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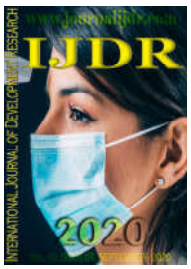

RESEARCH ARTICLE OPEN ACCESS

OBSERVATORIES: A SYSTEMATIC MAPPING OF THE LITERATURE

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ABSTRACT

In the last decades, there was an expansion in the meaning and application of observatories. These observatories started to have an important role in the knowledge society, for that reason many observatories applied in the most diverse areas of knowledge appeared. With diversity a variety of definition for the observatories appeared. The absence of a widely accepted definition for these organisms makes it difficult to identify observatories and, consequently, limits the analysis of the phenomenon. Given this scenario, this work aims to understand how the observatories have been defined and characterized by the existing literature. For this, a systematic mapping of the literature was developed, using snowballing as a method of data collection. Data were collected from 98 studies; these data were coded and grouped into twelve constructs. These constructs can contribute to the construction of a common definition for observatories.

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INTRODUCTION

For thousands of years, human beings have been observing not only this planet, but also other stars in the solar system. This way, the human eye acquired discipline and expanded to other environments than just the terrestrial, demanding the creation of a physical space where this activity could take place: the astronomical observatory. This environment of analysis, organization and storage of data and information was, for a long time, directly associated with the term "observatory" (BEUTTENMULLER, 2007). When the term observatory is mentioned, what comes to people's mind are the observatories connected to natural phenomena. However, the concept of observatory connected to nature was initially transported to a social area, and with this, a greater coverage (TRZECIAK, 2009). The business area also started to benefit with the development of the observatories, once they are responsible for the collection and dissemination of strategic information to assist in decision-making processes (TRZECIAK, 2009). As can be seen, the term has undergone a recent expansion of its meaning or of its semantic field since its original attribution to the astronomical observatories (BEUTTENMULLER, 2007).

In the last years, the term "observatory" it's found more and more in the order of the day, being addressed in his speeches by politicians, journalists and social researchers from Europe and Latin America (ALBORNOZ; HERSCHMANN, 2018). Currently, there are observatories related to the most varied themes, such as racism and xenophobia, immigration, industrial relations, technology, the environment and gender violence (ALBORNOZ; HERSCHMANN, 2018). Observatories take an important role in the knowledge society, after became instruments of support to natural phenomenon study. For Trzeciak (2009), in the context of the knowledge society, information is an important asset, subsidizing and supporting the decision-making process, becoming a critical factor in business management. In this scenario, we believe companies can benefit with the products and services of information offered by the observatories, defined as a device of observation created by one or several organisms, to follow a phenomenon evolution, domain or strategic theme, in time and space (TRZECIAK, 2009). The expansion of its meaning and use of observatories in the most varied areas of knowledge has added to the concept of observatory a relevant characteristic, typological diversity (PHÉLAN, 2007; SILVA et al., 2013;

SILVA, 2014). According to Phélan (2007) corroborated by Silva et al. (2013), there is not only one model of observatory, verifying differences in term of origin, thematic addressed, objectives (goals), methodologies, services and products, organizational structure, scope, administrative dependency, sources of financing, degree of evolution, among other points. For Albornoz and Herschmann (2018), this typological diversity of the observatories can significantly affect the work of these organisms. According to Ortega and Valle (2010), the absence of a widely accepted definition of observatory makes it difficult to identify observatories and, consequently, limits the analysis of the phenomenon. Given this scenario, this work aims to understand how the observatories have been defined and characterized by the existing literature about the theme. To achieve this goal, a systematic mapping of literature about observatories was developed. According to Petersen et al. (2008), systematic mappings are a way to categorize and synthesize existing information about a given area of interest, answering research questions. It is a secondary research method used to integrate results from several empirical studies published previously. In addition to the introductory section, this paper contemplates two more sections. In the second section, the materials and methods used in conducting this research are presented, and finally, the third and last section presents the results obtained and the final considerations of the research.

MATERIALS AND METHODS

The systematic mapping was developed following the recommendations of Kitchenham, Budgen and Brereton (2016), and it was divided into four steps: planning, selection, extraction and data analysis.

A. Planning: The objective of this mapping is based in comprehend the art state of the observatories, seeking to understand how they have been developed and characterized in the literature. To achieve this objective, it was necessary to formulate a set of research questions that were aimed to answer. According to Kitchenham, Budgen and Brereton (2016), for mapping studies, research questions are generally of a very high level. That is because the characteristics of interest in the specific topic area can be difficult to specify in advance. Thus, as the first activity of the planning step, the objective of this mapping was developed in the following main research question: how are observatories characterized in the literature?

B. Selection: After the planning step, the selection of works began. As a search method, it was decided to use the manual search based on snowballing. This step was performed following the guidelines presented by Wohlin (2014) for the use of snowballing in research in Software Engineering. For this step, three activities were planned: (1) construction of the initial list of jobs, (2) backward snowballing and (3) forward snowballing. According to Wohlin (2014), the first step that must be performed in a snowballing process is the identification of an initial set of articles. Also according to the author, a good initial set can be identified, for example, using Google Scholar. In this sense, this recommendation was followed and an exploratory research was carried out on Google Scholar with the objective of identifying articles that dealt with the theme "Observatory". This research returned 65 articles that met the following inclusion and exclusion criteria presented in Table 1.

Table 1. Inclusion and Exclusion criteria

Type	Code	Description
Inclusion	IC01	Primary and complete studies that deals with the theme of observatories
Exclusion	EC01	Editorials, tutorials, speeches, white papers, theses, dissertations, technical reports, books.
Exclusion	EC02	Articles that express personal views or opinions.
Exclusion	EC03	Documents that are not articles or complete studies, for example, presentations (PPTs), web posts, web content, quotes, pamphlets, brochures, prospectuses, newsletters or extended abstracts.
Exclusion	EC04	Articles published after 30/04/2019.
Exclusion	EC05	Article that are not about observatories.
Exclusion	EC06	Articles that are about observatories, but are clearly not related to research questions, and thus fall outside the focus of this research.
Exclusion	EC07	Second and third studies.
Exclusion	EC08	Article that are about astronomic observatories.
Exclusion	EC09	Works that are not written in English, Portuguese or Spanish.
Exclusion	EC10	Works that are not available in the web to access and download.

After the construction of the initial set, we went on to snowballing backward activity. In this activity, we use the reference lists from the initial set to identify new articles to be included. Thus, 1.556 new articles were identified. After the duplicated articles were removed, the title and abstracts were read and the inclusion and exclusion criteria was applied. After this process 22 articles remained. Next, forward snowballing which refers to the identification of new articles based on those that cite the article being examined. Thus, 869 new articles were identified. After the duplicated articles were removed, the title and abstracts were read and the inclusion and exclusion criteria was applied. After this process 32 articles remained. Backward and forward snowballing was performed; however, the initial idea would be to perform several iterations of each of the two types, until there were no new jobs included. However, the return of references and citations was high (2,425 articles including backward and forward snowballing) and, because of the time it would take for more iterations, it would not be feasible to carry out this research. For that reason, it was made just one backward and one forward iteration. The final list of included works is made up of the results of backward and forward snowballing activities plus the articles that made up the initial list of works, totaling 98 studies that advanced to the extraction step.

C. Extraction: The data extraction step was performed with the support of a form created in the Google Forms tool. The extraction was done from the full reading of all 98 studies identified in the selection stage. A complete list of the included articles are presented in Appendix A.

D. Analysis: As result of the data extraction step, we obtained a spreadsheet with all the responses collected via form. Thus, the analysis step aimed to organize this collected data, seeking to answer the research questions. Graphs of frequency distributions and tables were generated for data regarding author, year and place of publication. However, other data of a qualitative nature require a thorough reading and analysis of the details described in the form of sentences or excerpts cut from the body of the article. For this, a thematic analysis was carried out in which each answer was coded according to its content.

RESULTS AND DISCUSSION

A. Characterization of Studies: Figure 1 presents the time distribution of the analyzed studies. It is possible to notice an increasing in the number of studies published in the last decade, which may demonstrate an increase in interest in the subject. One of the exclusion criteria (EC04) used in the selection process limited the inclusion of articles published until the end of April 2019, which justifies the absence of articles published after 2018. In addition, Figure 2 shows the locations where the studies were published. The "International Conference on World Wide Web" is the place that concentrates the largest amount of studies analyzed. However, most articles are distributed among the most diverse places of publication. This demonstrates the variety of observatories applications.

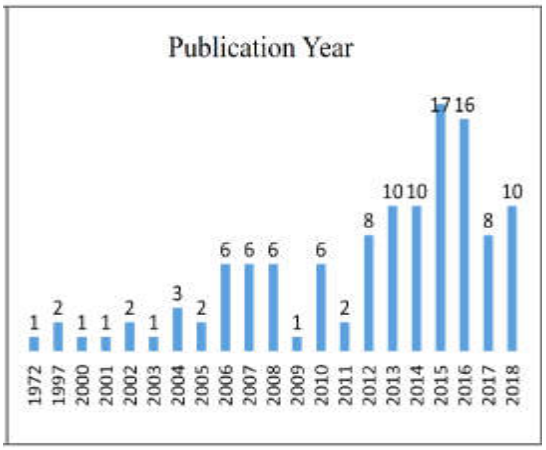

Figure 1. Year of studies publication

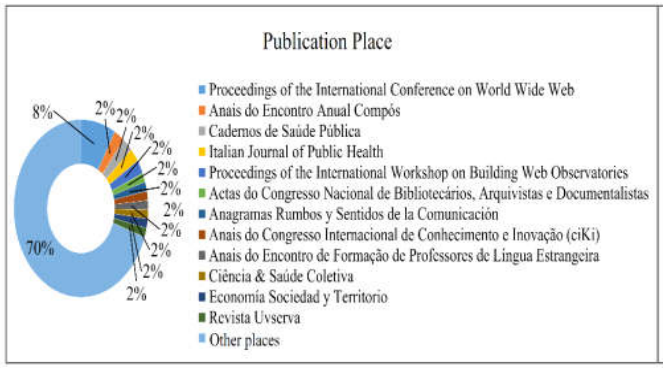

Figure 2. Place of studies publication

B. Observatories Application Areas: We can see that the studies identified present the observatories applied in the following areas: Health (P094, P120, P129, P133, P156, P187, P190, P191, P192, P194, P226, P231, P251, P256, and P258), social (P014, P025, P043, P062, P124, P153, P165, P168, P209, P227, P238, P239, and P240), Environment (P015, P063, P122, P130, P139, P155, P222, P224, P260, P261, and P263), Web (P001, P004, P011, P072, P083, P100, P101, P179, and P180), Media (P041, P052, P167, P169, P195, P196, P199, P202, P234, P235, and P237), Science & Technology (P049, P210, P211, P009, P161, P244, P017, and P035), Cities (P003, P006, P149, P197, P207 and P228), Social Medias (P019, P030,and P223), Education and Career (P069, P204, P218, P219, P220, and P073), Tourism (P002, P053, P164, and P243), Culture (P074, P145, and P257), Projects (P097, P183, and P252), Organization (P142, P254, and P079), Industry (P118 and P138) and Religion (P033).

C. Definitions, Characteristics and Objectives: During data collection and analysis, it was noticed that many studies defined observatories based on their characteristics and objectives. For that reason, in addition to the answers related to definitions, we also searched for objectives and characteristics of the observatories. After extracting the excerpts from the studies, a coding process was applied. Next, these codes were grouped in 12 themes: data, information and knowledge; analysis; monitoring and control; environment; storage; communication; study, training; search; identification and collection; sharing; and observation.

Information, Data and Knowledge: We can see that most of the definitions, objectives and characteristics identified revolved around the theme: data, information and knowledge. Within this theme, some of the studies presented the observatories as a data resource (P100), an information platform (P063), or even as a source of intelligence (P187). Studies P124 and P155 present the observatories as an information system. We found studies that deal with observatories as repositories of large amounts of data (P187, P083, P101, and P120) or as a database (P063, P260, and P243). Studies P001, P004, P011, P063, P100, P179, P187, P220, and P223 also describe observatories in this context of data storage. It is also possible to detect this theme in studies when they present the observatories as collectors or consolidators of data, information and knowledge. Many studies treat these observatories as instruments that collect (P006, P015, P019, P025, P030, P053, P069, P076, P149, P155, P156, P179, P190, P194, P204, P207, P211, P219, P228, P261, and P254), or that consolidate data, information and knowledge (P001, P025, P063, P122, P196, P204, P207, P243, P258, and P261). We also found studies that deal with observatories as instruments that analyze (P025, P072, P076, P120, P124, P149, P155, P168, P183, P194, P204, P207, P211, P226, and P254) organize (P019, P025, P052, P063, P079, P153, P190, and P224) and combine (P035 and P187) data, information and knowledge. We have also identified studies that present these observatories as producers of data, information and knowledge (P017, P025, P043, P052, P053, P063, P164, P165, P187, P204, P210, P219, P224, P243, P254, and P256). We also find this theme in the studies when they present the observatories as instruments of sharing (P002, P006, P053, P063, P072, P122, P153, P155, P179, P187, P204, P207, P223, P228, P243, and P254) and dissemination (P017, P063, P149, P187, P192, P204, P218, P219, P226, P251, and P263) of data, information and knowledge. Finally, most studies characterize data, information and knowledge in the context of observatories in public and private (P004, P011, P062, P179, and P180); historical and in real time (P179); data and metadata (P011, P179, and P180); primary and secondary (P101 and P187); homogeneous and heterogeneous (P179); stored locally and remotely (P004, P011, P124, and P179).

Analysis: A considerable amount of evidence found that dealt with definitions, characteristics and objectives was grouped under the theme Analysis. Within this theme, the studies present the observatories as an instrument of analysis (P001, P017, P025, P030, P033, P041, P052, P053, P063, P072, P076, P097, P100, P120, P124, P149, P168, P155 , P179, P187, P194, P199, P204, P207, P211, P226, P254, P252, and P263) or, as an instrument that supports analysis (P015, P168, and

P244). We also found studies that presented observatories as mechanisms to understand and reflect about a phenomenon (P001, P015, P025, P168, P196, P199, P204, P207, P209, P224, and P228), or yet as producers of critical reflection (P002, P041, P062, P063, P145, P235, P256, and P257). The observatories are also presented as a space for preparing panoramas (P017), providing early views of the future (P049), allowing the development of models (P263 and P100) and simulations (P100). In addition, the observatories make it possible to share and disseminate analysis, analytical methods and applications (P004, P011, P063, P072, P100, P179, and P223), which can also be seen as an instrument that: promotes diagnostics (P017, P052, P073, and P155); interprets and evaluates a phenomenon (P017, P025, P052, P063, P073, P155, P187, P204, P207, P218, P226, and P228); produces indicators (P052, P053, P063, P122, P124, P139, P142, P149, P153, P199, P204, P207, P211, P228, and P260); and makes it possible to perform benchmarking (P006).

Monitoring and Control: The Monitoring and Control theme was also found in most studies when we looked for definitions, characteristics and objectives of the observatories. In this sense, observatories can be understood as instruments for monitoring or monitoring a phenomenon, sector or theme (P001, P003, P009, P014, P017, P030, P041, P043, P052, P053, P062, P063, P069, P074, P094, P100, P122, P124, P153, P155, P156, P164, P187, P195, P196, P199, P202, P204, P207, P211, P118, P226, P228, P234, P235, P237, P256, P258, and P260). Observatories are also presented as instruments of control (P043, P063, P167, P207, P218, P234, P238, and P239). Still in the context of monitoring and control, observatories can be seen as mechanisms that enable: track, compare and measure the evolution of a phenomenon (P149, P202, P204, and P210); promote transparency (P017, P043, and P063); making complaints (P169 and P043); and inspect (P063, P196, P145, and P209).

Environment: We found that many studies defined, characterized and indicated the objectives of the observatories, insofar as they were presenting information about their environment. In this sense, observatories were presented as: information platforms, detection and tracking of a phenomenon (P030, P063, P199); monitoring organ (P014); control and investigation instrument (P073, P164, P199, P218, P234, and P238); space or channel for exchanging ideas and information (P224, P025, and P219); intelligence organization (P187); and a center for gathering and disseminating information and knowledge (P063, P196, P204, P207, P122, and P243). When talking about the environment it was possible to identify the observatories as being: a social instrument for monitoring and criticism exercise (P041, P063, P235, 0257); participatory management tool in the planning, monitoring and development of a sector (P063 and P074); technological platform for scientific-based studies and information sharing (P053, P072, P153, and P179); networks for exchanging experiences and technical-scientific support (P025, P063, P204, and P207); production and knowledge management centers (P025 and P204). We identified in some studies, references to observatories as open environments, online and collaborative (P100, P204, and P124), using digital platforms to carry out their work (P179 and P219). Observatories can be financed by governmental or non-governmental organizations (P187 and P196), or even belong to universities (P187). Observatories, as interdisciplinary and interinstitutional spaces (P155, P164, P199, and P204), allow democratic meetings to discuss and make decisions in a shared way (P002, P063, P074, P195, P256, and P167), using resources such as: construction of internet portals as a means of communication (P017, P033, P041, P063, and P155); creation of research groups (P063); study laboratories (P063); and discussion forums (P063, P074, and P196).

Identification and Collection: The theme Identification and Collection was also found in some studies when we sought to understand the definitions, characteristics and objectives of the observatories. Thus, observatories can collect or support the collection of data, information and knowledge (P006, P015, P019, P025, P030, P053, P063, P069, P076, P120, P149, P155, P156, P168, P179, P187, P190, P194, P204, P207, P211, P219, P228, P254, P260, and P261). In addition, according to study P076, automatized instruments can be developed to support this collection process. Observatories are also presented as platforms to identify phenomenon (P030), making possible the identification of: research demands (P049); opportunities (P049, P118, and P254); partnerships (P049); trends (P053, P161, P187, P204, P226, P244, and P254); problems and needs of a target audience (P069, P074, P197, and P207); good practices (P204 and P228); and demands and solutions (P049). The theme Storage is also very frequent in the evidence found for definitions, characteristics and observatories goals. For studies, these observatories can be seen as agglutination centers (P063, P122, P196, and P207), storage (P001, P063, P187, P220, and P223), combination (P035 and P187), consolidation and compilation (P001, P025, P063, P122, P204, P243, P261, and P258) of data, information and knowledge, or as a way of constituting the memory of a phenomenon or area (P017). The studies also associate the observatories with large repositories of data and observations (P004, P011, P015, P063, P083, P100, P101, P120, P168, P179, P187, P243, P254, and P260). Observatories provide mechanisms to explore and apply filters in these repositories (P183).

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Communication: The theme Communication was also identified in the studies when we looked for definitions, characteristics and objectives of the observatories. Studies P218 and P219 present observatories as promoters of communication between interested parties. Observatories also presented as strategies of socialization and knowledge by communication meanings (P002). According to studies P063, P204 and P243 observatories can be understood as diffusion center of information and knowledge. Observatories are also presented as mechanisms of institutional dialogue (P062). In addition, these organisms can be understood as instrument of dissemination of data, information and knowledge related to a theme, sector or area of knowledge (P015, P017, P041, P043,

P053, P063, P187, P191, P204, P207, P218, P219, P251, P260, and P263).

Community: Observatories can be seen as socio-technical artifacts (P011), which enable the creation of a network or community (P063, P195, and P260), stimulating collaboration between those involved (P100, P155, P204, P218, P219, P226, P231, and P260). In this sense, observatories contribute to these communities: providing forum and meetings for discussions (P002, P025, P049, P052, P063, P074, P164, P167, P195, P196, P199, P204, and P256); promoting interaction and dialog between the involved (P033, P049, and P073); connecting people (P063); and creating a network for exchanging experiences and identifying partnerships (P025, P049, P204, and P207). Some studies also characterize the observatories as Think Tank, formed by a group of specialists with high preparation for the development of their activities (P025, P052, and P063). Finally, observatories can be seen as a tool for social participation, including supporting the participatory management of a sector (P063, P074, and P169).

Study, Qualification and Training

Study, Qualification and Training was another theme identified in the studies to address the definitions, characteristics and observatories objective. In this sense, the observatories were presented as a space for study and training (P053, P062, P161, P164, P187, P199, P204, P207, and P260), contributing to the education of the population (P041, P063, P235, and P240) and for the training and qualification of academics, researchers and professionals (P100 and P187). Within this theme observatories make possible: make prospective studies (P009 and P254); perform training (P025, P129, P187, P199, and P204); produce guidelines (P043, P069, P122, and P187); investigate methods and mechanisms to study a phenomenon (P001 and P124); and generate references for a knowledge area (P199).

Research: Studies also present observatories as instruments, groups, spaces or research labs (P017, P025, P062, P063, P072, P076, P100, P124, P133, P149, P164, P168, P187, P199, P204, P219, P220, P228, and P243). The study P053 defines observatories as technological platforms for scientific studies. Within this theme, the observatories make it possible to: develop techniques and methods to support researchers (P001, P100, P124, P187, and P207); disseminate research results (P017, P199, P219, P149, P187, and P231); provide data and scientific evidence (P017, P149, P187, P199, P219, and P231); train researchers (P100); publish research (P204 and P251); and identify research demands (P049).

Sharing: Sharing was another theme identified when looking for definitions, characteristics and objectives of the observatories. Thus, the observatories are presented as mechanisms for sharing data, information and analysis (P006, P072, P122, P155, P204, P223, P254, and P263). The P002 study presents observatories as a strategy for socializing information and knowledge through communication. Observatories are also defined as technological platforms for sharing data, information and knowledge (P030, P053, P072, P0153, P179, and P199). Finally, some studies describe the observatories as a space, channel or network for exchanging knowledge, ideas, experiences and information (P025, P187, P204, P207, P219, P224, and P228).

Observation: Finally, Observation was the last theme that we identified in the context of definitions, characteristics and objectives. Thus, the observatories make it possible to observe themes or areas (P017, P025, P052, P063, P094, P122, P124, P138, P199, P204, P222, and P223); problems and ideas that make a phenomenon (P025 and P199); and the design, consequences and management of a phenomenon (P025). Studies P204 and P094 present observatories as a structure that allows a wide view of their surroundings. Some studies characterize observatories as instruments to support the collection, organization, storage, analysis and publication of observations (P015, P168, P194, P244, and P260). Studies P062 and P227 add that observatories can be active agents, and not just passive observers of a given phenomenon.

RESULTS AND DISCUSSION

It was possible to identify, from this study, a considerable amount of publications related to the theme "observatories". In addition, data demonstrate an increase in the interest of the scientific community about the subject specifically in the last decade. In addition, the results of this research corroborate with Albornoz and Herschmann (2018) when identifying the existence of observatories related to the most varied areas, among them: Health; Social; environment; web; media; science and technology; cities; social media; education and career; tourism; culture; projects; organization; industry; language; and religion. This variety of application areas and the lack of a single observatory model, as discussed in Phélan (2007) and Silva (2013) and confirmed in this study, led to variations in the definitions, characteristics and objectives of these organisms. The analysis of the published studies about the subject demonstrated that these definitions, characteristics and objectives are related to the following constructs: information and knowledge data; analysis; monitoring and control; environment; identification and collection; storage; Communication; community; study, training and qualification; search; sharing; observation. The results of this research also reinforce the lack of a definition of consensus in the literature for the concept of “observatories”, as pointed out in Ortega and Valle (2010). In this sense, this mapping study can contribute to the construction of a definition for these observatories, incorporating the thematic elements identified in the literature.

Conclusions

The typological variety of the observatories came up with different understandings and different definitions about these organisms. Thus, the absence of a definition for observatories can make it difficult to study and analyze this phenomenon. In this sense, this work aimed to understand how the observatories are defined and characterized by the literature. To achieve the goal defined to this work, a mapping study was executed using snowballing as data collection method. The research in literature resulted in 2,425 works related to the theme, after removed the duplicated works and applied the inclusion and exclusion criteria, 98 works left that answered to the research question defined for this study. The results obtained from this study confirm the existence of a considerable diversity of types and uses of the observatories. In addition, a variety of definitions related to observatories could also be identified. During the execution of this study, it was possible to realize that many observatories are defined by literature from its characteristics and objectives. For that

reason, in addition to the definitions this study also sought to identify characteristics and goals of the observatories. In an attempt to interpret and identify patterns in the extracted data, a coding process was applied. Next, these codes were grouped in 12 themes: data, information and knowledge; analysis; monitoring and control; environment; storage; communication; study, training; search; identification and collection; sharing; and observation. These constructs identified from the literature can contribute to the construction of a common definition for observatories. As future work, it is believed that a more in-depth study can be carried out based on the constructs identified, in an attempt to propose models that contribute to a better understanding of the observatories.

APPENDIX A

Table 1. List of papers included in the mapping

P001: Kleek, et al., 2014 - 7 billion home telescopes: observing social machines through personal data stores
P002: Meneghel&Luis, 2012 - A Comunicação e a Integração dos Atores do Turismo Regional: O Caso do Observatório de Turismo e Cultura da Serra Gaúcha (Observatur)
P003: Akerma et al., 1997 - A concepção de um projeto de observatório de qualidade de vida: relato de uma experiência realizada em Campinas - SP
P004: Tinati et al., 2015 - A Streaming Real-Time Web Observatory Architecture for Monitoring the Health of Social Machines
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