

Sustainability in metal Additive manufacturing: A bibliographic Systematic revision of the environmental, economical and social repercussions.

Código de la comunicación (06-023)



Autores: Fco. Javier Villafranca, Pedro Villanueva, Eneko Villabona y Fernando Veiga

Universidad Publica de Navarra

1. Introduction

To review a technical topic, there are several methodologies. Among the most used are: Critical, Integrative, Meta Analysis, Narrative, Rapid, Scoping and Systematic. After revising them the proposal of this paper is a method based in the Systematic Literature review as an adequate to search for papers with technical empirical data. For that, the method will be proposed with an example of technical topic research. When investigating a subject that is completely unknown, as was this case, it is necessary to make an exploratory review. Today, there are powerful search engines on the internet to find articles of a desired topic. Google Scholar being one of the most powerful. The topic was: "metal additive manufacturing sustainability". Because the purpose was to get some knowledge of the referred topic, some of the most cited papers were selected. The quality of the magazines where the 30 selected was verified in the Scimago Journal rank, being 19 of them in Q1 and 4 in Q2. After the reading, several questions aroused: How to look for papers in an accepted way? Where to find them? How to make a review? Which type of review? Will the findings and review be valid?

2. Review methodologies

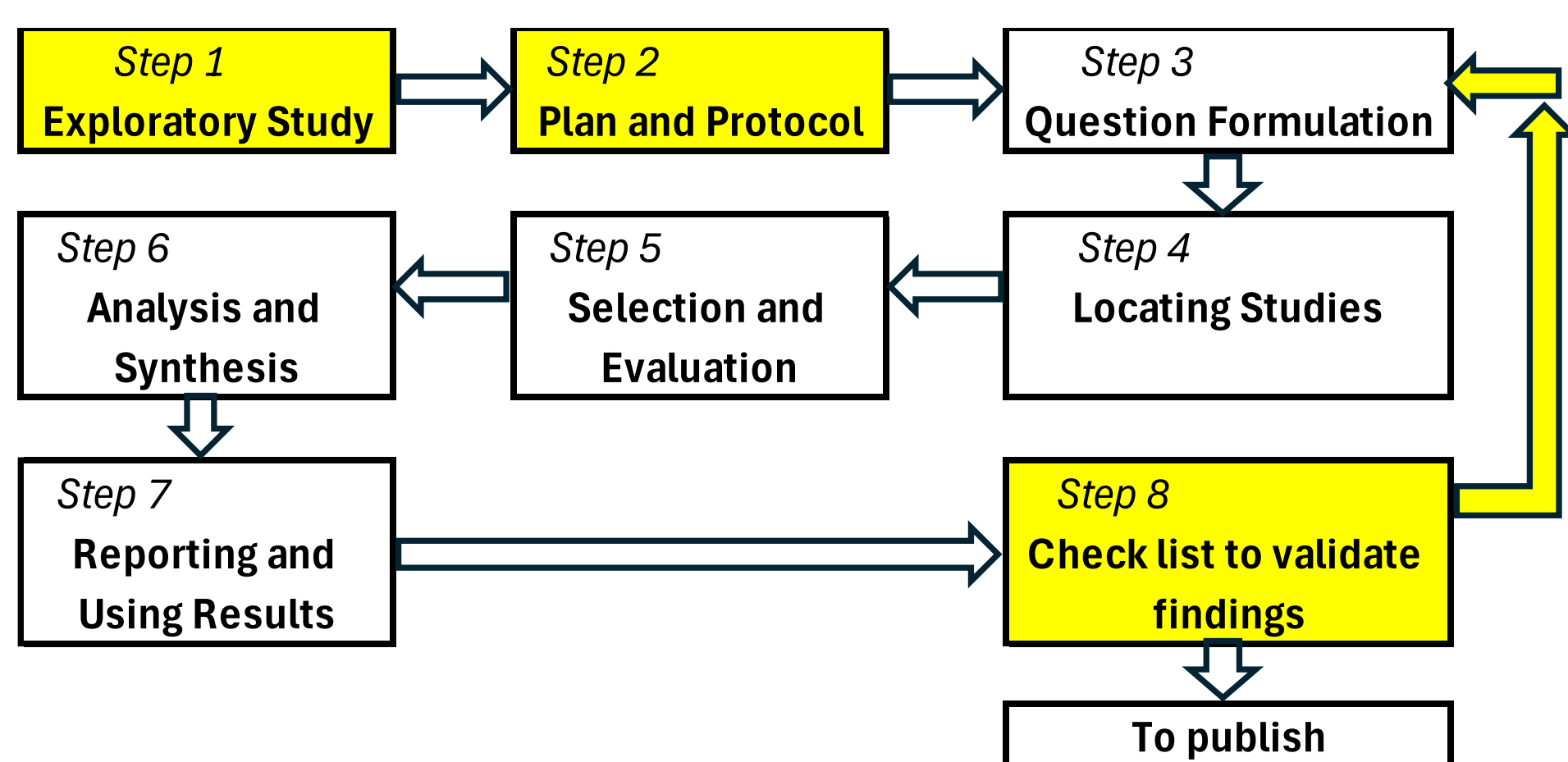
A literature review can follow different methodologies depending on the purpose of the study. The following are some of the most important methodological reviews:

- 2.1. Critical Review.
- 2.2. Integrative Review.
- 2.3. Meta analysis Review.
- 2.4. Narrative Review.
- 2.5. Rapid Review.
- 2.6. Scoping Review.
- 2.7. Systematic Literature review (SLR).

3. Systematic Literature Review: An 8 steps method.

The SLR approach was selected for the investigation used as example. The SLR review is made in 5 steps: from 3 to 7 both included. The proposed novelty of this paper consists in adding 3 additional steps: 1,2 and 8 marked in figure (1).

Figure 1: Step for the SLR with the additional 3 proposed in yellow.



3.1. Step 1. Exploratory study.

During the exploratory study, this question arose: "Are there empirical data demonstrating that metal Additive Manufacturing is more sustainable than metal Conventional Manufacturing?"

3.2. Step 2. Review Plan and Protocol.

Then a protocol is written which include the following subjects: Objective, Definition of the conceptual limits, Establish the search strategy, Establish an Inclusion / Exclusion criteria.

3.3. Step 3. Question Formulation.

The question formulated in PICOS is: "According to evidence from experimental studies, do metal Additive Manufacturing (mAM) technologies demonstrate greater sustainability than Conventional Manufacturing (CM) technologies, considering economic, environmental, and social indicators?"

3.4. Step 4. Locating studies.

To make the searching, three strategies are done: find keywords, joined by Boolean operators, and to group the concepts in several sets, in this case: Sustainability, metal Additive Manufacturing and Conventional Manufacturing, and the result is the intersection of them, as shown in Figure 2

Figure 2: The 3 search groups with the findings in red.

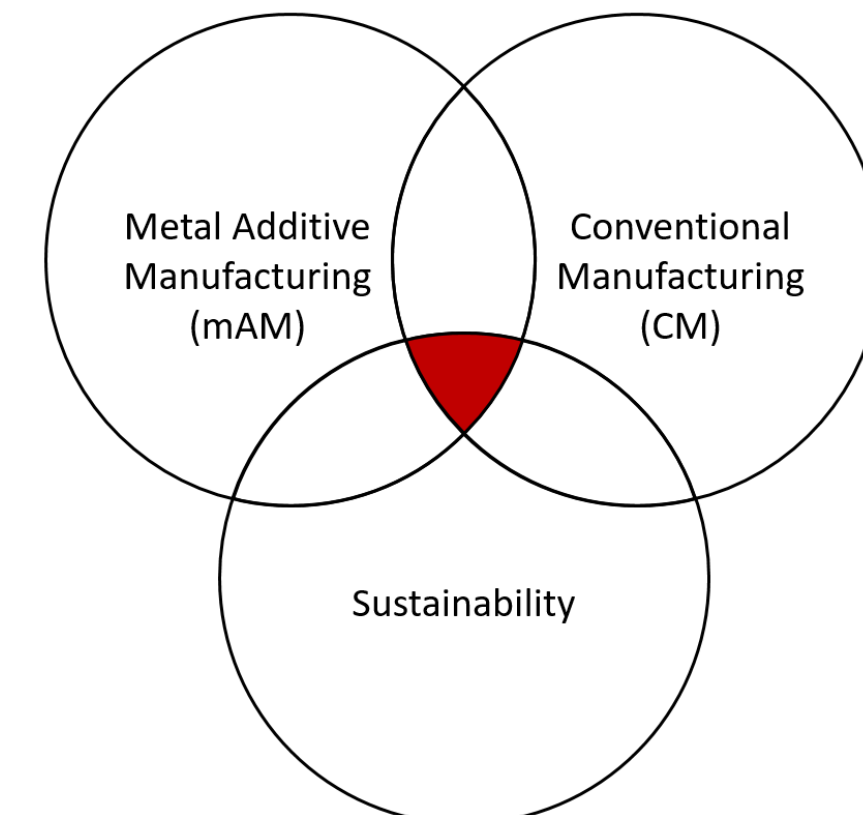
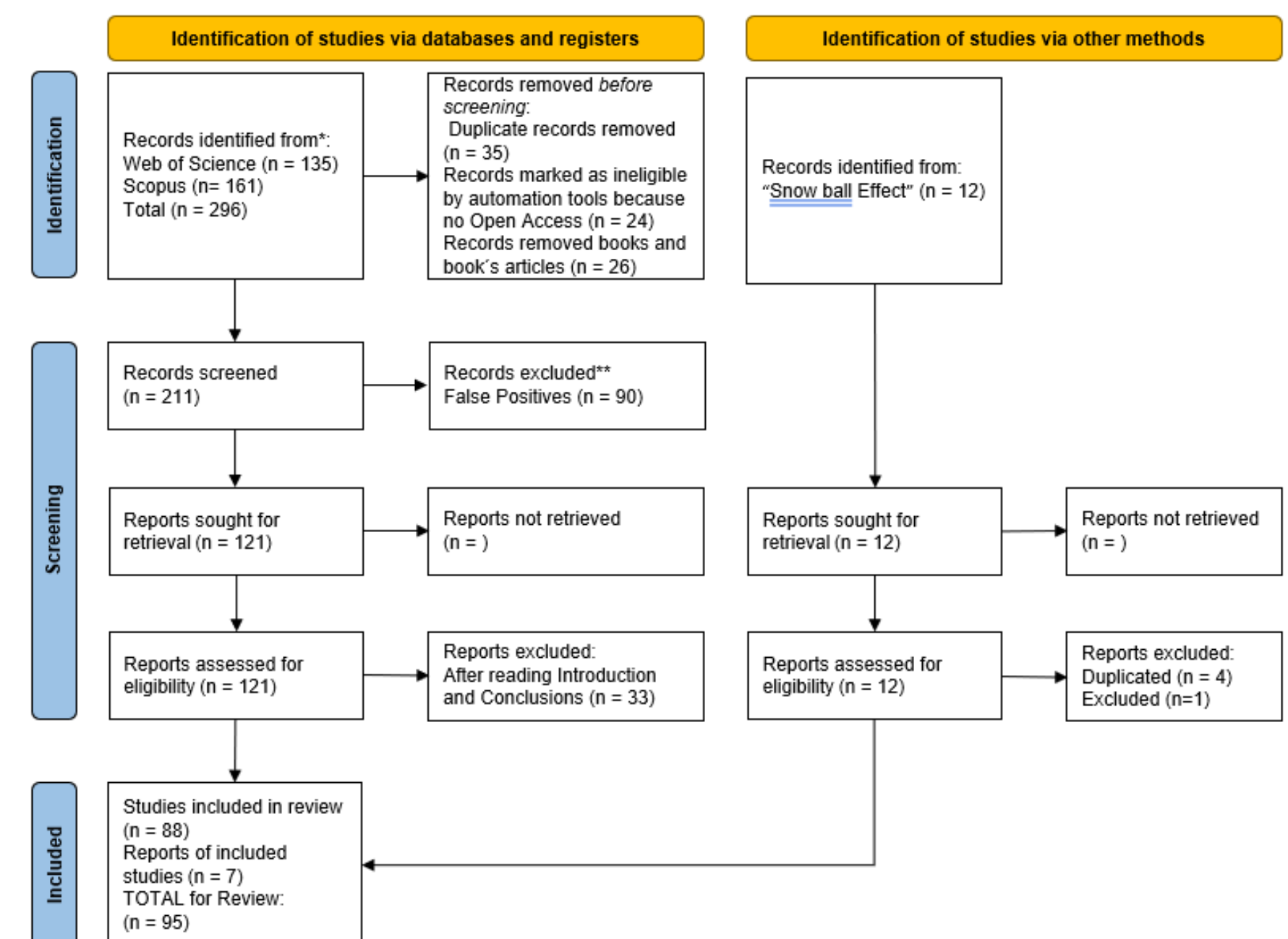


Figure 3: Prisma Flow Diagram for the SLR.



3.5. Step 5. Selection and Evaluation.

To help in the management of all papers obtained in the data bases, it was used the Bibliographic Reference Manager Zotero. Now the following stages are performed:

- a) To eliminate Duplicated.
 - b) To Exclude books and not open access papers
 - c) To exclude "False positives".
 - d) Exclusion after Introduction and Conclusions.
 - e) To include "False negatives" identified via other methods
- In the following chart is the summary of the process, according to PRISMA 2020 flow diagram for new systematic reviews:

3.6. Step 6. Analysis and synthesis.

Then it will be examined the contents with the aim to identify main topics, research lines and gaps. After the analysis, authors will look for analogies of results and discrepancies to make a Synthesis.

3.7. Step 7. Reporting and using the results.

Classification of the papers analysed according to the three Main Topics, Research Lines and Research Sublines identified. All Research Lines and Research Subline. Gaps identified and future research lines: making suggestion of future line of works.

3.8. Step 8. Check list to validate the findings.

A check list will be used to help to discover if the Review has been well performed.

4. Conclusions

A review methodology was proposed for this technical investigation based on Systematic Literature review. It is considered the most appropriated method due mainly for 2 important characteristics: Replicable (following all the process any investigator should get the same results of the review) and Exclusive (the studies are selected based on relevance for inclusion and assessed by "Peer review"). To the 5 steps method of the SLR it was added 3 more that authors are convinced it will improve it. These are steps 1,2 and 8. Additionally, to incorporated steps, it was adopted a criterion to add papers to the findings. This is the so called "snowball effect" adding the papers that appeared in the bibliography of 20 % of the authors of the search.