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Agnostic Extended Reality Development Strategies and Policies: A Systematic Literature Review

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Abstract
This paper addresses the challenges of finding suitable literature. The objective of this study is to identify and evaluate agnostic Extended Reality (XR) development strategies to compare with the reference strategy. The research methodology used in this study is the PRISMA systematic literature review from four academic databases, two search platforms, ten non-indexed journals, and eight XR websites from 2019 to 2023. This research creates a systematic exclusion structure that researchers and stakeholders can adopt to identify potential XR development strategies or policies. The quantified breakdown of excluded and included literature from various sources and search strategies can guide future research work. This paper recommends removing data limitations, increasing literature sources, utilising non-academic search engines and Artificial Intelligence Large Language Models (AI LLMs), and implementing real-time alerts for new publications. It emphasises the need for more publications on clearly defined agnostic XR development strategies and policies. This paper demonstrates the value of reporting and publishing PRISMA studies that contain one or fewer records in the inclusion dataset.

Contents

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1. Introduction

Since the COVID-19 pandemic occurred, there have been numerous published articles in the literature about developing Extended Reality (XR) applications for various industry sectors and personal uses. There appears to be a lack of a clearly defined single, unified agnostic XR development strategy and policy framework for creators to adopt.

As such, in searching for a suitable framework the creator must examine and evaluate too many sources of information, many of which may not apply to their purpose. This makes it difficult to encourage and accelerate XR development to improve a geographic region's innovation, competitiveness and sustainability (Rameshwar and King, 2020, 2022).

XR references the range of technologies and applications that utilise computer-generated imagery (CGI) to create partial or full immersive experiences for the user. These systems comprise virtual reality (VR), augmented reality (AR), and mixed reality (MR) (Matthews et al., 2021; Rauschnabel et al., 2022; Vasarainen et al., 2021). The technology utilises the artificial creation of light, sound, touch, taste, or scent to either produce a new reality, as in VR, enhance the real world, as in AR, or enable the combination of both as in MR (Rameshwar and King, 2023a).

The objective of this research is to identify and evaluate other XR development strategies to compare with the reference strategy. The authors created the reference strategy from the analysis of the primary data (Rameshwar and King, 2023a) and not from secondary sources about XR development strategies. The 2021 Caribbean XR survey data provided the authors with the ability to understand and assess regional creators' XR development during the COVID-19 pandemic. Thus, this work aims to identify the existence of any similar agnostic XR development strategies within the literature.

This study addresses the following research questions:

RQ#1: Since the start of Covid-19 are there English-language, publicly accessible online, clearly defined agnostic strategies that encourage and accelerate XR development for use within multiple industry sectors to improve innovation, competitiveness and sustainability of a geographic region?

RQ#2: Since the start of Covid-19 are there publicly accessible English-language, publicly accessible online, clearly defined agnostic policies that encourage and accelerate XR development for use within multiple industry sectors to improve innovation, competitiveness and sustainability of a geographic region?

This paper answers the research questions in the following five sections. The next section is the literature review that outlines the PRISMA structure and highlights its use in I4.0 and XR research. The methodology is the third section. It outlines the two search strategies used to identify suitable literature as well as the processes used to capture and evaluate the material for relevance to the research questions.

The fourth section contains the findings of this study. It highlights the outcome of each search strategy using the PRISMA process, clarifies the exclusions performed by each search strategy, the possible impact on the eligible data, and itemises the factors affecting and limiting the study. The conclusion summarises the paper's value by clearly stating the eligible document, answering the research questions, addressing the issue of treating the paper as an empty review, and providing recommendations for future research based on the work and lessons identified in this paper.

The main objective of this study is to answer the two research questions. Additionally, this paper adds value in the following ways. It demonstrates the use of two distinct search strategies using the PRISMA format. One uses a title keyword search and the other uses co-occurrence keyword phrases in the search. This work demonstrates the importance of publishing reviews that are empty or only have one record in the inclusion set as it provides insight into the methodology and criteria used by the researcher.

This work uses a systematic exclusion structure that others can adopt to reduce the size of their dataset. However, it highlights the need to remove search limitations to expand the quantity of literature to review. This research process identified existing literature that can contribute to the development of a partial strategy for XR development. As such, it brings attention to the need for English-language clearly defined agnostic strategies or policies that can encourage and accelerate XR development. Consequentially, it supports the need for assessing stakeholders' insights and perspectives on factors that encourage and accelerate XR development.

2. Literature Review

It is important to note that there continues to be ambiguity in clearly delineating segments along the immersive experience spectrum (Rameshwar and King, 2023a). Hence, it becomes increasingly complex to have a separate development strategy for each type of immersive experience (Tynes and Seo, 2019). This highlights the benefit of the phrase "agnostic XR development" that covers the current and future nomenclatures within the spectrum. The phrase refers to varying types of XR and the openness to apply to any use case. This concept promotes flexibility and in-

teroperability allowing a developer to create any type of immersive experience using a common set of principles.

This goal is to encourage and accelerate XR development. Thus, the strategy focuses on the general method to achieve the goal and the policy outlines the specific decision-based actions needed to accomplish the goal (Rameshwar and King, 2023b). Within this approach, the strategy is a higher-level summary of the policy, thus the latter provides actionable events, including what not to do.

2.1 Agnostic XR development strategies

The reference XR development strategy's factors of influence, design foci (user, task, and location), industry sectors, financial strategy, UX strategy, and I4.0 strategy affect the selection of the appropriate technology (Rameshwar and King, 2023a). Therefore, the focus on technology emerges naturally from the strategic process. For instance, the choice between AR, VR, or MR depends on the user, task requirements, and location constraints. This influences the choice of hardware (e.g., headsets, smartphones, and smart glasses) and software (e.g., game engines, SDKs) which become an output of the strategy as the developer clarifies the specific details.

A universally accepted XR development strategy should be agnostic to user, task, location, industry, and geography. Thus, it should be adaptable to a variety of factors and provide explanations to enable customisations. It should guide the development from a concept idea to a functional proof of concept. For example, an XR development strategy for education focuses on creating engaging learning experiences such as providing interactive historical events for students to appreciate the significance of the events. Whereas a strategy for healthcare prioritises patient safety and data privacy to protect confidential personal data exchanged between the patient and the medical professional. The agnostic nature allows the same strategy for both the education and the medical purposes.

The agnostic XR development strategy should guide any developer to understand the overall direction of the project. This would encompass a wide range of areas such as defining the target audience, setting the project timeline, allocating resources, and determining key performance indicators. The XR development codebook itemises these elements to guide the various stages of the project such as conceptualisation, implementation, project tracking, and finally analysis and comparison to drive optimisation in future XR projects (Rameshwar and King, 2023b). One can clearly identify an agnostic XR development strategy by using the XR development codebook to determine if the strategy addresses all of the elements without focusing on a specific XR type.

The purpose of an agnostic XR development strategy is to provide a universally applicable template that anyone can understand and use in a variety of contexts to create a unique and customised immersive experience bounded by specific user requirements.

2.2 Agnostic XR development policies

In this context, the agnostic XR development policy provides clarity. It helps the developer understand the 'why'. This aids in identifying the specifics of 'who', 'what', 'when', 'where', and 'how' to develop the PoC. In this way, the policy is an extension of the strategy (Rameshwar and King, 2023b). It is important to understand that the agnostic XR development policy should align with each parameter of the agnostic XR development strategy. There should be a close coupling between the two. As such, an agnostic XR development policy should not exist without an agnostic XR development strategy. The policy contains the rules and guidelines that govern the implementation of the strategy. It defines the realistic limits or boundaries of the parameters to allow someone to achieve the goal of encouraging and accelerating XR development.

The intent is to encourage and accelerate XR development to increase the competitive advantage of a region's metaverse development (Rameshwar and King, 2022, 2023a). These decision-based actions should increase the number of projects and the number of developers as well as reduce the development time (Rameshwar and King, 2023b) to form an agnostic XR development policy within this context. It should define a specific course of action based upon a decision linked to the strategy and thus the codebook elements.

In essence, an agnostic XR development policy serves as a detailed guide that complements the agnostic XR development strategy, providing specific decisions and their associated actions that align with the broader strategic goals.

2.3 Sources lacking an agnostic XR development strategy or policy

The following examples demonstrate literature without a clearly defined agnostic XR development strategy or policy. Some identified specific components present in the reference strategy (Rameshwar and King, 2023a). The identified codes demonstrate the potential for components of a strategy. However, they require additional information and only provide a general overview of the category as defined in the codebook (Rameshwar and King, 2023b). In other words, the codes are not reflective of applying the codebook's inclusion and exclusion criteria.

- "The reality of social studies Teachers Awareness regarding the notion of augmented reality technology and the strategy of its usage in teaching to develop geographical phenomena from the social stud-

ies teachers perspectives" (Alsanea and Alawaidi, 2021). This research focuses on the use of augmented reality technology to teach geographic phenomena from the perspective of social studies teachers in the Al-qunfudhah province (in Saudi Arabia). The authors stress the importance of using augmented reality technology in the classroom, creating computer-assisted educational programs based on augmented reality technology, and working to overcome barriers limiting the use of augmented reality. However, there is no specific mention of the XR development strategy and the development is specific to AR, the education sector, and Saudi Arabia. Thus, the potential codes are DFUS, DFPU, IEDU, and G682.

- "Developing augmented reality in mathematics learning: The challenges and strategies" (Ikhsan et al., 2019). This paper focuses on the challenges and strategies used by math teachers when developing AR-enabled learning media. While it does not provide specific XR development strategies, it describes the following strategies teachers use to address the challenges of developing AR-enabled learning media, such as gradually upgrading your laptop, finding sources in foreign languages, and trying to form a collaborative learning community. It identifies strategies as providing hardware and software, training, and community support to overcome challenges that Indonesian teachers experience in AR development. Therefore, it is specific to AR, the education sector, and Indonesia. Although it is not agnostic, these strategies will help in the development of XR applications in other educational contexts. Thus, the potential codes are IEDU, ENST, ENFU, ENSO, ENTD, and G360.

- "Design, Development, and Validation of an Augmented Reality-Enabled Production Strategy Process" (Nassereddine, 2019; Nassereddine et al., 2022). The authors do not explicitly mention a development strategy for XR and the development identified is not agnostic. It explores the potential of AR in the construction industry and the need for construction companies to adopt new technologies to remain competitive and grow in the industry. The research goal is the roadmap for the design and development of a new AR-Enabled Production Strategy Process (AR-PSP). It uses assessments with subject matter experts and users selected 25 (out of 58) requirements as well as describing their experiences for the application. Although there is no mention of a specific XR development strategy, the authors discuss the potential of AR and its integration into the design process. The authors' information can assist in making decisions. However, it is specific to the development of an AR application in the construction industry and not a clearly defined agnostic XR development policy. Thus, the potential codes are DFUS, DFPU, DFLO, STUX, ICON, STYE, POYE, STME, and POME.

- "Building the "Complete Game": An Overview Study of a Development Strategy for Geo AR Mobile Games" (Liu, 2022). The author identifies the key components of a successful AR game as having a game engine, geolocation, monetisation, notifications, responsive user experience, and most importantly being fun to engage. The selection of specific parameters within each component is dependent on an understanding of the user and the tasks performed using the game. It is a useful development strategy specific to AR and the arts, entertainment, and recreation sector. The potential codes are DFPU, DFLO, STFI, IAER, ENSO, ACSO, STYE, and STME.

- "The effectiveness of virtual environments in developing collaborative strategies between industrial robots and humans" (Oyekan et al., 2019). This work focuses on the specific case of VR in manufacturing to provide a test environment that trains workers before allowing them to use real equipment. The authors highlight the functionality of the system as creating a realistic version of the physical world in a 1-to-1mapping. This enabled persons to move freely within the 3D space and experience the effect of the virtualised real-world elements. The potential codes are DFPU and IMAN.

- "A Development Study of Instructional Design Strategies for Metaverse Based on Goal-Directed Design Methodology" (Lee and Im, 2022). In this work, the focus is on the educational sector to improve the learning objectives when engaged within the metaverse as a classroom environment. The authors used a systematic literature review and validation from experts in the field to develop the metaverse instructional design strategy. This consisted of seven design strategies to form 31 instructional guidelines. The potential codes are DFPU, IEDU, STME, and POME.

Highlighting the codebook codes in the authors' papers provides valuable insight into their types of XR development. Each of the author's research provides information to build an agnostic XR development strategy that may be similar to the reference case (Rameshwar and King, 2023a).

Similarly, the examples of XR-focused websites highlighted below did not present a clearly defined agnostic XR development strategy or policy. As a whole, each of the XR-focused websites contribute elements that can form an agnostic XR development strategy. For example, Meta (Meta, 2023) and EON Reality (EON Reality, 2023) provide clarity and guidance in creating applications specific to

their software and technology platforms. They also provide financial information in the form of identifying how to monetise the application and providing resources to apply for funding the development.

The XR Association (The XR Association, 2023), European Association for Extended Reality (EuroXR Association, 2023), The VR/AR Association (The VR/AR Association, 2023), and The Metaverse Standards Forum (The Khronos Group, 2023) do not advocate a specific type of technology or immersive experience and thus embraces any type within the immersive spectrum. The XR Association developer guides provide clarity on how to design for the users and their experiences using specific industry sectors such as the education sector (XR Association, 2018, 2019, 2020, 2022). Whereas the VR/AR Association's resources section itemises information into areas such as specific software platforms and publications containing various geographic areas and industry sectors.

However, the International Virtual Reality Professionals Association (IVRPA, 2023) and Augmented Reality for Enterprise Alliance (Object Management Group, 2023) narrow their focus. The former provides information on other immersive experiences such as 360°Panoramas, 360°Video, 360°Virtual Tours, and Gigapixel Panoramas that are part of the XR content development ecosystem. Similarly, AREA focuses on AR and addresses the issue of financing, increasing the number of developers, and use of no-code and low-code applications.

Within this selection, no single source addresses all the codebook codes to form a clearly defined agnostic XR development strategy or policy. However, they demonstrate that their combined information can develop an agnostic XR development strategy.

The examples highlight the potential for the following codebook codes: design foci (DFUS, DFPU, DFLO), UX strategy (STUX), financial strategy (STFI), industry foci (such as IEDU (education), ICON (construction), IAER (entertainment), IMAN (manufacturing), (various industry sectors) IXXX), geographic areas of the study (such as G682 (Saudi Arabia), G360 (Indonesia), and (multiple geographies) GXXX), encourage XR development (ENFU, ENSO, ENTD, ENST), accelerate XR development (ACSO) and strategy and policy-focused (STYE, POYE, STME, POME).

These examples highlight a general lack of focus on the adoption of the full I4.0 strategy (STI4) that enables real-time customisation to suit any persona. However, both AREA and The Metaverse Standards Forum emphasise interoperability. This concept highlights the potential need for including the Industry 4.0 strategy.

2.4 PRISMA Systematic Literature Review

Published research needs to be transparent and reproducible to enable other researchers to understand the process, replicate the findings, and validate the work performed (Diaba-Nuhoho and Amponsah-Offeh, 2021; Iqbal et al., 2016). This ability stems from the format used to represent the methodological approach and results. One way of achieving this is to adopt the format known as the "Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)" which started in 2009 (Page et al., 2021). It emphasises the clarity of answers to questions such as why the researcher performed the study. What steps did the researcher take? What are the results?

The PRISMA statement contains a variety of extensions that address a particular focus of research. The following examples outline these differences. The Equity extension (PRISMA-E 2012) focuses on health equity and social determinants of health (Welch et al., 2012). The PRISMA-P 2015 extension focuses on protocols and outlines the planning and methodology of the intended systematic review (Moher et al., 2015). The PRISMA-S extension solves the problem of inadequate reporting of literature searches (Rethlefsen et al., 2021).

Although the basic PRISMA flowchart format is simple and understandable, there are issues regarding poor and low-quality diagrams. This resulted in the development of a "free-to-use, Open Source R package and web-based Shiny app to allow users to design PRISMA flow diagrams for their systematic reviews" (Haddaway et al., 2022). Regardless of the specific PRISMA format, the important criteria include providing information that explains the different phases of the research process. These phases include the identification of literature, the deduplication and screening of the documents, the assessment of eligibility, and the final dataset of included material. The following section outlines the specific methodology used in this work.

It is essential to understand that a PRISMA study can result in no applicable results in the inclusion list. The term given to this condition is an empty review. However, an empty review contributes value to the research process. It provides information about a researcher's interest in the subject, highlights existing research gaps for future research questions, outlines the type of evidence reviewed, and the methods used to identify the information (Montgomery, 2017).

Empty reviews exist and are part of academic investigations, as illustrated in the 2010 study of empty reviews in the Cochrane Database of Systematic Reviews (Yaffe et al., 2012). It is critical to indicate the value of research with an empty review to avoid the label of 'incomplete' and considered a waste of time (Créquit et al., 2016; Gray, 2021). One approach to alleviate this problem is to adopt a

continuous system as data consistently evolve to provide a "living systematic review" (Elliott et al., 2014).

As this study focuses on XR, which is an enabling technology of I4.0 (Rameshwar and King, 2022), the following eight examples illustrate the authors' use of the PRISMA format in the search for literature on topics relating to I4.0 and XR. These are not exhaustive and merely serve as an illustrative point in the use of the PRISMA format.

- The review of the state of the art of I4.0 (Liao et al., 2017).
- The I4.0 impact on innovative organisations (Mustapha et al., 2023)
- The I4.0 readiness models and their dimensions (Hizam-Hanafiah et al., 2020).
- The I4.0 relationship with supply chain sustainability (Naseem and Yang, 2021)
- The use of Extended Reality in nutrition education and behaviour change (McGuirt et al., 2020).
- The use of AR, MR, and VR HMDs (head-mounted devices) in medical education for low- and middle-income countries (Barteit et al., 2021).
- The influx of Extended Reality technologies in workplace environments (Vasarainen et al., 2021).
- The application of VR and AR technologies in the movement-focused rehabilitation of musculoskeletal disorders (Kiani et al., 2023).

3. Materials and Methods

The literature sourced for evaluation follows the archival research strategy using the PRISMA format for systematic literature review (Page et al., 2021). It is a structured approach for systematically collecting, analysing and synthesising relevant literature. The search strategy outlines how the researcher identified the data. This includes the selection of keywords, inclusion and exclusion criteria to define the dataset, and the sources used to curate the literature.

There are two search strategies performed. The first is to examine an article's title for the presence of a specific set of keywords. The second is to determine the existence of a co-occurrence keyword phrase anywhere in an article. The similarity between the two strategies is that they each use a predetermined set of words defined by the research question.

The title-focused method restricts the search to the article's title but the keywords' order placement is not important. In other words, it does not matter where the keywords appear in the title once they all exist. However, this is different in the search for a co-occurrence keyword phrase. The specific order of keywords is critical. This search returns a positive result only if the words are in the correct placement. The use of quotation marks in the search ensures it only looks for a particular phrase.

3.1 Keywords

The research questions focus on the phrase XR development strategy or policy. The inclusion of the term 'roadmap' as one of the keywords is due to its association with strategy and policy development (Ghobakhloo et al., 2023; Phaal et al., 2004, 2009).

Although XR is the collective term for VR, AR, and MR (Rauschnabel et al., 2022; Vasarainen et al., 2021), searching only for XR excludes papers whose titles do not have XR but focus on VR. Therefore, this search includes additional related terms that have a strong association with XR. These are VR, AR, MR, metaverse, and immersive as they each refer to experiences in the virtual domain (Park and Kim, 2022; Rameshwar and King, 2022, 2023a). Table 1 lists the variations of the keywords used in the literature searches.

The bracketed words indicate what the keyword fully represents. Some authors may not use the full phrase 'virtual reality' in the title although the paper contains information about virtual reality. An example is the paper "The effectiveness of virtual environments in developing collaborative strategies between industrial robots and humans" (Oyekan et al., 2019). Thus, to capture these types of titles in the search query, the researcher removed the word 'reality' from phrases such as virtual reality or augmented reality.

3.2 Inclusion criteria

The following points summarise the inclusion criteria that identify this dataset.

- Literature published from 01-01-2019
- Literature published in the English language
- Literature with titles containing variations of the words XR, development, strategy, policy, and roadmap for the title-focused search strategy
- Literature containing the exact quote phrase of keywords for the co-occurrence strategy
- Literature focused on clearly defined agnostic XR development strategies or policies

The use of the specific start date of 1-1-2019 provides the ability to identify changes in patterns of published XR development strategies before and during the pandemic. Expanding the start search date further, (such as in 2018 or 2017) increases the scope of the study, whereas the interest is in determining any effective change due to the pivot

Table 1. Keyword Variations for Literature Search

Keyword 1	Keyword 2	Keyword 3A	Keyword 3B	Keyword 3C
Virtual (Virtual Reality)	Development	Strategy	Policy	Roadmap
VR (Virtual Reality)	Develop	Strategic	Policies	Roadmaps
Augmented (Augmented Reality)	Developed	Strategies	Policymaking	
AR (Augmented Reality)	Developing		Policymaker	
Mixed (Mixed Reality)			Policymakers	
MR (Mixed Reality)				
Extended (Extended Reality)				
XR (Extended Reality)				
Metaverse				
Immersive				
Immersion				

point of COVID-19 and not other disturbances in previous years.

The focus on literature published only in the English language is due to the researcher's inability to effectively understand or accurately translate foreign languages. The latter is due to the costs of translation services and the time required to validate the accuracy of free translation resources.

Although the inclusion criteria are clear and specific, there is a need to evaluate the dataset to remove unwanted data that is outside of the research scope. The following section specifies the exclusion criteria used in this process.

3.3 Exclusion criteria

The process provides an efficient and effective method of systematically reducing the size of the data based on the following conditions:

- Literature published before 2019
- Non-English-language literature
- Duplicated literature
- Titles of literature that do not contain the search keywords in the title-focused search strategy
- Literature not containing any of the quoted phrases in the co-occurrence strategy
- Titles of literature that do not clearly reference the XR domain for the title-focused strategy
- Literature that does not focus on clearly defined agnostic XR development strategies or policies
- Inaccessible abstracts and full texts of records whose titles satisfy the search criteria

E0 refers to the removal of records published before 2019. E1 applies to literature not published in the English language. Within a set of duplications, a randomly selected duplicate becomes a unique record by applying labels to the other documents. Thus, one item becomes an original. The E2-0 tag applies to duplicates occurring in the same database and search focus (such as Google Scholar and Strategy). The E2-1 tag identifies duplicates in the same database. The E2-2 tag applies to the remaining duplicates in the dataset.

The search produced some results that did not match the search keywords or date range. These false positive results may be due to the database's search function and date limiter. These records received the respective labels E3-1 and E3-3. However, some documents did not have any clear reference to the XR domain although their titles matched the search criteria. These documents received the label E3-2.

The records received the following labels based on the researcher's ability to access information. This process highlights the difficulty in accurately identifying ineligible records.

- E4-1: Abstracts or full paper with no clear reference to XR
- E4-2: Only a partial abstract is available on a search platform or database and unable to access the full paper
- E4-3: Only a partial abstract is available on a search platform or database and not in English on the linked page
- E4-4: Available abstract is not in English
- E4-5: Neither abstract nor full paper available
- E4-6: No abstract is available on the search platform or database and the full paper does not focus on XR
- E4-7: Neither information on the search platform or database, nor the linked page is in English

The application of the exclusion label E5-1 depends upon the absence of a clearly defined agnostic XR development strategy or policy. There is a clear distinction between the steps of a task to create a specific type of XR application and a general structure to develop any type of XR application. However, an XR development strategy provides the framework to create any type of product.

Accepted literature should include more than the identification of the intended user and the specific task or a detailed breakdown of the steps to create the application. This only satisfies one type of XR development. It is not a strategy for developing any XR project. There must be a clear identification and justification of goals that encompass each element of building any XR application to meet the needs of a specific economic activity area or industry sector, using the parameters of user, purpose, and location, and considering the independent strategies of industry 4.0 (I4.0), user experience (UX), and financial (Rameshwar and King, 2023a).

The following points extracted from the reference strategy (Rameshwar and King, 2023a) provide a guide for an acceptable clearly defined agnostic XR development strategy. Thus, an eligible paper should:

- Identify the factors of influence that contribute to the success of XR projects and discuss the development process.
- Guide on customising XR projects to align with the requirements of specific industry sectors.
- Clarify that the design foci are a combination of user, purpose, and location and outline how to achieve customisation through the application of the I4.0 strategy, UX strategy, and financial strategy.
- Discuss the support mechanisms needed to develop XR ideas, including financial support, training and development, and human resource requirements.

3.4 Literature search

The search term used in the title-focused strategy comprises the format of keyword 1 AND keyword 2 AND (keyword 3A OR keyword 3B OR keyword 3C). Keyword 3A focuses on strategy, keyword 3B focuses on policy, and keyword 3C focuses on the roadmap. The Boolean search syntax phrase combines each keyword 1 with each keyword 2 and each of the alternatives of keyword 3 (Table 2 and Table 3). For example, part of a search phrase for XR development strategy is Virtual AND Development AND Strategy or Virtual AND Developing AND Strategies.

The co-occurrence strategy could benefit from a similar Boolean process to combine all the phrases to search. For example, the quoted syntax "(Virtual OR VR OR Augmented OR AR OR Mixed OR MR OR Extended OR XR OR Metaverse OR Immersive OR Immersion) AND development AND strategy" combines all of the phrases in Table 4. However, not all of the sources of literature have a search tool that processes nested Boolean logic. Thus, the researcher copied and pasted the entire cell content containing the quoted phrase.

The databases to search for literature include Web of Science, ProQuest, EBSCOHost and IEEE Xplore. The researcher used the search platforms Google Scholar and UWIlinC to expand the sources of literature. The former is a "crawler-based search engine" (Gusenbauer, 2019). The latter is an information portal that provides access to multiple databases simultaneously via one search interface, as The UWI has a subscription (The Alma Jordan Library, 2023).

Although Google Scholar searches grey literature (de Winter et al., 2013; Giustini and Kamel Boulos, 2013; Haddaway et al., 2015; Orduna-Malea et al., 2017) the following entities provide a focused resource of XR grey literature. These include the XR Association (XRA) (The XR Association, 2023), VR/AR Association (The VR/AR Association, 2023), IVRPA International Virtual Reality Professionals Association (IVRPA, 2023), EuroXR European Association for Extended Reality (EuroXR Association, 2023), AREA Augmented Reality for Enterprise Alliance (Object Management Group, 2023), and Metaverse Standards Forum (The Khronos Group, 2023). The researcher included Meta (Meta, 2023) and EON Reality (EON Reality, 2023) to this list as they partnered with Caribbean entities to develop XR competencies in the region (IDB Lab, 2022; Loutoo, 2021; OAS, 2021).

The researcher refers to the following list of ten journals as non-indexed. During the literature search, their websites contained no information about their indexing status. These non-indexed journals should augment the sources of XR literature not found in the databases because they may offer additional perspectives on XR that complement the indexed journals.

- International Journal of Virtual Reality, IJVR (2023)
- Metaverse (Met), Metaverse (2023)
- Virtual Reality & Intelligent Hardware, VRIH (2023)
- International Journal on Stereo & Immersive Media, IJSIM (2023)
- Journal of Immersive Media and Creative Arts, JIMCA (2023)
- Journal of the Virtual Reality Society of Japan, JVRSJ (2023)
- Proceedings of Annual Conference of Japan Society for Medical Virtual Reality, JSMVR (2023)

Table 2. Boolean Search Syntaxes for Identifying Record Titles by Platform and Focus - Part 1

Database or Search Platform	Search Focus	Boolean Search Syntax
Web of Science	Strategy	(Virtual OR VR OR Augmented OR AR OR Mixed OR MR OR Extended OR XR OR Metaverse OR Immersive OR Immersion) AND (development OR develop OR developed OR developing) AND (strategy OR strategic OR strategies)
Web of Science	Policy	(Virtual OR VR OR Augmented OR AR OR Mixed OR MR OR Extended OR XR OR Metaverse OR Immersive OR Immersion) AND (development OR develop OR developed OR developing) AND (policy OR policies OR policymaking OR policymaker OR policymakers)
Web of Science	Roadmap	(Virtual OR VR OR Augmented OR AR OR Mixed OR MR OR Extended OR XR OR Metaverse OR Immersive OR Immersion) AND (development OR develop OR developed OR developing) AND (roadmap OR roadmaps)
Google Scholar	Strategy	allintitle: (Virtual OR VR OR Augmented OR AR OR Mixed OR MR OR Extended OR XR OR Metaverse OR Immersive OR Immersion) (development OR develop OR developed OR developing) (strategy OR strategic OR strategies)
Google Scholar	Policy	allintitle: (Virtual OR VR OR Augmented OR AR OR Mixed OR MR OR Extended OR XR OR Metaverse OR Immersive OR Immersion) (development OR develop OR developed OR developing) (policy OR policies OR policymaking OR policymaker OR policymakers)
Google Scholar	Roadmap	allintitle: (Virtual OR VR OR Augmented OR AR OR Mixed OR MR OR Extended OR XR OR Metaverse OR Immersive OR Immersion) (development OR develop OR developed OR developing) (roadmap OR roadmaps)
IEEE Xplore	Strategy	("Document Title": Virtual OR "Document Title": VR OR "Document Title": Augmented OR "Document Title": AR OR "Document Title": Mixed OR "Document Title": MR OR "Document Title": Extended OR "Document Title": XR OR "Document Title": Metaverse OR "Document Title": Immersive OR "Document Title": Immersion) AND ("Document Title": development OR "Document Title": develop OR "Document Title": developed OR "Document Title": developing) AND ("Document Title": strategy OR "Document Title": strategic OR "Document Title": strategies)
IEEE Xplore	Policy	("Document Title": Virtual OR "Document Title": VR OR "Document Title": Augmented OR "Document Title": AR OR "Document Title": Mixed OR "Document Title": MR OR "Document Title": Extended OR "Document Title": XR OR "Document Title": Metaverse OR "Document Title": Immersive OR "Document Title": Immersion) AND ("Document Title": development OR "Document Title": develop OR "Document Title": developed OR "Document Title": developing) AND ("Document Title": policy OR "Document Title": policies OR "Document Title": policymaking OR "Document Title": policymaker OR "Document Title": policymakers)
IEEE Xplore	Roadmap	("Document Title": Virtual OR "Document Title": VR OR "Document Title": Augmented OR "Document Title": AR OR "Document Title": Mixed OR "Document Title": MR OR "Document Title": Extended OR "Document Title": XR OR "Document Title": Metaverse OR "Document Title": Immersive OR "Document Title": Immersion) AND ("Document Title": development OR "Document Title": develop OR "Document Title": developed OR "Document Title": developing) AND ("Document Title": roadmap OR "Document Title": roadmaps)
ProQuest	Strategy	TITLE((Virtual OR VR OR Augmented OR AR OR Mixed OR MR OR Extended OR XR OR Metaverse OR Immersive OR Immersion) AND (development OR develop OR developed OR developing) AND (strategy OR strategic OR strategies))
ProQuest	Policy	TITLE((Virtual OR VR OR Augmented OR AR OR Mixed OR MR OR Extended OR XR OR Metaverse OR Immersive OR Immersion) AND (development OR develop OR developed OR developing) AND (policy OR policies OR policymaking OR policymaker OR policymakers))
ProQuest	Roadmap	TITLE((Virtual OR VR OR Augmented OR AR OR Mixed OR MR OR Extended OR XR OR Metaverse OR Immersive OR Immersion) AND (development OR develop OR developed OR developing) AND (roadmap OR roadmaps))

Table 3. Boolean Search Syntaxes for Identifying Record Titles by Platform and Focus - Part 2

Database or Search Platform	Search Focus	Boolean Search Syntax
EBSCOHost	Strategy	((TI Virtual) OR (TI VR) OR (TI Augmented) OR (TI AR) OR (TI Mixed) OR (TI MR) OR (TI Extended) OR (TI XR) OR (TI Metaverse) OR (TI Immersive) OR (TI Immersion)) AND ((TI development) OR (TI develop) OR (TI developed) OR (TI developing)) AND ((TI strategy) OR (TI strategic) OR (TI strategies))
EBSCOHost	Policy	((TI Virtual) OR (TI VR) OR (TI Augmented) OR (TI AR) OR (TI Mixed) OR (TI MR) OR (TI Extended) OR (TI XR) OR (TI Metaverse) OR (TI Immersive) OR (TI Immersion)) AND ((TI development) OR (TI develop) OR (TI developed) OR (TI developing)) AND ((TI policy) OR (TI policies) OR (TI policymaking) OR (TI policymaker) OR (TI policymakers))
EBSCOHost	Roadmap	((TI Virtual) OR (TI VR) OR (TI Augmented) OR (TI AR) OR (TI Mixed) OR (TI MR) OR (TI Extended) OR (TI XR) OR (TI Metaverse) OR (TI Immersive) OR (TI Immersion)) AND ((TI development) OR (TI develop) OR (TI developed) OR (TI developing)) AND ((TI roadmap) OR (TI roadmaps))
UWIlinC	Strategy	(Virtual OR VR OR Augmented OR AR OR Mixed OR MR OR Extended OR XR OR Metaverse OR Immersive OR Immersion) AND (development OR develop OR developed OR developing) AND (strategy OR strategic OR strategies)
UWIlinC	Policy	(Virtual OR VR OR Augmented OR AR OR Mixed OR MR OR Extended OR XR OR Metaverse OR Immersive OR Immersion) AND (development OR develop OR developed OR developing) AND (policy OR policies OR policymaking OR policymaker OR policymakers)
UWIlinC	Roadmap	(Virtual OR VR OR Augmented OR AR OR Mixed OR MR OR Extended OR XR OR Metaverse OR Immersive OR Immersion) AND (development OR develop OR developed OR developing) AND (roadmap OR roadmaps)

Table 4. Focus Area Co-Occurrence Keyword Search Phrases

Strategy Focused Phrase	Policy Focused Phrase	Roadmap Focused Phrase
“XR development strategy”	“XR development policy”	“XR development roadmap”
“Extended reality development strategy”	“Extended reality development policy”	“Extended reality development roadmap”
“VR development strategy”	“VR development policy”	“VR development roadmap”
“Virtual reality development strategy”	“Virtual reality development policy”	“Virtual reality development roadmap”
“AR development strategy”	“AR development policy”	“AR development roadmap”
“Augmented reality development strategy”	“Augmented reality development policy”	“Augmented reality development roadmap”
“MR development strategy”	“MR development policy”	“MR development roadmap”
“Mixed reality development strategy”	“Mixed reality development policy”	“Mixed reality development roadmap”
“Metaverse development strategy”	“Metaverse development policy”	“Metaverse development roadmap”
“Immersive development strategy”	“Immersive development policy”	“Immersive development roadmap”
“Immersion development strategy”	“Immersion development policy”	“Immersion development roadmap”

- The Japanese Journal for Medical Virtual Reality, JJMVR (2023)
- VAST: International Symposium on Virtual Reality, ISVR (2023)
- Transactions of the Virtual Reality Society of Japan, TVRSJ (2023)

4. Findings and Discussion

The following sections clarify the exclusions performed by each search strategy and the impact on the data. These steps are useful in decreasing the size of the dataset. However, they also increase the risk of rejecting a potentially eligible document before the stage to identify the presence of an agnostic XR development strategy or policy. This risk arises because the exclusion criteria might inadvertently filter out documents that contain relevant but not immediately apparent information.

The analysis of the results from each search strategy provides an understanding of the data distribution based on the timespans used, such as 'Any Time' and '2019-2023'. The former represents all the data available before the application of the 2019 date limiter. The combined search strategies generated 2,876 records for 'Any Time' and 1,000 records for the focused period 2019 to 2023. The methods applied in each search strategy as well as the similarity of the keyword phrases used in each strategy generated many duplicated records.

4.1 Title Keyword Search Strategy

This title keyword-focused PRISMA study started with 2,844 records. After applying the exclusion criteria it produced one eligible document that is "Analysis of Caribbean XR Survey Creates an XR Development Strategy as a Path to the Regional Metaverse Evolution" (Rameshwar and King, 2023a). Fig. 1 provides a detailed breakdown of the exclusions performed and the resulting literature accepted in each stage.

As illustrated in Fig. 2, applying the data limiter to focus the search from 2019 to 2023 reduced the search results in all of the databases and platforms by an average of 35%. Google Scholar produced the highest number of search results before the date range limitation (at 975 records). Whereas, ProQuest's dataset became the largest contributor (294) after the date limiter reduced Google Scholar's dataset to 267. Although the date restriction reduced the overall quantities of each dataset (Fig. 2), the percentage contribution of each database to the whole dataset within a specific date limiter was small (Fig. 3). As expected, the largest variation occurred in Google Scholar and ProQuest. The former decreased by 7% and the latter increased by 9%. This indicates a small relative change in each database's contribution to the total number of records within the specific period. However, this quantitative evaluation does not clarify whether the remaining records are eligible for evaluation as per the research questions.

Data from IEEE was the only one that did not contain any duplicates. ProQuest contained duplicates only within the specific search categories of strategy, policy, and roadmap. However, duplicated titles existed in Google Scholar, Web of Science, UWIlinC, and EBSCO within the search categories and the database. Results from UWIlinC created duplicates as some of the results came from the aforementioned databases. In total, 409 duplicates required removal (Fig. 4). This represented 42% of the 965 English titles.

The researcher experienced problems using the same Boolean search syntax to identify suitable titles within a select list of journals. As illustrated in Fig. 1, the journals with N/A indicate the search was not possible for the following reasons:

- The search tool does not provide the ability to narrow the search on an article's title in the journals JJVR, IJSIM, JIMCA, and ISVR
- The Boolean operators did not provide accurate results based on tests of existing articles within specific journals. For example, the JSMVR contains the two articles "Virtual reality simulation of robotic pediatric surgery" and "Evaluation of VR Annotation Based Teaching Using a Digital Rectal Examination Simulator". The Article title Boolean test using (virtual OR VR) AND (robotic OR teaching) resulted in the message "No article has been found that matches the search query". This problem identified by a similar test also occurred with JJMVR and TVRSJ.

4.2 Co-occurrence Keyword Phrases Search Strategy

This co-occurrence keyword-focused PRISMA study started with 32 records. After applying the exclusion criteria it produced one eligible document that is "Analysis of Caribbean XR Survey Creates an XR Development Strategy as a Path to the Regional Metaverse Evolution" (Rameshwar and King, 2023a). Fig. 5 provides a detailed breakdown of the exclusions performed and the resulting literature accepted in each stage.

Most of the results are from the Google Scholar search (Fig. 6) which produced approximately 88% of the total. ProQuest generated two results for the syntax "Metaverse Development Strategy". The other sources searched did not produce any data for the focused period.

Without the date limit, there are more results identified. Google Scholar still accounted for the largest share corresponding to 23 records that are 72% of the total (32). The additional three records from ProQuest increased its con-

Figure 1. PRISMA Process of Title Keyword Search Showing Literature Sources and Exclusions

tribution from 11% (in the 2019-2023 limit) to 16%. This unrestricted search also identified four additional records. Two were each from The Japanese Journal for Medical Virtual Reality (JJMVR) and VAST: International Symposium on Virtual Reality (ISVR).

The percentage change from 'Any Time' to '2019-2023' (Fig. 7) showed that there was an increase of 16% in Google Scholar's results although its total decreased from 23 to 15. ProQuest had the opposite effect through a 4% reduction from 16% with five papers to 12% with two papers. This illustrates that Google Scholar captured more articles during the 2019 to 2023 period as compared to the prior. This is the opposite of the other sources as their largest contributors were before the date limit.

This search strategy did not contain the same quantity of duplicates as in the title keyword search. Fig. 8 illustrates that there were only three duplications throughout the process. The majority occurred from Google Scholar.

Some XR websites did not have a search tool to check for the presence of the co-occurrence keyword phrase. These

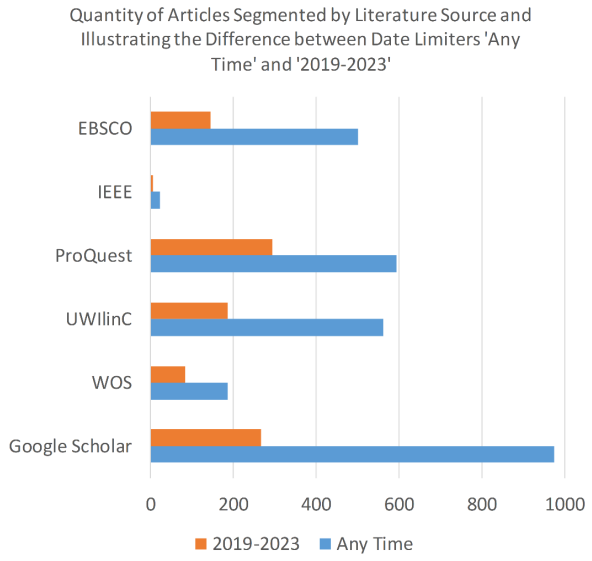

Figure 2. Comparison of Article Quantities by Source and Date Range for Title Keyword Search

are EON Reality, VARA, and Metaverse Standards Forum. However, the Meta website is unique. The search tool does not appear on the main page (https://www.meta.com/). The researcher discovered that the search tool results via the creator link (https://creator.oculus.com/) are different to the results from the search tool in the developer link (https://developer.oculus.com/). Thus, it appears to search the specific website and not the entire system. Additionally, quotation marks did not work in the developer link's search tool as none of the results contained the quoted statement tested. A further test showed it searches for any word in the quotation marks.

E0: Date limited from 2019 to 2023: The possibility for eligible documents exists before 2019. The initial search supports this idea through a combined 2,876 possible documents (segmented as 2,844 from the first strategy and 32 in the second). This is only an approximation of the potential as these results contained duplicates, as outlined below.

However, the research questions' search criteria focused on the strategy or policy development surrounding the impact of COVID-19. Thus, it reduced the dataset of potential records by limiting the usable data from 2019 to 2023. This reduced the total number of records from each strategy. This reduction was not equal to the records from the title-focused strategy decreased by 65% and those from the co-occurrence changed by approximately 47%. This demonstrates the potential loss of valuable data. It also indicates the publication of more articles with the co-occurrence keywords after 2019 as compared to the other strategy.

E1: Non-English titles: ProQuest and IEEE were the only sources with only English titles in both strategies. This may be due to the types of articles indexed during the timespan. As expected, there are considerably more non-English titles removed from the title-focused strategy as it has almost 58 times more records than the co-occurrence strategy. The non-English languages in this dataset are Spanish, Korean, Chinese, Thai, Ukrainian, Arabic, Portuguese, Indonesian, and Russian. The latter three occurred in both strategies.

E2: Duplications: The duplicated results existed due to two key reasons. The first was the occurrence of duplicated titles in the same database due to different entities publishing the same work. The second was because the researcher conducted separate search syntaxes within each strategy.

This created multiple results that contained combinations of two or more of the specific keywords. This segmentation was primarily due to the limit of characters in the Google Scholar search string and the decision to maintain this pattern for all searches.

The deduplication process is essential to provide a true account of the viable data and identify a unique record for analysis. This produced 556 unique titles in the title-focused strategy and 11 in the co-occurrence strategy. There was only one duplication between the two strategies. That is the eligible document.

E3: False positives: False positives are titles that do not match the initial search criteria keywords or date range. The former occurred when the keyword search extracted results based on information in addition to the title. The record's title field data contained more information than the true title of the document. However, in some instances, it was not clear why the search selected the title, as the data in the field did not have all of the required keywords. The following examples highlight these problems. No data from the co-occurrence strategy received these exclusion labels.

UWIlinC truncated the titles of some papers in such a way that they did not meet all the search keywords. The keyword search using Google Scholar identified some results that contained each keyword in a different title of all the articles in a publication. Thus, they did not occur in the same article's title. Therefore, the error occurs based on how the platform recognises and records an individual title.

Within the unique dataset, only one title had a publication year outside of the 2019-2023 filter. This received the label E3-3. A review of the raw data revealed it is a common occurrence among results from Google Scholar, UWIlinC, and EBSCO. The difficulty in identifying this problem is because the exported Excel data's date field was blank. This requires a manual recording of the lost dates to correct the errors.

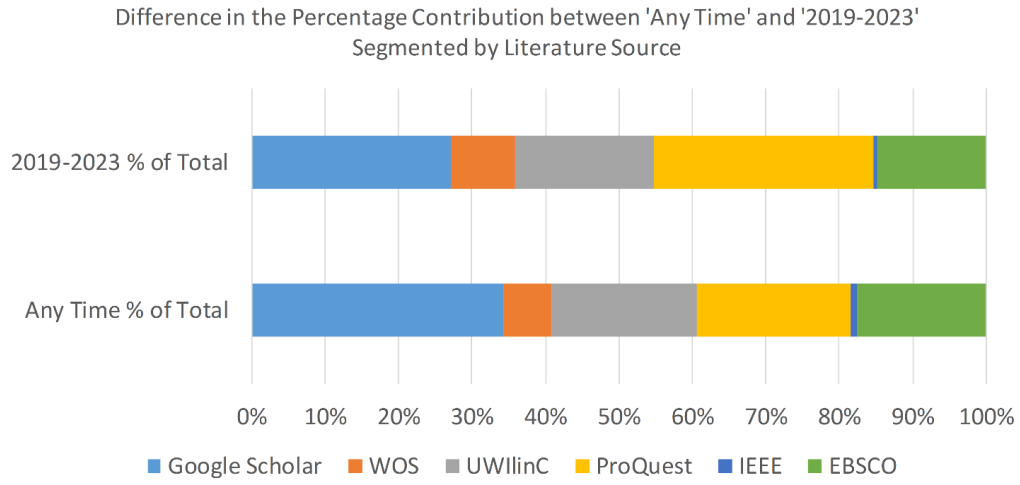

Figure 3. Comparison of Literature Sources Contribution by Date Range for Title Keyword Search

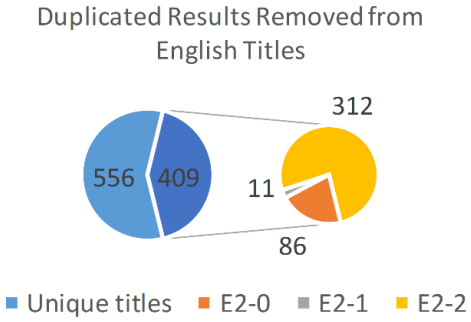

Figure 4. English Title Deduplication Breakdown for Title Keyword Search

The use of partial phrases and abbreviated words in the search syntaxes (as noted in Section 3.4) created false positives. This occurred as the search identified these terms as valid keywords although there was no reference to XR. For example, the inclusion of the words “extended” or “augmented” created false positives once there was no association with XR. An occurrence of “extended” is in the title “Development of analytical solution for Photoacoustic Imaging of an Extended line source with acoustic lens based reconstruction strategy”. The presence of the word "augmented" does not refer to XR in the title "Impact of monetary policy on China’s tourism market development: An application of factor –augmented vector auto-regression (FAVAR) model”.

There is a choice to constrain the results by using the entire search term "virtual reality". However, it omits potentially useful titles in which the authors only state the word “virtual” and highlight XR within the paper. For example, only the word "virtual" occurs in the title "The effectiveness of virtual environments in developing collaborative strategies between industrial robots and humans". However, the paper “presents the use of a Virtual Reality digital twin” (Oyekan et al., 2019). The next section evaluates the remaining 311 papers’ abstracts (or full paper if there is no available abstract) for a clear focus on XR.

E4: Records with no clear focus on XR: This section describes the problem experienced in trying to source a record’s abstract or full paper to validate the term that identified a potential XR reference in the title.

As an example, Google Scholar provided a partial abstract (noted by the ellipsis at the end) for the paper “Effectiveness of Virtual Trips Strategy Based on Guided Imagination in Developing Analytical Thinking for Sixth Grade Students”. The available information did not highlight a clear focus on XR. The researcher was unable to access the full abstract to validate this lack of focus on XR based on the following reasons. The EBSCOHost database (provided by the Google Scholar link) did not provide access to the article. A search directly on EBSCO did not locate the article. The Malwarebytes Browser Guard blocked access to the paper’s journal website rigeo.org. The error message stated it “may contain malicious activity”. As such, the researcher accepted the warning and did not access the online journal ‘Review of International Geographical Education Online (RIGEO)’. The researcher did not try to locate a physical copy of the journal as the research questions focused on online availability. Thus, this paper received the label E4-2.

Records received the labels E4-1 or E4-6 if there was no clear reference to XR in either the abstract or full paper (if there was no abstract). As an example, the English abstract of the Korean paper “A Development Study of Instructional Design Strategies for Metaverse Based on Goal-

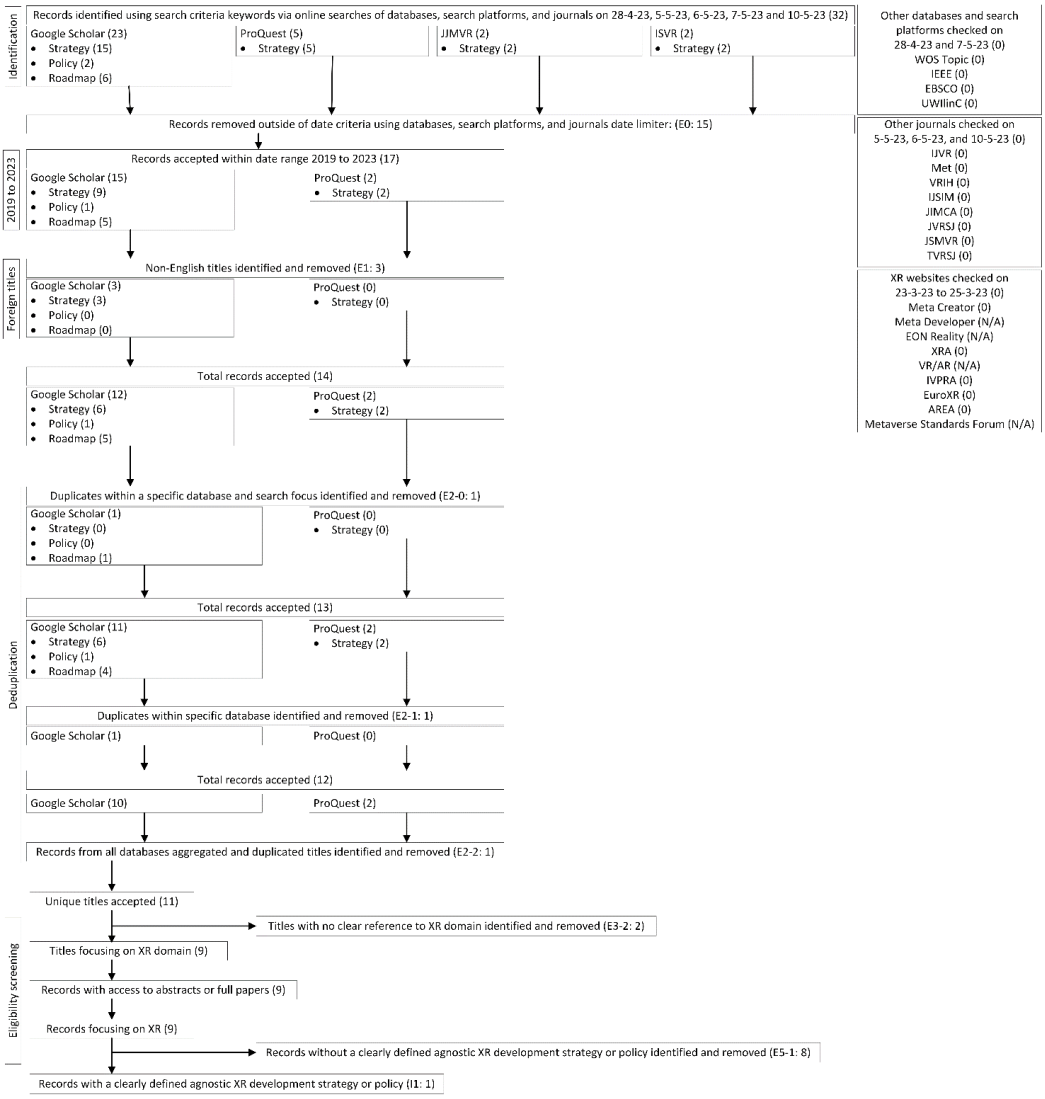

Figure 5. PRISMA Process of Co-Occurrence Keyword Phrase Search Showing Literature Sources and Exclusions

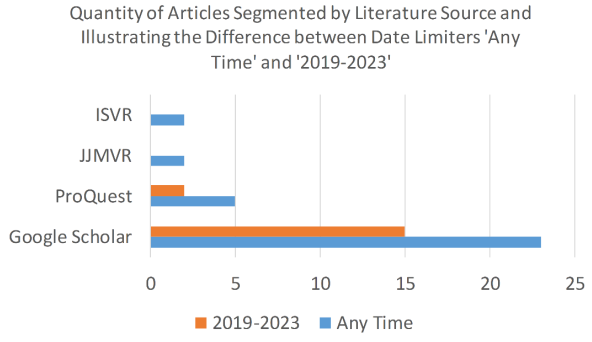

Figure 6. Comparison of Article Quantities by Source and Date Range for Co-Occurrence Keyword Phrase Search

Directed Design Methodology" receives the E4-1 label. Although it focuses on the wider concept of the metaverse, which can include XR, there is no clear identification of any of the terms VR, AR or MR within the English abstract (Lee and Im, 2022). The full text may contain information relevant to XR. However, the translation of the Korean text into English was outside the scope of this research study.

E5: No clearly defined agnostic XR development strategy or policy: The researcher evaluated each document to identify the presence of a clearly defined agnostic XR development strategy. Once a paper's focus is an XR development strategy or policy then there would be a clear indication in the abstract. Thus, the inability to access the full paper is not a problem to identify it for exclusion once the abstract is available in English.

An excluded document does not address the elements to enable anyone to have a concept idea and develop any type of XR (either AR, VR, or MR) proof of concept ap-

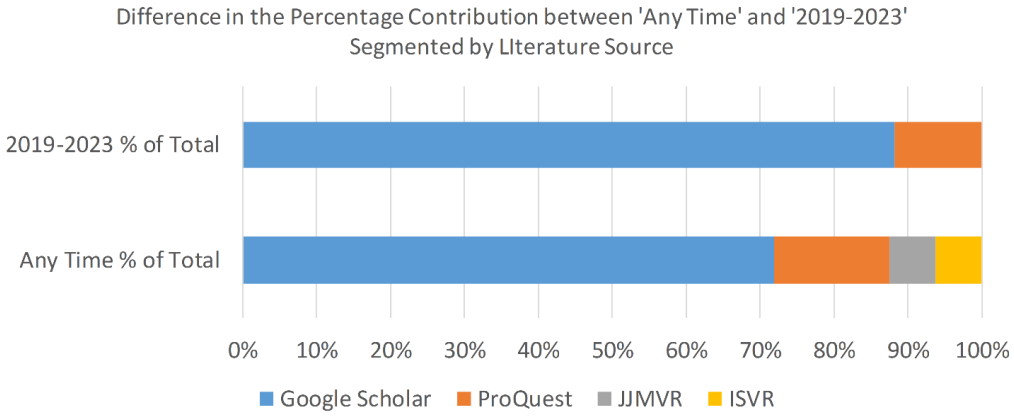

Figure 7. Comparison of Literature Sources Contribution by Date Range for Co-Occurrence Keyword Phrase Search

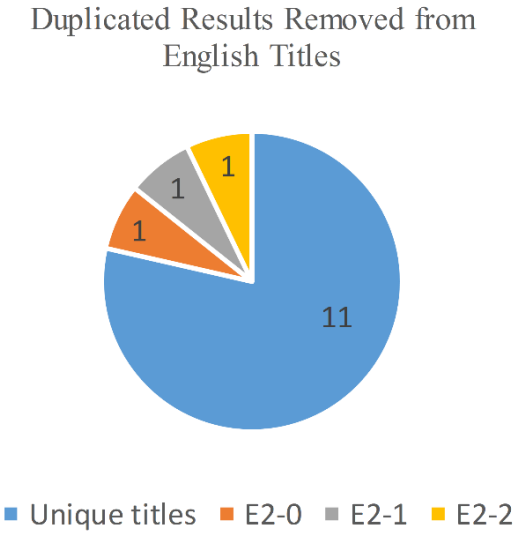

Figure 8. English Title Deduplication Breakdown for Co-Occurrence Keyword Phrase Search

plication. Therefore, an excluded document only focuses on designing for a specific persona in a specific industry sector without explaining how to transfer this information and apply it to another role or sector.

However, 67 documents received the label E5-1 from the title-focused strategy and eight from the co-occurrence strategy received the label. They did not meet the requirement. For example, the papers identified in the literature review Section 2.3 that did not address all types of XR or the full list of codebook codes (Alsanea and Alawaidi, 2021; Ikhsan et al., 2019; Liu, 2022; Nassereddine, 2019; Nassereddine et al., 2022) were part of this exclusion group. Additionally, no labelled E5-1 papers incorporated the I4.0 strategy. This illustrated the need to have literature that contained all of the codebook elements. Therefore, a recommended research focus is to apply the codebook to XR development literature and compare the codes identified with the reference case.

I1: Eligible records with a clearly defined agnostic XR development strategy or policy: The eligible document (I1) occurred once in the title keyword search and twice (as a duplicate) in the co-occurrence keyword search. The key difference is that the phrase "XR development strategy" appears in both the title and throughout the document, whereas there is only one occurrence of the phrase "XR development policy" in the abstract. Therefore, the co-occurrence keyword searches identified the phrases ending in the terms "strategy" and "policy" in both the title and abstract.

This document is the researcher's own published work (Rameshwar and King, 2023a). It is the reference strategy used to develop the research question, exclusion criteria, and codebook. It contains a clearly defined, agnostic XR development strategy, written in English, as the key focus of the work. The identification of this singular document demonstrates the effectiveness of the PRISMA process. This discovery also highlights the gap in the literature regarding clearly defined agnostic XR development strategies or policies.

Although there are no other strategies to compare, the researcher recognised the importance of assessing the paper to highlight its value as an eligible document. The strategy points creators to the elements needed for a successful product, such as achieving the minimum criteria in the factors of influence; the importance of aligning the design foci (user, task, and location) with the concepts of Industry 4.0, user experience, and financial mechanisms; and the suggested selection of the target market(s) in the form of industry sectors. The paper provides a comprehensive framework for the strategy and supports it with data from developers about their experiences with creating

XR projects. The strategy is explicit. It clearly defines the parameters required to develop any type of XR project, including information necessary for a policy framework development.

4.3 Answering the research questions

Table 5 provides the specific answers to the research questions based on the PRISMA studies. It demonstrates that this research successfully identified an English written clearly defined agnostic XR development strategy since the start of Covid-19. Although there was no positive answer to the second question, it outlined the existence of the policy framework to develop policies that encourage and accelerate XR development. It also highlights the research gap.

5. Conclusion

This work focused on two separate PRISMA search strategies that produced 2,876 records. One strategy focused on restricting a Boolean keyword search to an article's title. The other strategy searched for the presence of co-occurrence keyword phrases anywhere in a document. The former accounted for 2,844 records and the latter for 32. However, the application of the date limitation to focus only on data from 2019 to 2023 reduced this to 983 and 17 respectively. This was the first step in the PRISMA process used to exclude unwanted data based on the research questions.

The PRISMA diagrams (Fig. 1 and Fig. 5) illustrate the sources of literature searched and the individual exclusion processes involved in each strategy. The basic steps are the same (identification of literature, restriction of data to the search period, removal of non-English papers, deduplication, and eligibility screening). The differences between the two PRISMA strategies are the types of exclusions performed and the completion time. The title-focused strategy required the removal of false positives (E3-1 and E3-3) and records that the researcher was unable to validate a clear focus on XR in the abstract or full paper (E4). The title keyword strategy was more time intensive due to the larger quantity of records and difficulty searching for the abstracts or full papers of some records. On the other hand, the researcher had access to all the English-language papers from the co-occurrence strategy results.

However, the researcher did not conclude whether any strategy was better than the other, as both provided the same eligible document. In this study with the specific keywords used, each strategy approached the search differently and both provided useful data. This outcome may not be the same for different keywords. Thus, it is advisable to combine both.

The last step identified only one document from each strategy that contained a clearly defined agnostic XR development strategy. This paper is "Analysis of Caribbean XR Survey Creates an XR Development Strategy as a Path to the Regional Metaverse Evolution" (Rameshwar and King, 2023a). This is the researcher's work used as the reference strategy for the development of the research questions, inclusion and exclusion criteria, and codebook.

This work is not an exhaustive review of XR development literature. As such, the assessments depend upon the deliberate methodological limitations used to identify eligible data. The first limitation placed on the data was the inclusion of the keywords used in the individual searches. This effectively eliminated potential data. The researcher did not quantify this amount. However, this decision stemmed from the clarity of the specific research question to identify the existence of an English clearly defined agnostic XR development strategies or policies.

The next decision was to use the following sources of literature in the search strategy. These databases, search platforms, journals, and websites are as follows:

- Databases and search platforms are Web of Science, EBSCOHost, ProQuest, IEEE Xplore, Google Scholar, and UWIlinC (this is specific to the researcher's university library)
- Non-indexed journals used in the study: International Journal of Virtual Reality (IJVR), Metaverse (Met), Virtual Reality & Intelligent Hardware (VRIH), International Journal on Stereo & Immersive Media (IJSIM), Journal of Immersive Media and Creative Arts (JIMCA), Journal of the Virtual Reality Society of Japan (JVRSJ), Proceedings of Annual Conference of Japan Society for Medical Virtual Reality (JSMVR), The Japanese Journal for Medical Virtual Reality (JJMVR), VAST: International Symposium on Virtual Reality (ISVR), Transactions of the Virtual Reality Society of Japan (TVRSJ)
- XR websites: Meta, EON Reality, XRA, VR/AR, IVRPA, EuroXR, AREA, and Metaverse Standards Forum.

This is not an empty review as there is a non-zero outcome from the PRISMA searches. However, the researcher treats it as such due to the eligible document being the one used to establish the parameters of this study and written by the researcher. Thus, it is important to understand the value of these types of systematic reviews in which there is no data to analyse in the inclusion list.

5.1 Implications

This study identified surprising results. This work illustrates that academic databases do not contain the same records. Only Google Scholar contained the inclusive paper. Thus, the choice of databases and search platforms

Table 5. Responses to the Research Questions

Research Question	Response
RQ#1: Since the start of Covid-19 are there publicly accessible online English clearly defined agnostic strategies that encourage and accelerate XR development for use within multiple industry sectors to improve innovation, competitiveness and sustainability of a geographic region?	Yes. This study identified an English clearly defined agnostic XR development strategy that can encourage anyone to develop a PoC, increase the number of PoCs, and reduce completion times. However, the researcher used this strategy as a reference case to define the research questions and to compare it to other strategies discovered. It is the researcher's work.
RQ#2: Since the start of Covid-19 are there publicly accessible online English clearly defined agnostic policies that encourage and accelerate XR development for use within multiple industry sectors to improve innovation, competitiveness and sustainability of a geographic region?	No. It is not a clearly defined agnostic XR policy, as it does not define a specific course of action based upon a decision. This reference work provides information to develop the policy framework to identify and address the policy questions of who, what, when, where, why, and how to encourage and accelerate XR development. It provides the reasons for the decision of an action. It provides guidelines and rules for making decisions to develop an XR application. The paper contains a clear methodology, in the form of the survey analysis. It also demonstrates the development of the strategy through the identification of the goals based on the decision options.

determines the data quality.

Additionally, the records eliminated revealed a prevalence of information to develop partial strategies or policies for specific types of XR applications (such as AR, VR, or MR) under specific conditions such as industry sector, and design foci (user, purpose, and location). Some documents also contained information to create an agnostic XR development strategy or policy. The data showed a limited focus on the funding required or obtained for the specific development of the application (although some authors identified funding for the entire research project). The focus on I4.0 was non-existent in the data.

Although only one document was eligible, this does not indicate that there are no other XR development strategies. The limitations of the study defined the scope of the research. As such, it is possible that removing these constraints would reveal existing agnostic XR development strategies or policies. The application of the codes for XR development clearly shows that existing development in this area contains partial building blocks. This researcher believes that expanding the literature review could result in the creation of a similar XR development strategy used as the reference case. However, this is not the focus of this paper's work.

A question for future research work is why the authors, of excluded papers, did not expand their data analyses in their respective studies to develop agnostic XR strategies and policies. This would benefit the wider XR developer community by providing a clearly defined system of goals and decisions to apply within any geography, industry sector, or persona. This result would be similar to the work created in the reference case using the survey of Caribbean XR developers.

Therefore, this paper's value focuses on the following:

- Proves the research gap as there is inadequate research material on English-language clearly defined agnostic strategies or policies that can encourage and accelerate XR development
- Creates a systematic exclusion structure
- Justifies the continued research focus on the policy framework that involves stakeholders' feedback on the proposed strategy elements
- Identification of existing research focusing on a specific type of XR development (such as AR, VR, or MR) that contains information to create a partial XR development strategy
- Recognition of the need to remove the dataset limitations to include more literature such as from non-English sources; any publication date; a wider variety of databases and non-indexed journals; utilise the search prowess of AI Large Language Models (AI LLMs) and non-academic search engines; and implement continuous real-time research alerts
- This brings attention to the need for more publications on clearly defined agnostic strategies and policy frameworks that encourage and accelerate XR development

The strategy based on the study of Caribbean XR developers was the only eligible record identified in the PRISMA study. This raises three questions. The first is to understand the perspectives and opinions of XR-focused companies in adopting the strategy. The second focuses on the strategy's significance in encouraging and accelerating regional XR projects by examining the perspectives and opinions of Caribbean XR development stakeholders. The third determines whether COVID-19 influenced Caribbean digital transformation strategies to embed a focus on XR development.

5.2 Limitations of the study

The search strategies identified only one suitable literature to address the research questions. However, it is important to recognise that the PRISMA criteria excluded potential documents from the study. The following list of limitations addresses the issue of the low return rate of eligible records that match the search criteria of the research question.

- Limited scope of the keyword search: This study restricted the Boolean keyword search to the document's title and not the entire paper. As such, it would not identify potential literature that did not use the keywords in their titles. The co-occurrence keyword phrase search of the entire document mitigated some of these possible exclusions. The omission of the keywords "spatial" and "spatial computing" occurred as the researcher understood the terms "immersive" and "immersion" encapsulate a broad range of experiences that can also include a spatial quality, however, in-depth interviews with XR stakeholders from October 2023 to January 2024 identified 'spatial' and 'spatial computing' as a distinct concepts within the XR nomenclature.
- Limited search period: The study confined its scope to documents published between 2019 and 2023. This constraint might have inadvertently omitted pertinent studies from earlier years. However, the research questions' specific focus dictated this limitation. It is also worth noting that the literature sources might reveal eligible documents after the researcher's search period.
- Limited sources of literature evaluated: This study only searched a finite set of four academic databases, two search platforms, ten non-indexed journals, and eight XR websites to identify an exhaustive list of records. It is possible that these specific sources did not index or publish all eligible material. Additionally, the researcher did not use general, non-academic search engines (such as Google.com) to identify grey literature which may contain suitable information.
- Limited language of the literature: This work excluded non-English papers, due to language barriers and lack of translation resources, which removed potential literature published in a language foreign to the researcher.
- Limited access to documents: The university's library subscription limitations prevented access to a database's full repository of literature. Fortunately, the use of multiple sources of literature reduced this issue. However, in some instances, the researcher was unable to access a potential record's abstract and full paper to determine its suitability.

5.3 Directions for further studies

The following recommendations identify future work aimed at improving the quality of the data because of the PRISMA study limitations.

- Expand the sources of literature: This approach encompasses a wider variety of academic and non-academic material to improve the possibility of identifying eligible documents.
- Increase the search timeline: This involves using an earlier start date and a later end date in the search options. The removal of the start date restriction may identify older documents that meet the eligibility criteria. In addition to the possibility of increasing the quantity of relevant documents, it will also enable a comparison of the COVID-19 effect to different disturbances in the previous years. It is important to understand that the specific search platform limits the start time based on the earliest date of their data retrieval. Increasing the end date requires the researcher to perform a continuous search each year to capture new articles published that meet the criteria.
- Apply the Boolean keyword search on the entire document: Extending the Boolean search syntax beyond the title will capture any reference to keywords within the entire paper. This process may increase the number of false positives as this search process does not identify co-occurrence phrases and the keywords may not be closely associated in the text.
- Extend the keywords to include all terms used in XR nomenclature: The researcher recognised that "spatial" and "spatial computing" are important keywords and that there is a need to find other terms associated with XR. As such, it is necessary to conduct an exhaustive search for XR search parameters during each of the annual search cycles. This will require the search of old data using the new keywords. However, as the field of XR evolves, this may be an ongoing activity as new ideas and terms become associated with XR.

- Create alerts for new material matching the search criteria: Subscription services will notify the researcher of new publications that match the search criteria. This can also include services such as RSS feeds and social media.
- Use AI LLMs to find material: AI LLMs can automate the process of identifying relevant literature using the search criteria. This feature may exist in a search platform, such as Sourcely (https://www.sourcely.net/), Elicit (https://elicit.com/), and SciSpace (https://typeset.io/).

In addition to improving the data quality noted by the previous points, the researcher recommends two examples for future projects. The first is a research project that applies the codebook to XR development literature, builds an XR development strategy from the existing material, and then compares it to the reference development strategy used in this work. The second is a research project that analyses the existing dataset to identify any changes pre-Covid-19 and post-Covid-19.

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