Mapping Contextual Aspects that Influence Women in Computing in Latin America

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ABSTRACT. In light of the already acknowledged underrepresentation of women in Computing, the ongoing project "Latin American Open Data for Gender Equality Policies Focusing on Leadership in STEM" aims to support the implementation of institutional policies to promote gender equality in STEM. Activity 4 of this project involves mapping the factors, actors and policies that influence the career development and leadership of women in STEM, as well as collecting and analyzing this data. To explore these factors, both a systematic mapping study and a grey literature mapping were conducted. The results encompass 8 types of contextual factors and 196 sub-factors. Some competency questions were also raised, providing valuable data for future steps.

KEYWORDS: women / policies / equality / leadership / STEM / Latin America

MAPEO DE LOS ASPECTOS CONTEXTUALES QUE INFLUYEN EN LAS MUJERES INFORMÁTICAS DE AMÉRICA LATINA

RESUMEN. Teniendo en cuenta la ya reconocida subrepresentación de las mujeres en la informática, el proyecto en curso "Datos abiertos latinoamericanos para políticas de igualdad de género centradas en el liderazgo en STEM" tiene como objetivo apoyar la mejora de las políticas institucionales para promover la igualdad de género en STEM. La actividad 4 de este proyecto se encarga de mapear los factores, actores y políticas que influyen en el desarrollo profesional y el liderazgo de las mujeres en STEM, así como de recopilar y analizar estos datos. Para explorar estos factores, se llevó a cabo tanto un estudio de mapeo sistemático como un mapeo de literatura gris. Los resultados abarcan 8 tipos de factores contextuales y 196 subfactores. También se plantearon algunas cuestiones de competencia, que proporcionaron datos valiosos para los próximos pasos.

PALABRAS CLAVE: mujeres / políticas / igualdad / liderazgo / STEM / América Latina

MAPEAMENTO DOS ASPECTOS CONTEXTUAIS QUE INFLUENCIAM AS MULHERES NA ÁREA DE INFORMÁTICA NA AMÉRICA LATINA

RESUMO. Considerando a já reconhecida sub-representação das mulheres na área de informática, o projeto em andamento "Dados abertos latino-americanos para políticas de igualdade de gênero centradas no liderança em STEM" tem como objetivo apoiar a melhoria das políticas institucionais para promover a igualdade de gênero em STEM. A atividade 4 deste projeto é responsável por mapear os fatores, atores e políticas

que influenciam o desenvolvimento profissional e a liderança das mulheres em STEM, assim como coletar e analisar esses dados. Para explorar esses fatores, foi realizado tanto um estudo de mapeamento sistemático quanto um mapeamento de literatura cinza. Os resultados abrangem 8 tipos de fatores contextuais e 196 subfatores. Algumas questões de competência também foram levantadas, fornecendo dados valiosos para os próximos passos.

PALAVRAS-CHAVE: mulheres / políticas / igualdade / liderança / STEM / América Latina

1. INTRODUCTION

Despite the growing demand for STEM skills, there is still a significant gender gap in these fields (Wang and Degol 2017), as women only represent 29% of workers with disruptive technology skills (World Economic Forum (WEF), 2020) and occupy only 30% of science positions worldwide (UNESCO, 2020). This disparity can even be observed in younger ages, with only 30% of girls choosing STEM careers (UNESCO, 2017), which indicates that there are factors that influence female choices from a very young age. Furthermore, in Latin America,, this issue is exacerbated in fields related to mathematics, where girls' performance is generally lower than boys', especially due to cultural biases and norms that continue to greatly influence female behavior (OECD, 2019).

These points are critical in understanding that the development of Women's careers in STEM over time is a continuous process that begins early in childhood and is met with access and permanence issues, both at the educational and professional levels, all the way to the top leadership positions in adulthood, as represented in Figure 1.

Figure 1

Women's careers in STEM over time

Hence, in order to meet the United Nations Sustainable Development Goal 5, which is to "Achieve gender equality and empower all women and girls.", it is essential to develop strategies that promote female inclusion in STEM. One of the difficulties is the lack of clear, recent and well-structured information that supports the creation of data-driven policies and strategies, as well as using and feeding this data in order to monitor progress in the field (García-Peñalvo, 2019).

Aware of these challenges, the ELLAS project[1] proposes creating and publishing a linked open cross-cultural data infrastructure (Hyvönen, 2020) to support research in the STEM field in a comparative and structured way. Activity 4 is part of the project's goal to research the factors that influence the inclusion and permanence of women in Computing and Engineering as well as the motivations or difficulties faced by both faculty and students in encouraging the inclusion of girls in Computing and Engineering. To this end, a systematic mapping study and a grey literature mapping have been conducted so far. This paper shows the partial results of this research.

1 https://ellas.ufmt.br

2. METHODOLOGY

To fulfill the goals of Activity 4, the methodology has so far included a Systematic Mapping Study and a Grey Literature Review in order to research the contextual factors that influence Women Leadership in Computing focusing on evidence based data, the results of which are presented in more detail below.

2.1. Systematic Mapping Study

A Systematic Mapping Study is meant to provide a general view of the main research trends regarding the state of the art in a given area (Petersen et al., 2015) and it comprises three main phases: (i) Planning, (ii) Execution, and (iii) Reporting the results (Kitchenham and Charters, 2007). As for the aim of Activity 4, a systematic mapping of the last 12 years was carried out, guided by some general goals:

1. to group and categorize primary studies
2. to identify the research methods and techniques used
3. to identify and categorize the contextual factors already researched in the literature
4. to provide a general view of the topic

In the planning phase, the Research Questions (RQ) were enunciated to support the research and data extraction process, which are shown below:

- RQ01. What contextual factors enable the inclusion and permanence of Latin American women in Technology and Engineering leadership roles?
- RQ02. What contextual factors constrain the inclusion and permanence of Latin American women in Technology and Engineering leadership roles?
- RQ03. What contextual factors observed in universities and schools enable the inclusion and permanence of Latin American women in Technology and Engineering areas?
- RQ04. What contextual factors observed in universities and schools constrain the inclusion and permanence of Latin American women in Technology and Engineering areas?

The search strategy is how studies are searched for in order to retrieve as much of the available literature as possible. The solution adopted for this work was automated search (database search), using the search string (presented on Table 1) on the chosen search engines: ACM Digital Library[2], IEEE Xplore[3], Scopus[4], and Web of Science[5].

2 http://portal.acm.org
3 https://ieeexplore.ieee.org/
4 http://www.scopus.com
5 https://clarivate.com/webofsciencegroup/solutions/web-of-science/

Table 1

Search string - Systematic Mapping

Search string - Systematic Mapping
("Wom?n" OR "Female" OR "Gender") AND ("Inclusion" OR "Diversity" OR "Permanence" OR "Leader*" OR "Retention") AND ("Influenc*" OR "Constrain*" OR "Barrier" OR "Challeng*" OR "Experienc*" OR "Enabl*" OR "Mentor*" OR "Self-efficacy" OR "Sense of belonging" OR "Factor" OR "Context*") AND ("Comput*" OR "Technolog*" OR "Engineer*" OR "Science")

The selection criteria were applied to classify the suitability of the studies in relation to the research questions. Studies considered relevant were those that met all the inclusion criteria and none of the exclusion criteria. All studies were first identified as *Unclassified* and later classified as *Accepted* or *Rejected* according to the selection criteria.

The data extracted from accepted papers was synthesized to categorize the studies and factors. In addition, some meta-data was extracted to assemble an overview of the studies, such as Title, Authors, Country, Publication Year and Source (database).

2.2. Grey Literature Mapping

A Grey Literature Mapping was additionally outlined to complement the Systematic Mapping of academic literature, with the purpose of lifting factors already identified by governments, projects, initiatives and other document sources from Latin American countries, as well as international organizations. The Mapping targets text based documents such as Reports, Papers, Research or Survey Results, Government Documents and Policy Documents. With this in mind, the planned phases for the Grey Literature Mapping were formulated as follows:

- Phase 1. International non-governmental organizations focusing on Education with digital libraries (e.g. OECD, UNESCO)
- Phase 2. International non-governmental organizations and research institutions focusing on Gender with digital libraries (e.g. UNWOMEN, Gender Data World Bank)
- Phase 3. Government, non-profit research institutions and other local organizations focusing on: Education; Technology and Gender (e.g. for Brazil: IBGE, INEP, SaferNet Brasil, CGI.br/NIC.br/CETIC.br, Gênero e Número, Meninas Digitais, PretaLab)

As for the Research Questions (RQ), the following ones were delineated:

- RQ01. What data could lead/point/map to contextual factors that enable the inclusion/permanence of women in Computing and in leadership roles?

- RQ02. What data could lead/point/map to contextual factors that constrain the inclusion/permanence of women in Computing and in leadership roles?
- RQ03. What data could lead/point/map to contextual factors observed in education that enable the inclusion/permanence of women in Computing and in leadership roles?
- RQ04. What data could lead/point/map to contextual factors observed in education that constrain the inclusion/permanence of women in Computing and in leadership roles?

The search method was defined based on the search categories by Bonato (2018) and included (1) a quick grey literature search, with the goal of locating very few select hits; (2) a search for specific information from a predefined list of organizations; (5) a search conducted to prepare for a more detailed search in the future; and (6) a search for a systematic review.

Finally, for Phase 1, the search string (Table 2) was applied to the OECD iLibrary[6] and UNESDOC[7]. The string was also adapted to be applied to Portuguese and Spanish versions.

Table 2

Search string - Grey Literature

Search string - Grey Literature
("Wom?n" OR "Female" OR "Gender") AND ("Inclusion" OR "Diversity" OR "Permanence" OR "Leader*" OR "Retention") AND ("Influenc*" OR "Constrain*" OR "Barrier" OR "Challeng*" OR "Experienc*" OR "Enabl*" OR "Mentor*" OR "Self-efficacy" OR "Sense of belonging" OR "Factor" OR "Context*") AND ("Comput*" OR "Technolog*" OR "Engineer*" OR "Science")

3. RESULTS AND DISCUSSION

The Systematic Mapping was performed in July 2022, according to the defined protocol. The search results yielded a total 259 papers, which were imported to Parsifal to carry out the study selection. Paper distribution by source is shown below:

- ACM Digital Library: 30 results
- IEEE Xplore: 31 results
- Scopus: 139 results

6 https://www.oecd-ilibrary.org/
7 https://unesdoc.unesco.org/

- Web of Science: 59 results

In the selection phase, 37 duplicated papers were eliminated and 172 papers were rejected for meeting one or more exclusion criteria after reading the abstract. The 50 remaining papers were selected for full reading, data extraction and analysis.

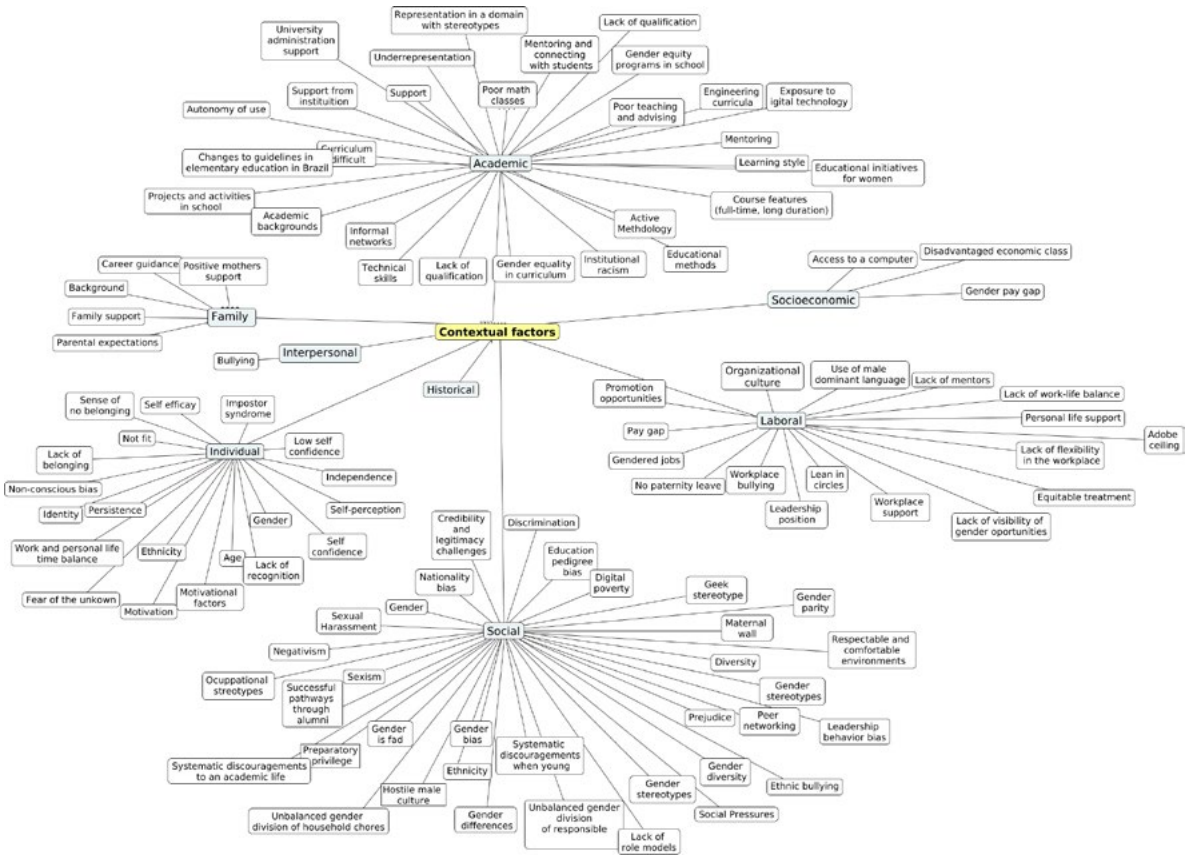
Eight (8) types of contextual factors were identified following the analysis of the papers: individual, interpersonal, academic, work-related, family-related, socioeconomic, social and historical; these factors comprise 196 sub-factors, which are laid out in Figure 2. These factors were later classified by impact type (positive or negative), to reflect whether they enable or constrain the development of women's careers in technology and/or engineering, in order to answer the research questions.

The studies also brought out some competency questions, which span topics outside contextual factors. The purpose is that these competency questions could provide useful elements for the development of the ontology. All results mentioned can be found on the following spreadsheet[8].

8 https://docs.google.com/spreadsheets/d/1Gjcn9yhO5wGVv82I18_IuXiWQLevCjrA/

Figure 2

Contextual factors and sub-factors



When analyzing the impact of each category (types of factors), the distribution of papers revealed the categories with the most papers to be Social (38 papers), Academic (25 papers), and Individual (25 papers). Moreover, the most frequent contextual factors observed were "Gender stereotypes" (10 occurrences), "Unconscious bias" (6 occurrences), "Lack of support" (4 occurrences) and "Role models" (4 occurrences). Lastly, the papers with the most identified factors are depicted below:

- Work in Progress: Addressing Barriers for Women in STEM in Mexico (Lappe et al., 2021): 20 factors
- Gender Equity in Computing (Hamilton et al., 2016): 19 factors
- A Literature Review on Challenges and Opportunities for Women in Engineering (Longe and Ouahada, 2019): 13 factors
- The influence of gender, and race/ethnicity on advancement in information technology (IT) (McGee, 2018): 11 factors
- Presence of black women in Brazilian Engineering (Santos Carvalho et al., 2018): 10 factors
- As for the Grey Literature Mapping, 120 documents were found after applying the English and Portuguese versions of the search strings, here divided by source:
- OECD Library: 101
- UNESDOC: 19

Of the 120 documents, 63 duplicates were removed, 40 of the remaining documents were discarded after reading the abstracts and 17 were accepted for full reading and analysis in relation to the research questions. However, the total number of pages retrieved exceeded 1,800, which poses a significant challenge in terms of whether it is possible to automate the task of extracting the relevant data from these documents, and if so, how.

4. CONCLUSION

This work aimed to present the partial results of Activity 4 of the ELLAS project, which focuses on understanding what contextual factors influence the development of Women's careers in STEM. The methodology described how the studies were selected and evaluated and the extracted data was then analyzed and summarized.

So far, we have been able to produce a significant number of contextual factors and competency questions, which are naturally important for the next steps, which are planned as follows:

i) Prepare and run surveys and/or individual/group interviews in schools and universities using the collected results

ii) Data analysis with coding procedures of Grounded Theory (Moghaddam, 2006)

However, there are still some limitations in this study. The systematic mapping, for instance, was conducted using only English strings. This suggests that a new search using strings in Portuguese and Spanish could potentially yield more significant results regarding the scope of local contributions in Latin American countries. Additionally, Grey Literature mapping is a critical and ongoing task, but the substantial amount of data demands a challenging amount of time and resources, something that must be addressed in order to execute the three phases proposed.

Hence, to proceed with these steps, it is essential to establish a strategy to deal with the extensive amount of data produced by the Grey Literature Mapping and then combine it with the previously modeled data from the Systematic Mapping. This will provide us with very useful information for the following phases.

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