific communication. To ensure maximum impact, OS may be accompanied with appropriate actions to promote it. It has been described as a paradigm shift towards open, collaborative scientific research that supports flexible forms of educational delivery alternative to traditional models (Toli, Sifacaki, Manola, Ioannidis, Ross-Hellauer, Görögh, & Woutersen-Windhouwer, 2018).

Ayris and Ignat (2018) OS allows for more creativity, innovation and new knowledge as openness affects the way research is produced, shared, accessed, described, and used as the basis for further research. It also allows for a more collaborative approach to research which in turn can improve active learning among students.

OS could lead to increased human capacity at research institutions around the world as it may be easier to find and relate to other people who have similar interests/skills. A larger group of people would mean a larger potential for collaboration, and therefore more resources and skills for research institutions to draw upon. The idea of 'open' relates to the way in which knowledge/data is made available for anyone to re-use. Open data can also come in other forms such as open source and open content (McKiernan, Bourne, Brown, Buck, Kenall, Lin, & Yarkoni, 2016).

CS is a field that involves the engagement of individuals to collect data that serves the purpose of furthering scientific inquiry. CS is a valuable tool that has the potential to bridge the gap between what is understood to exist in scientific literature, and reality. There are both benefits for academics as well as students from engaging with CS. CS can help provide insights into what issues are important across all disciplines where it can lead to improved understanding of certain findings and studies inside or outside academia(Brovelli, Pontti, Schade &, Solis, 2020).

OS and CS are important because they allow the scientific community to collaborate in and learn from a wide range of sources. They are also important because they can include active learning and engagement, which is often not possible through traditional courses that emphasize, lectures (Condon & Wichowsky, 2018).

According to Rentier (2016), OS may be the next scientific revolution. However, it is still in the preparatory stage and is characterized by an unestablished definition and discipline.citizen science" as a brand emerging in the context of the changing, participatory rotation of science policy, from consideration to production. CS can really be seen as the next step in the participatory process (Sariola, 2019). In addition, OS and CS have not been widely accepted or used in Higher Education Institutions (HE) and has led to the lack of clear methodology indicating how OS and CS could be integrate into different curricula. University may require exploring new and ground-breaking initiatives to address scientific issues regarding OS and CS (McKiernan et. al., 2016).

This report aims to review the following and based on literature from the last five (2016 to 2021)

- Create a knowledge base on how and to what extent OP has been integrated into European HE curricula.
- European HE studies modules, curricula, and studies, pedagogical models.
- OS-related European Union (EU) projects

Research Method

To answer the research questions, Systematic Literature Review (SLR) was employed as a research method as this guides the researcher through the study of what is already known about the research questions and to what extent.

This is an SLR study which aimed at discovering what is already known on OS/CS, the extent of the integration in Active Learning in HE through answering specific research questions. SLR is a method that has been used by researchers for many years now to combine all the data from various studies on a particular research question to find answers (Mahdavi-Hezavehi, Durelli, Weyns, & Avgeriou, 2017).

Snyder (2019) indicated that SLR research methods are intended to influence potential readers as to whether the topic is worth further study. In this context, Okoli and Schabram (2010) and Ramey and Rao (2011) referred to SLR as studies that are conducted for different reasons such as answering a research question taking into consideration the prior knowledge using the three main phases of planning, reviewing, and reporting the findings.

Conducting literature review helps to build a solid foundation of helpful evidence for planning and executing new research. The term literature review is used to describe the process and the products of information retrieval, analysis, synthesis, and organization. Because literature reviews are investigations into research quality, it becomes necessary to outline the stages involved in this investigation so that quality standards can be identified and implemented (Xiao & Watson, 2019).

Table1. SLR review steps

Step	Task
Research Questions	Present the research questions of the study
Develop Protocol	Planning time, searching relevant libraries and journals, and retrieving research data to be reviewed and indicating the inclusion and exclusion criteria.
Conduct Research	Selecting and reviewing the selecting articles
Select and assess the studies	Writing the review according to the research question
Extract and analyse and synthesize relevant studies.	Synthesizing the studies selected is essential because it provides a larger perspective to the readers.
Interpret results	Interpreting resulting is a research and writing literature based on the synthesized studies.

Table1 elaborates the steps taken when presenting the literature review as expounded by Ramey and Rao (2011), Mahdavi-Hezavehi et al., (2017) and, Cho, Mansfield, and Claughton, (2020) which guides the steps to follow.

2.1 Research Approach

Prior to conduct the systematic literature review (SLR), the author scanned through various articles and books accessed through different online digital libraries and journals. When planning the review, the author took note of the key words that needed to be articulated and paid attention to get the preferred and relevant documents for reviewing and synthesizing. Searching articles was necessitated by limiting the search strings to the specific keywords and limiting the period when the articles and books were published as recommended by the INOS project.

Therefore, the following databases were used to find articles and books used in the study.

- ACM Digital Library - http://dl.acm.org/
- Emerald insight - http://www.emeraldinsight.com/

- Google Scholar - http://scholar.google.fi/
- IEEE - http://ieeexplore.ieee.org/Xplore/home.jsp
- Inderscience - http://www.inderscience.com/
- Science Direct - http://www.sciencedirect.com/
- Web of science - webofknowledge.com
- World Scientific - http://www.worldscientific.com/

2.2 Study Selection

2.2.1 Inclusion Criteria

Inclusion criteria of the articles and book in research depended on whether they were written in English. There were restrictions on the date of publication as this was emphasized by the INOS project. The keywords were an important inclusion aspect as they allowed for the retrieval of the relevant information required to answer the research questions. The articles reviewed for the study ranged from 2016 to 2021, written in English language and mostly were feature articles as these tend to give more details about phenomenons.

2.2.2 Exclusion Criteria

The exclusion of the articles and book in research depended on whether the subjects were part of the reviewed entry. The terms used to identify the excluded articles and books were that they either were not written or published in the specified period of time required for consideration or they did not relevant information on the subject such as the keywords.

2.2.3 Research Limitations

It is important to inform the reader of the research limitation because it will affect the validity of the argument. Research limitation refers to a limitation that is imposed on research, resulting in an incomplete picture. They are often imposed by external constraints like lack of time, funding, and access to participants.

It is difficult for researchers to conduct a study with absolutely no limitations which may affect its validity due to time or money constraints. This can lead them to certain potential outcomes that they cannot definitively conclude due to their studies being limited. However, in this study report it is important to not only acknowledge this but also provide explanations as how these research limitations affected the findings and what conclusions were made from them given the information I collected through my limited scope of study.

The systematic literature was conducted using prior knowledge from a specific period (2016 - 2021), this meant that vital information which could have been relevant to this study was not used as it was restricted to this period.

Therefore, the scope of the study was limited as it only looked at the study conducted during the last 5 years (2015-2021); this period was selected to coincide with the INOS project guidelines.

Given these limitations, the conclusions were reached, and the extents of the findings are limited to that period. These findings may be further evaluated with further research which is important to reach new insights regarding this field of research.

2.2.4 Research Questions (RQ)

- Q1. To what extent has Open/Citizen Science been integrated into Active Learning in Higher Education?
- Q2. What are impacts and benefits of integrating Open/Citizen Science in Higher Education?
- Q3. What are the challenges that higher education institutions face about Open/Citizen science?

Systematic Literature Review

This section explored different articles and books from the period of 2016 to 2021 assembled from various libraries as shown. This period especially was selected to be studied in conformity with the project requirements. The review encompasses OS, CS, and OS/CS integration into Active Learning in Higher Education and concluding with challenges of OS and CS in HE.

3.1 European Higher Education Area

The High-Level Expert Group on the Implementation of EU Initiatives in Lifelong Learning, established by Council Decision 2005/184/EC, oversees monitoring the implementation of EU initiatives on lifelong learning (LLL) as a basis for future policy programs and policy developments. Concerning HE, this means that member states must ensure that they maintain their current competence in this area (Karseth and Solbrekke, 2017). Exchanges programs are also encouraged fostering the cooperation between higher education institutions and the mobility of students, researchers, and lecturers. The EHEA is also concerned about equal opportunities in access to education in general and equal pay for equal work (Volles, 2016).

Volles (2016) further explained that under the first pillar (access) of the EHEA, all European higher education institutions should facilitate access to learning for all students within their jurisdiction. This includes dealing fairly with learners who have recognized qualifications from other countries, regardless of their nationality. Students that reside in another country are provided with information on all aspects of study at a particular institution, including living expenses and approximate costs of tuition fees before they decide where they will study to make sure they are aware of any additional costs they might encounter when studying abroad.

Study Modules, Curricula and studies, Pedagogical Models, Teaching and Assessment

Weedon and Riddell (2016) pointed out that academic degrees in European countries can be classified into three major groups, depending on level of academic or institutional qualifications:

- Undergraduate degree programmes in those countries are normally for three to four-year courses. They lead learners to Bachelor of Arts (BA), Bachelor of Science (BSc) or other equivalent instead.
- Postgraduate degrees such as master’s degree
- Doctorate or Doctorate Coursework usually take two years but may take longer.

It is impossible for undergraduates from different countries to transfer their credits from one institution to the other without taking a conversion exam at that institution, known as an "Equivalency Exam".

Sometimes, a BA or BSc under the British system is called an "undergraduate degree". In the United States and Canada, the equivalent of an undergraduate degree is less than four years. An associate degree in those countries is generally completed in two years.

While a person with an associate degree may be accepted as an entry level worker, they will not be qualified to enter a four-year Bachelor program without prior study. For example, a two-year college graduate from Canada or the US who later wants to undertake studies at Cambridge University would first have to complete three years of study towards a Bachelor at King's College London and other such British universities.

The first type is a three-year degree that allows students to major in only one or two fields (e.g., philosophy or history). The second type has been historically adopted by many European countries regarding their ancient and medieval universities. For example, in Finland, Sweden and the Netherlands, it is a five-year degree, which allows students to study a broader array of subjects. The third type is a "tournée" (or "majeur/mineur") degree system. In French-speaking countries (e.g., Belgium, Luxembourg, Switzerland), it is a four-year degree that requires students to take courses of both major and minor subjects (e.g., economics and languages). The fourth type is like the third type except that instead of taking courses from both major and minor fields, they are required to take more courses in their major field than in their minor field.

Generally, in Europe there are similarities in the modules between these types of bachelor’s degrees: Courses finished in the required number of subjects (usually at least 60 credits) are assigned a grade. The grade is from 0 points (the worst) to 10 points (the best). Some universities do not assign grades but print a statement from a computer, such as "GOOD SUCCESS". Students may choose to take their final examination at no later than three months after the start of the exams session to have enough time to prepare for an entrance exam. If they fail an exam or do not take it within three months after the start of exams, they must retake it until they pass (Gaebel, Zhang, Bunescu & Stoeber, 2018).

OS is open to everyone and encourages collaboration with people who may not be traditional scientists. This is the idea behind CS, where anyone can take part and contribute. However, the key difference is that unlike in OS, CS projects are not openly available to everyone (Dai, Shin, & Smith, 2018).

3.2 Higher Education Study Modules

HE is the type of education that is made available to those who have graduated from high school. Completion of a Higher Education programme usually results in the award of some academic degree. It may also be referred to as post-secondary school education. This kind of education is mainly optional as compared to other forms of education like elementary school, junior high, and secondary school (Cantwell, Marginson & Smolentseva, 2018).

On the other hand, Caroleo and Pastore (2018) contended that HE can also be attained even without completing High/Secondary school, this may happen in a case that an individual has obtained a professional qualification and has vast experience working in a particular job, such people can be exempted from the high/secondary qualification that qualifies individual to attend higher education.

De Boer, File, Huisman, Vukasovi, and Westerheijden (2017), European Higher Education systems are regionally scattered for a variety of reasons such as historical ties to higher education organizations and established higher education traditions. There are also variations within the European Higher Education system from one country to another due to differences in tradition and culture as well as Higher Education policy-making processes.

Many European countries have a three-tier system of higher education. The first tier is composed of universities conferring bachelor's degrees, the second tier is composed of universities open to students holding bachelor's degrees and conferring master's degrees and the third tier is composed of universities that require applicants to hold a master's degree for admission (Sin, Veiga & Amaral, 2016).

Similarly, within the EU some countries, such as France and Italy, many institutions only confer bachelor's degrees. Many countries have developed a two-tier system, where those who hold a bachelor's degree can continue their education at the master's level (for example in Germany or Denmark). Some countries still have one-tier systems (in this case most often covering both levels). The one-tier system is usually, but not always, financed by the government (Darmody and Smyth, 2016).

Whereas Finland and Norway are two countries in EU with a well-established higher education system with full autonomy for universities and institutions at all levels. In Finland, the universities have been autonomous since 1969 when legislation to this effect was passed. In Norway, the autonomy of universities was established in 1988 (Jørgensen, Olsen & Thungvist, 2018).

3.3 Curriculum and studies

HE Curriculum and studies in Europe is a three-level system that is provided by the Bologna Process. It has a bachelor's degree, typically lasting three to four years. The second level is a master's degree, typically lasting one to two years. And the third level is doctorate degrees or PhDs. There are many universities in Europe but not all of them offer bachelor and master's degrees. The higher education curriculum is a set of rules that should be followed for the development of higher education in Europe. The HE curricula consist of four areas: general education, social studies, scientific and technological studies, and humanities. According to the Bologna Process, students must have at least one year's experience working as teachers before they can apply for a university program (Dudin, Bezbakh, Frolova, & Galkina, 2018).

However, Dakowska and Velarde (2018) noted HE curricula differ from country to country, but the structures are similar in some ways. Depending on the subjects in a specific university, it is also possible for such to be accepted in another university and usually recognized within the member states especially the courses in Arts and Sciences.

European higher education is a broad term referring to undergraduate and post-graduate levels of education in Europe, as well as permanent degrees or qualifications, such as Diplomas awarded by Guilds (Hunt & Boliver, 2019).

The European Higher Education Area (EHEA) was established in Lisbon in 2000 as the political basis for a common policy at EU level on higher education issues. The aim of this Agreement is to provide a legally binding framework for cooperation between the member states in education covering topics of common interest such as: competences, recognition, and mobility of third-level qualifications. This is an important step as it helps to shape the future of, HE in EU and the cooperating partners. However, in 2008 the EHEA was replaced by the EHEA Regulation which entered into force on 1.1.2010 and is fully applicable from 1 July 2010 (Zahavi & Friedman, 2019).

3.4 Open Science

The following section discusses OS and what it is regarding HE. The term OS was probably coined around 2010, a decade after the term Open Access (OA) gained visibility in the academic sphere. The OA is a recent and important movement in science, as it allows for a free access to the scientific literature. This term OA is not a synonym for open data or open science, but it's often used interchangeably with these terms. The OA describes the idea that researchers should be able to publish their research work in digital format without having to go through the journal publishing process and make it freely available on public platforms like Internet (Whiteley, 2019).

Ayris and Ignat (2018) defined OS as a movement to form research project, data, and dissemination of research data, results accessible in the least levels of an interested parties. Intrinsically it represents a transformation within the way research is conducted, recorded, and disseminated. OS is therefore a paradigm shift within the routine of research and science impacting the whole scientific process. In addition, OS may also be as a way through which people are encouraged and allowed to participate openly in an endeavour. This could be through making results freely available or by encouraging collaboration with people who may not be traditional scientists. With OS projects, it is expected that everyone can participate, ideally, there should be no discrimination based on age, gender, ethnicity, or level of education.

In recent years, OS has gained visibility and being discussed amongst several stakeholders that would like to see it being integrated and accessible into various spheres. OS has different synonyms, for example, Van der Zee and Reich (2018) OS employs the practices that intensify and strengthen the availability of scientific research resources.

HE institutions are beginning to realize the importance of open data and have started introducing open repository systems. Open Data refers to the data made available to freely accessed and used by anybody without copyright restriction (Sadiq & Indulska, 2017). Open repository is a software tool used for storing and archiving data which can be accessed freely. Open Data encourage transparency in the scientific community, create more public involvement in science, lower the costs for researchers and help to establish collaborations with companies and other universities. More and more institutes are also starting to store their research information with institutional repositories. There are two main types of institutional repositories: those that manage full-text documents and e-prints and those that manage research data. Scholarly publishers are now also getting involved in the OA movement, an example being BioMed Central, which has launched a new fund to support OA advocacy (Zervas, Kounoudes, Artemi, & Giannoulakis, 2019)

To support the OS movement, Nature Index (2018) top authors have been rewarded with open science awards in previous years. The winners' list is published annually by Elsevier's Scopus, which are an international scientific, technical, medical, and scholarly database containing abstracts and citations for over 14 million articles from more than 5,500 international journals. In 2017, Elsevier and the Dutch Open Science Institute (DSI) established the Open Knowledge International Awards under the auspices of the Open Knowledge Foundation to reward individuals, groups, and institutions for their dedication to open science and data.

The Leibniz Prize is a high acknowledgment of open data in Europe. It was created in 2012 by the German Federal Ministry of Education and Research (BMBF) as part of its activities concerning promoting a knowledge-based economy (KBE) in Germany. It recognizes pioneering work on open science & data in European research projects that are collaborative and non-competitive (Aman, 2018).

OS as a movement is replacing the traditional and closed scientific model, which is characterized by high prices of journals, expensive article-processing charges, and limited accessibility of scientific data even for the authors, and restricted access to scientific articles.

3.5 Citizen Science

Strasser, Baudry, Mahr, Sanchez, and Tancoigne (2019) CS is the act of members of the public undertaking tasks traditionally done by scientists. This is helpful for several reasons, including increasing the amount and variety of the data available to generate maps, models, and other research projects; improving the understanding of how science relates to society; and helping laypeople gain a sense of empowerment through their engagement in scientific endeavour. The term is sometimes used interchangeably with 'public participation. CS can be both professional and amateur (McKinley, Miller-Rushing, Ballard, Bonney, Brown, Cook-Patton, & Soukup, 2017).

CS may be referred to as 'public participation in scientific research (or similar) and can be officially facilitated but may also occur as volunteers collaborating without official support. CS is closely related to crowd sourcing, which originated with a call by Tim O'Reilly (2016) for collaboration between the technology-oriented "crowd" and experts in the scientific community. The EU's "Citizens' Awareness Project" has formalized the concept of participatory sensing, focused on the development of better user interfaces for the public.

Condon and Wichowsky (2018) pointed out that CS has had the following impact on higher education: (1) the impact on engaging underrepresented populations in STEM, (2) it has led to increased understanding of complex phenomena and questions, and (3) Citizen Science can be used as a recruitment tool.

CS is a field that relies heavily on collaboration between scientists and citizen scientists. Citizen Scientists are people outside the scientific community who use their time and skills to help answer important questions facing society. The term also refers to projects which incorporate public participation in collaborative scientific research such as collecting data for climate change studies.

The impacts of CS are attributed to the rapid advancement in technology, the increasing participation of people in scientific fields and more. Citizen Scientist must be licensed to handle their own personal data that is. The use of Web 2.0 tools has increased participation from those who want to see their data make a difference. There are no concerns about how or what they learn as de-facto librarians who can navigate the complexities of retrieving research-related information, it is more important for them to know how to integrate that information into current and future projects.

In today's world technological progress has been so rapid and complex that it becomes a difficult task for one person or group alone to conduct research and come up with innovations for STEM subjects (Condon & Wichowsky, 2018).

Open Science in Academics (HE)

Ben, Guedes, Barton, Bates, Baxter, Andrew Bevan, Elizabeth, and Bollwerk (2017), OS is becoming more accepted in academia; it may not be accepted by many academics. OA to academic work and data has been a problem for academics for a long time. Some academics have argued that publishing works through OA journals reduces the number of fees that they can charge their students to fund their research. But the benefits of OA research seem to far outweigh the costs and so academic institutions are now finding ways of making sure that all researchers' research is either free or very cheap. While some do still have problems with this, there are some signs that this problem will be overcome soon (Allen & Mehler, 2019).

Some of the motivations by students to engage in open and citizen science projects is the interest is the desire to learn about certain phenomenon such as biology, astronomy, and environment. For example, a student may be interested in studying how the weather changes based on location of the origin of a lightning bolt. The student can then collaborate with professional scientists by conducting an experiment during which they collect data on location, lightning data, and relevant environmental factors. This data is then analysed by professional scientists to help them gain a greater understanding of the phenomenon in question. Students have been found to be motivated to participate in OS projects because it gives them an opportunity to work collaboratively with other students and faculty. They have found that they are able to challenge themselves at a higher level when working on these projects (He, Parrish, Rowe, & Jones, 2019).

Meanwhile, Hecker, Haklay, Bowser, and Vogel (2018) argue that OS is still being developed and there are some members of the academic community who are still unsure about how to fully integrate this into the academic environment. This includes debating over which OA journals to publish in so that they gain a decent number of citations and whether publishing works via digital portals makes them more likely to be accepted for research grants.

While there is a lot of debate about how OS might be integrated into academia, it will become increasingly important in academics' work. It may be that most authors would work towards making their research as open as possible and with the right incentives and support, I think that this will become increasingly common (Vicente-Sáez, R., & Martínez-Fuentes, 2018).

3.5.1 Impact and Benefits of OS/CS in Higher Education

According to Kimura, and Kinchy (2016), the benefits of CS are that it is a relatively low-cost and easy way for people to get involved in scientific research. They also feel engaged and less like passive observers. CS, once it engages the public with a topic, will greatly increase the chances of important discoveries that can lead to new technologies or treatments. Many people who get involved in CS have no previous scientific background whatsoever, but they can easily learn about science through self-directed projects. These projects are often based around their interests which helps create more opportunities for creativity and innovation while learning more about a subject matter that they care deeply (National Academies of Sciences, Engineering, &Medicine, 2018).

CS is a great way for people to learn about science and it can also be a fun way for people to get involved in scientific research. Most CS projects offer incentives such as T-shirts or small monetary rewards for those who participate. Unfortunately, some of these rewards cost too much money which prevents some people from participating in CS projects (Ainsworth, 2019).

Furthermore, Bonney, Phillips, Ballard, and Enck, (2016), pointed that the benefit of CS is that it allows members of the public to engage with scientists in new and exciting ways. Through projects like the Galaxy Zoo, users can learn about astronomical features they may never have had access to before. Another example is the University of Washington initiative called ´´Foldit Project´´ which allows players to contribute insights into how HIV assembles and interacts with its target cells. The game attracted over 190 million players during its first 3 years online, all of whom contributed a total of 1 billion player hours during that period.

CS has been gaining interest in the past decade since it has been shown to improve the quality and relevance of citizen's input. The value of CS can be seen in the creation of the Scientific Curation Center at Iowa State University. The centre focuses on increasing the visibility and reproducibility of CS projects to academia and working with scientists and innovators to launch new citizen-science approaches, develops resources for researchers who are interested in working with citizen scientists, as well as a portal for researchers interested in collaborating with citizen scientists around the world (National Academies of Sciences, Engineering, & Medicine, 2018).

CS is also seen as having an important role in education, research & development, conservation & sustainability. A combination of CS and big data is central to the paradigm shift from an Industrial Age society to an Information Age society (Chen & Sun, 2018).

The value of CS to higher education continues to grow as researchers develop new projects and technologies that allow for greater collaboration between the public and scientists. However, some challenges continue to be seen in this field movement toward CS. One challenge is in how best to implement CS into a traditional higher education curriculum. Another challenge is in developing new technology for public involvement to facilitate more effective use of the tools already available (Brovelli et al., 2020).

3.5.2 Challenges of OS/CS in Higher Educations

There are several challenges regarding OS in higher education institutes, the following were noted in this study (McKiernan, Bourne, Brown, Buck, Kenall, Lin, & Yarkoni, 2016).

- Social-Cultural
  There is lack of awareness of the advantages and importance of opening research, and the unwillingness to share data along the research process. Researchers consider this a time and effort-consuming activity to feature to their existing workloads. The lack of a transparent recognition and a gift system that promotes open

science practices. In addition to researchers and research institutions, there's also a change to be made on the part of the research funders.

- Technological:
  Information and communication technologies have rapidly improved but there's still work to be done to support and ease researchers' workflows towards more open practices.
- Political:
  There is a transparent need for political commitment to market open science and integrate it into the government agendas, also at the international level. The necessary resources got to be allocated so as for these policies to succeed. There is a challenge of lack of commitment for the development policies and strategic planning needed for both at the research institution and country level.
- Organisational:
  The working environment (e.g., university, research institution) can have a big impact on how quickly and broadly research becomes open. A closed culture may be a challenge for individual researchers and slows down the general openness of research. Organisations got to develop and acquire the acceptable skills to support open science within their organisation. The other issue to be considered is whether each individual higher education institute has its own open access repositories, services, and policies for supporting open science and also what is their response towards OS?
- Economic:
  Even if one among the most arguments for open science may be a higher efficiency of research that within the future will end in a far better use of resources and acceleration of innovations, significant investments need to be made at the start so as to develop the technical, political and organisational ecosystem for open science.
- Legal:
  OS may change the manner at which we look at the ownership of data, copyright, privacy, and accountability in research. Many of those changes got to be reflected in legislation and research guidelines. A clear legislation framework must be developed at the international level and researchers must remember of this legislation (Hand, 2018).

Apart from the challenges listed, Allen and Mehler (2019) identified other challenges regarding the practicing of open science in HE such as the lack of flexibility and the restrictions encountered at different levels of research. OS requires and allows the opportunity for research results and data to be replicated and used by others; however, this causes a constraint on generality. However, meta-analyses have shown that most studies still do not meet open science requirements and standards, including reproducibility, even though they claim to do so (Nuijten, Hartgerink, van Assen, Epskamp & Wicherts, 2016).

Schröter, Kraemer, Mantel, Kabisch, Hecker, Richter, and Bonn, (2017) pointed out that CS studies are hardly published i scientific journals and if they did however get published, they usually fail to acknowledge the volunteers involved in the study and they equally fail short of advancing the wording of appropriate CS wording to make an emphasis. These challenges make it difficult for the advancement of CS in HE.

The process of publishing scientific research is essential for ensuring that other scientists have access to it. The publication process has been historically quite slow and complex, causing a great deal of anxiety among researchers who are concerned about missing out on the attention they deserve. The publication process has also slowed down scientific progress by making the results from research available only in academic papers. This means that the average person cannot evaluate different scientific claims if they can't read the academic paper (Spellman, Gilbert& Corker, 2017).

3.6 The Current State of Open Science research

There is evidence to suggest and show that there are some promising developments in the field. For example, there are an increasing number of OA journals that have been developed by academics that see the benefits of sharing their work with the world. OA makes it possible for readers to access and use academic work without paying any fees or subscriptions and this means there are more people accessing information.

Besides, it has been observed that most published work in open source have increased the citations which means that they are more accessed as compared to those which are not in OA repositories. There are also a growing number of repositories for databases and other data assets from universities and research institutions. These repositories make it possible for fellow researchers to access the valuable data. In this way, academics can work together and utilise each other’s data for research (Tennant, Waldner, Jacques, Masuzzo, Collister & Hartgerink, 2016).

The academic community is also becoming more interested in OS. The emergence of new journals that embrace OS has been one of the most significant breakthroughs. These are OA journals such as ´´OS and OA Scholarly Publishers Association (OASPA) ´´which require accepted academic publications to be made freely available to the public after publication. Furthermore, much OA publication is now done online through digital portals, and data intensive research is becoming a more popular field of study. Instead of waiting for print versions of academic papers to be published, readers can get material via web pages or electronic portals. (Price-Whelan, Sipőcz, Günther, Lim, Crawford, Conseil & Astropy, 2018).

3.7 Integrating Open/Citizen Science in Higher Education

There are different approaches involved in integrating OS/CS in HE which range from informal research collaborations between students and citizen scientists to crowd-sourced experiments conducted in the university laboratories. By engaging with these emerging modes of knowledge production, the traditional model whereby research-based academics act as gatekeepers for 'the truth is being challenged and replaced by a new paradigm that values collaborative processes that involve students and citizens as co-producers with academics (Viberg, Hataka, Bälter, & Mayroudi, 2018).

Promoting collaboration studies amongst universities is another way through which OS and CS can be integrated into learning, and this may best be done with the help of Communities of Practice. In this way we can create 'learners' networks' and there is a vital role for universities in the promotion of such communities. OS and CS pre-empts the need for academic gate keeping, and thus lends itself to integration into open educational practices (Preece, 2016).

The focus on active learning presents an exciting opportunity to integrate a more diverse set of approaches into current research practices, which are over-reliant on quantitative methods. Condon and Wichowsky (2018) established that majority of countries around the world lack locally relevant scientific resources to support young people's development. For example, the development of a global science, technology, engineering, and mathematics (STEM) network using the internet provides a platform for furthering local and global STEM educational efforts.

Students from remote communities in Australia can interact with students around the globe, including countries such as Brazil and China to share experiences and develop their skills. The benefits of such initiatives are twofold. Firstly, they allow students to interact with experts in an online community with researchers. Secondly, they provide opportunities for students to develop media skills (such as video editing) and entrepreneurial capacity that could be beneficial in promoting the advancement of science within their local community. While several ideas have been floated on how to integrate OS into active learning, Zourou and Tseliou suggested the following initiative that could be used or adopted to facilitate the integration of Open Science into Higher Education (Zourou & Tseliou, 2020).

3.7.1 Strategies for facilitating Open Science practices in Higher Education

Online social networking platforms, such as Facebook and Twitter (social media) have become key tools for public engagement and digital activism, encouraging greater collaboration among both groups of stakeholders in contributing towards the development of shared knowledge. By doing so, it is possible to improve access to open science resources and free educational content which are vital for improving the way research is undertaken (Chamakiotis, Petrakaki, & Panteli, 2021).

As a way of seeking and building upon existing knowledge, OS allows for more creativity, innovation, and new knowledge by making scientific research freely available to everyone. This could be seen as an extension of the concept of "open education" in that it allows for a more collaborative approach to information sharing which can promote active learning among students, improve research processes and ultimately foster institutional reform.

The research culture is broken, and only open science can fix it. She emphasises the importance of open science in HE and presents a compelling case for its implementation at all levels of education. OS is essential to solving major global problems and enabling better healthcare, technology, and education. Ainsworth further pointed out that the idea of an open world view has emerged as a new educational paradigm which moves away from traditional notions of transparency, openness, and social justice (Ainsworth, 2019.

Tennant, Waldner, Jacques, Masuzzo, Collister, and Hartgerink (2016), there are four open research principles namely, availability, access, usage, and reuse. He explains how these ideas can be implemented effectively whether professional or citizen scientists are conducting the research. His post is a great review of the current research on Open Scientific practices in science teaching. Considering the four principles, OS can help to address some of the key factors that inhibit the progress of scientific research. These relate to economic, technical, cultural, and political barriers that have created a monopoly among large corporations. This limits access to scientific knowledge for all audiences. OS may indeed be the key in ensuring that knowledge is shared openly so that it can be used more effectively for the benefit of society (Taylor, 2016).

An example of how OS and CS are being integrated in HE can be seen from the Finnish such as the Helsinki University were they implemented the Language Change Database for their language studies (Kesäniemi, Vartiainen, Säily, & Nevalainen, 2018),and Netherlands Universities' perspective. Zervas et al., (2019) noted that Finnish universities have created online repositories for data and other assets that are needed for research. This means that academics from different institutions can work together more easily by using each other's data. These repositories are a great way to ensure that valuable data sources are not lost because they are simply not being used properly. In addition, because researchers can easily access these online repositories, they do not have to worry about where the data is stored. Instead, they can be confident that their data will remain accessible and up to date in the future.

In addition, several new journals have been established by academics for example in the Netherlands and Finland to support OS. These publications are in OA journals that require academic articles to be made free of charge to everyone if they are accepted for publication. This means that the research is then accessible to everyone across the world, and it encourages academics to collaborate. The journals also ensure that the data from research activities is not being hidden or sold off in any way. Instead, all this information is made freely available to anyone who needs it (Ayris & Ignat, 2018).

OS has been integrated into graduate curricula some universities in Finland and researchers can now choose between either traditional or OS approaches when developing their projects. Some degree programs are even dedicated to OS. As a result of this, there are now more people working in the area and there are a growing number of academic research related to OS(Biesenbender, Petersohn & Thiedig, 2019).

3.8 Open Science Project

There have been campaigns to assist the Open Science movement, as well as standards for implementing open practices and ensuring high-quality open data. One such initiative is FOSTER (fosteropenscience.eu), a broader EU project that provides classes and online materials for researchers to learn about open practices. Another attempt is the Go FAIR initiative (go-fair.org), which advocates for open data to be discoverable, accessible, interoperable, and reusable. It has practical applications for data producers such as academics and metadata editors, as well as infrastructure developers who provide access to this data (Heck, Peters, Mazarakis, Scherp, & Blümel, 2020). Besides these initiatives, there is also the INOS project objectives are.

Problematize the social impact of Higher Education Institutions (HEIs) as knowledge creation, sharing, and (re-) use ecosystems in the digital economy and to better situate their role in current demands for civic engagement, societal impact, and learning opportunities for all.

- Develop a pedagogical foundation supported well-proven active learning pedagogies for open/CS practice to encourage creativity and skill development, and to extend knowledge dissemination among citizen scientists during a pedagogically sound way.
- Up skill HE academic and library staff and students through the exposure to contemporary trends in public engagement (such as OS and CS).
- Enrich HE is teaching, learning, and training resources on active learning pedagogies (problem-based learning, game-based learning, maker education, crowdsourcing education, inquiry-based learning) with OS and CS initiatives as demonstrations of current trends that claim an active role of citizens in decision making and governance.
- Bring together target stakeholders and external stakeholders, to address the widest possible audience, raising awareness on societal impact from OS and CS inside

and outside HEIs, thus maximizing the impact of the project outputs. (https://inos-project.eu/ accessed on 15.04.2021).

The European Commission's Directorate-General Research and Innovation have allocated over €21 million to the H2020 OA and OS projects in 2014-2017. In 2016, Springer Nature committed €1 million to support some of these projects with a focus on data management and reuse (Leonelli, 2017).

The European Commission recognizes the importance of OA research which they believe "makes Europe more competitive". This includes easier access not only for Europeans but also for foreign researchers, better integration of research in teaching, increased visibility, and wider social recognition for research results as well as an increase in innovation because more innovations can be based on scientific knowledge obtained through research. It can also promote convergence in European research which is important for the development of industry and society in Europe. This is especially relevant if the funding of research is following a national framework of the EU.

The European Commission highlights that OA allows cross-discipline collaboration. Moreover, it means that all researchers must have ready access to research outputs regardless of where they work or their legal status. Finally, it promotes more efficient use of science by increasing efficiency in acquiring information whilst reducing duplication and unnecessary costs (i.e., publishing fees) to society (Karjalainen, Hoeveler, & Draghia-Akli, 2017).

Results

This section reports the findings of this study. The findings are presented in the order of the questions.

4.1 Q1. To what extent has Open/Citizen Science been integrated into Active Learning in Higher Education?

Heck et al., (2020) lack of resources and incentive led some academics not to accept OS and this means that while some Higher Education institutions are open to integrating Open OS it into their curriculum, others are still sceptical about its implementation Henceforth, Ainsworth (2019) emphasises the importance of open science in education and presents a compelling case for its implementation at all levels of education. OS is essential to solving major global problems and enabling better healthcare, technology, and education. He suggests that the idea of an open world view has emerged as a new educational paradigm which moves away from traditional notions of transparency, openness, and social justice.

The integration of open science approaches into existing teaching methods makes it possible to engage more learners in a greater variety of active learning activities. This is especially important considering the need to create scalable models that can be applied globally so that all students can experience an active learning-based curriculum (Viber et al., 2018).

The lack of understanding between teaching and active learning limits their collaboration potential. There may also be tensions regarding the ownership of knowledge created through open scientific practices and whether the knowledge should be free for later use or kept proprietary. The development of a common language and conceptual understanding around these differences is essential to resolve these future tensions so that open science and active learning can flourish at the same time without conflict (Sanders et al., 2017).

An individual's open science skills and the extent to which they can be used to support active learning depends on their ability to comprehend how open science is applied in given contexts. These include a range of social, economic, and cultural factors which have been shown to influence how open science can be incorporated into existing teaching methods (Brame, 2016).

For example, it was interesting to learn that in Finland, some universities have created online repositories for data and other assets that are needed for research. This means that academics from different institutions can work together more easily by using each other's data. These repositories are a superb because of confirm that valuable data sources aren't lost because they're simply not getting used properly. Additionally, because researchers can easily access these online repositories, they're doing not got to worry about where the data is stored. Instead, they're going to be confident that their data will remain accessible and up thus far within the longer term (Zervas et al., 2019).

Besides the depositary's initiative, Chamakiotis et al., (2021) argue that Facebook and Twitter (social media) have become key tools for public engagement and digital activism, encouraging greater collaboration among both groups of stakeholders in contributing towards the event of shared knowledge. By doing so, it's possible to strengthen access to open science resources and free educational content which are vital for improving the way research is undertaken.

Concluding the results in Q1, Ayris and Ignat (2018) emphasised that there are several parts of OS which are beneficial to research and learning such as.

- Open Access to publication
- Open Source-codes
- Pre-prints in Green Open Access repositories
- Open Peer Reviews
- Collaborative Bibliograhies
- Science Blogs and, Alternative Reputation Systems.

4.2 Q2. What are the impacts and benefits of integrating Open/Citizen?

Open and citizen science have had an impact on Higher education like never. These two concepts are based on collective intelligence, participation, and collaboration. Learners of all types have a benefit in this scenario, whether it be from participating in the design or from doing the research after they graduated to make their own contribution. Collaboration by students, professors and researchers has a positive effect on their experiences, attitudes, and academic success (Kimura &Kinchy, 2016).

Participation in a research project can also be an opportunity for students to demonstrate knowledge that they may not have obtained in the classroom or gained from other forms of learning. It can also create a major source of motivation for the student if they see themselves as solving real-world problems. Participating in research before or after graduation can also help the student understand what they want out of their future jobs and careers.

Brovelli et al. (2020) impacts of open and citizen science are that it encourages students to think creatively about possible solutions to problems. The combination of creativity, collaboration, and the ability to work in teams all come together when thinking about research projects. The problem-solving aspect of the open and citizen science process will ultimately benefit any student in their career for decades to come through problem solving, critical thinking and problem-solving skills all used in their career.

These skills all play a role in how productive and happy a student will be when they are working on specific projects with their job. Open and Citizen Science increases engagement in science and engineering research by students, professors, and professionals from all educational levels.

Facilitating hands-on research opportunities for undergraduate and graduate students participating in scientific research with industry leaders or university professors is one of the easiest things a university can do to bridge the gap between the scientific community, business community and government agencies.

4.3 Q3. What are the challenges that higher education institutions face about Open science?

As noted, and elaborated by McKiernan et al. (2016) and Hand, (2018), there are several challenges with open science in higher education that need to be overcome to achieve the goal of opening science. What are challenges for higher education in relation to open science?

First, there is a lack of awareness of the advantages and importance of opening research - the idea behind this being that people don't know how much it may help them.

This is a big challenge, as researchers don't want to do time or effort-consuming activities that may not be important. To achieve the aim of opening science in higher education, the following challenges must be overcome:

So how do we improve this? To get people to see its importance, it is important that funders provide a good example. Most research funders use impact evaluation as a way of gauging the success or failure of their programmes. They may not be considering open science, but many of them are using the same metrics (e.g., a journal impact factor) that researchers do to evaluate their work. Making these tools available or having a 'transparent recognition' so that people know how to use them would help as well.

It is also important to get researchers and institutions to understand why this is important, as it may take dozens of conversations before people truly grasp the importance of it. To achieve this, platforms such as the 'Open Science Policy Platform' aim to provide a place where the importance of open science can be discussed and promoted.

A third challenge is that researchers do not always understand why sharing their data is so important. To promote open science in higher education, it should be shown that data sharing will lead to more research being published. For example, if a researcher finds a huge dataset on a government website and asks for permission to access it, they are very likely to be given access. However, the researcher may not be asking to share their data - they may simply want to make use of it. By offering free data access instead of asking for permission, it will help create a culture where it is more likely that the researchers will share their data.

There is also the challenge in the difficulty of making sure that researchers are aware when their work is open and when it is not. Researchers are not necessarily aware that in order to produce a research article in a scientific journal, their work will have to be open by default.

Citizen science is a promising way to provide opportunities for people to participate in research and contribute to the progress of knowledge. Integrating citizen science in higher education can be beneficial by improving learning, teaching and scientific collaboration; providing an opportunity for students with potential but underprivileged backgrounds; and enabling new curricula, research questions, data collection methods, etc. However, there are challenges: firstly, the lack of publishing in scientific journals poses a challenge to citizen science being integrated in higher education; secondly because it takes time and money which universities cannot spare while dealing with stringent budget constraints (Schröter et al., 2017).

Some of the challenges facing higher education ranged from a lack of awareness of the dissemination benefits and importance of research to reluctance to share data during the research process. Researchers see it as an activity that accumulates time and effort to highlight existing workloads. Lack of a transparent system of awareness and donation supports open scientific work. It changes not only on the researchers and research institutions, but also on the research sponsor side (McKiernan, et al., 2016).

Although information and communication technologies have advanced rapidly, much remains to be done to support and facilitate the workflow of researchers in a more open direction. A transparent political will is needed to commercialize open science and integrate it with government at the international level. These policies must allocate the required resources to succeed. One problem is the lack of commitment to the necessary development policies and strategic plans at the research institute and national level (Heck et al., 2020).

Universities and research institutes can have a significant impact on the speed and openness of research. A closed culture can challenge individual researchers and reduce the overall openness of research. Organizations need to develop and master certified technologies to support open science within their organizations. Another question to consider is whether each higher education institution has its own open access repository, open science and science support services and support policies.

One of the claims in favor of open science can lead to better research efficiency, better resource use and accelerated innovation in the future, but open science technology and politics. A considerable investment is required from the beginning to develop a targeted and organized ecosystem. Change of ownership, copyright, privacy protection and liability of data from open scientific research. Many of these changes are reflected in the law and research guidelines. A clear legislative framework at the international level should be developed, and researchers should keep this law in mind (Hand, 2018).

According to Allen et al., (2019) issues related to the practice of open science in higher education, such as inflexibility and limitations pose a challenge. At other levels of research, OS requires and permits other people's search results and data to be copied and used. However, this requires a generality limitation. However, a meta-analysis found that most studies, including reproducibility, did not meet the requirements and criteria of open science, even if they claimed to do so (Nuijten et al., 2016).

Discussion

OS is a relatively new area of inquiry, but research conducted shows positive results for both students and faculty who engage in it (Hand 2018). OS can affect the retention of students and increase student engagement in science. OS can also motivate students by increasing their ability to access knowledge more quickly and efficiently (Hand, 2018). OS can also lead to greater connections between academia and industry, which gives the students access to a larger industry network (Hand, 2018). These connections open doors for potential employment opportunities for the student in their future career. According to Hand (2018), collaboration is one mechanism that OS/SC have been shown to positively influence students' academic success. Collaboration in OS/SC is not only good for student learning outcomes, but it is also good for character development

Heck et al., (2020) Due to the lack of resources and incentives, some scholars have not accepted the OS. This means that some higher education institutions are active in integrating OS into their curriculum, while others are still sceptical of their implementation. The emphasis on the importance of opens science in education and provides compelling examples for its implementation at all levels of education. She explains several OS programs and projects that are already implemented at the K-12 level and various institutions.

At the college level, examples of OS programs include those involving scientific inquiry, service learning, research experiences for undergraduates (REUs), and internships. These programs are intended to help undergraduates develop a passion for science by implementing concepts such as scholarship, research, and education. Conversely, at the graduate level, OS is implemented into graduate school through integration into the curriculum or through the formation of a fully developed OS program. At the high school and undergraduate levels, OS can be implemented through formal or informal programs to ensure that students are prepared with necessary skills for future jobs in science and engineering. These formal programs can be mapped out for students to prepare them for future careers in science.

However, According to Biesenbender, Petersohn and Thiedig (2019) OS is integrated into the graduate curriculum of some universities, allowing researchers to choose between traditional and OS approaches when developing projects. Some degree programs may also be dedicated to OS. As a result, many people today are working in the area and more relevant academic research is being done.

Academics need to think about how they are conducting their research and how they deal with ethical issues. It is important to be aware of free and open-source software tools that can be used to conduct the research, collaborate with others, and create valuable publications. If learning resources such as videos and blogs are available on the Web, these should be used in conjunction with other free software tools (such as LaTeX) to ensure that there is a documented research process and that data can be transparently shared with potential collaborators after the project has come to an end (McKiernan et al., 2016).

Kimura et al. (2016) collaboration by students, professors and researchers has a positive effect on their experiences, attitudes, and academic success. A study (Kimura et al., 2016) found that there were moderate to large positive relationships between collaboration with faculty and academic success. This was true for all forms of collaboration but more so for informal collaborations such as undergraduate research, student-led projects with faculty, and student-faculty collaboration. At the graduate level, the relationship between collaboration and success is more complex. Overall, the study found that there was mixed outcomes regarding collaboration and success.

There are many reasons that students may participate in OS projects. Of these, the reasons are most commonly: Such as traditional academic motivation, career preparation, social/professional inclusion, and personal interest find that students have a strong motivation for participation in OS because of their desire to understand how biological discoveries are achieved. They may participate in OS projects to gain knowledge of how science is conducted and to get a better understanding a specific issue and hence the interest to participate in citizen science project (Kimura et al., 2016).

Although there are many reasons why students participate in OS projects, the main types of participation are: individual, team, and formal. Of these three types of participation, individual participation and team participation are more likely to be associated with academic success than formal or informal activity (Kimura et al., 2016). Individual and informal interactions lead to both social inclusion and greater motivation.

The level of collaboration used in OSCs has proven to be a key factor in academic success (Kimura et al., 2016). At the college level, some examples that raise collaboration include scientific inquiry, service learning, and research experience for undergraduates (REUs), and internships. These programs are intended to help undergraduates develop a passion for science by implementing concepts such as scholarship, research, and education.

McKiernan, et al. (2016) and Hand (2018), there are several challenges with open science in higher education that need to be overcome to achieve the goal of opening science. What are challenges for higher education in relation to open science? Demanding researchers and institute administrators have limited time to allocate to research, teaching, and administrative tasks. This leads to a gap in which students are expected to take over some of the work that they are not fully prepared for regarding data collection, data analysis workflows, methods, etc. (McKiernan et al., 2016). McKiernan et al., (2016) also noted some areas of concern regarding open science with academic research such as copyright law. Another concern is that researchers and academics are more accustomed to traditional ways of conducting research, and these challenges may be hard to overcome for both sides.

There are some benefits of OS/SC that higher education professionals could implement to increase their open science practices. (McKiernan et al., 2016) argues that increasing the amount of online resources such as blogs and articles can be a great way to boost collaboration between students and professors, which in turn increases overall learning outcomes. These online resources should be easily accessible from institution level with no restrictions or protected content access rights.

Another challenge is that researchers don't always understand why shared data is so important. To promote open science in higher education, we must show that data sharing can lead to more research publications. For example, if a researcher finds a large data set on a government website and requests access to it, they are likely to grant you access. But researchers may not ask you to share your data; they may just want to use it. By providing free access to data rather than requesting permission, you help create a culture in which researchers can share data. Researchers and administrators also face the problem of insufficient time allocated to research, teaching, and administration. However, this can be solved by allowing students to perform tasks that are not well prepared in terms of data collection, data analysis workflow, methods, etc. (McKiernan et al., 2016).

Other challenges in the practice of open science in HE, such as the lack of flexibility and the limitations found at different levels of research. It is strongly recommended to practice open science in the ES and follow the transparent scientific publishing method, even if various problems can be observed when using open-source hardware in the ES. The main objective of Open Educational Resources (REA) is to freely share and reuse educational content through digital technologies (such as Web 2.0) to contribute to the development and improvement of education. The same applies to open educational resources on scientific hardware, equipment, or facilities. OS Hardware (OSHW) is also called free hardware, which means that it is freely available and not hampered by restrictive patents or license agreements (Allen and Mehler, 2019).

To sum up the discussion, OS/SC is an important way of improving science by allowing for greater access to and sharing of data. Having a good research process is essential to producing quality results and having a transparent research process is essential for justice in science. Having a transdisciplinary vision of OS/CS allows for the integration of different types of knowledge such as citizen and student-generated data into existing research. Finally, OS/SC should be available in all areas of research - not just physical sciences as is usually a trend.

Current practice of OS/CS should be explored and supported by policies and regulations to make them viable and widespread, so long as research is conducted with a good scientific method. To support OS/CS and research, there needs to be a good open-source hardware capability that is integrated into the research process. This will allow for greater access to data and allows for documentation of the processes involved in doing research.

Conclusions

The aims of the study we mainly understanding to what extent OS and CS have been integrated in HE, what their impacts and challenges faced in HE. In answering the research question several topics were covered related to HE, their curriculum etc, were presented in SLR.

Through the results, there is some evidence to suggest that OS and CS have been integrated in someone HEIs in EU and there are some projects running besides the INOS project whose report this is based on, there is also evidence to show that there are several challenges regarding the OS/CS in HE.

It is important to note the limitations in this study as they had an impact on the outcome. Limiting the study to prior knowledge published after 2016 meant that the author was not able to include more knowledge that would have added value to the study. Besides the study being limited to a year period, the study had another limitation in geography; this meant that the study only dealt with HE in the EU. This further imposed a limitation to look at examples of similar projects outside of the union.

Therefore, in the future research of similar study, it would be more beneficial to widen the geographical study as well as expanding the prior studies in order to get more familiar and continue to expand the research knowledge already published by making use of it. Time factor also played a big role in this study as the author took into consideration the time of graduation.

Recommendation, since CS/OS are a field that involve the engagement of unprofessional people to collect data that serves the purpose of furthering scientific inquiry. They are a valuable tool, if only used correctly. To have an impact in higher education, the following must be considered: Education and outreach; Engagement; and Research opportunities.

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